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Publications of

THE DAVID DUNLAP OBSERVATORY

University of Toronto

VOLUME I

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PLATE 1

The David Dunlap Observatory from the air, looking south-west

DESCRIPTION OF THE BUILDINGS AND EQUIPMENT

By R. K. Young

Introduction

THE David Dunlap Observatory, the gift of Mrs. Jessie Donalda Dunlap to the University of Toronto as a memorial to her husband, was formally opened on May 31, 1935.[1]

The progress of astronomy as a department of the University during the past twenty-five years has been due to the continued efforts of Dr. C. A. Chant to emphasize its importance as a cultural subject in education and as a training for the advanced student. It was a part of his plan, even from a very early date, that the University should have an observatory and contribute to the knowledge of the subject, but it was hardly expected that the money for its erection would be obtained from the provincial grant to the University. In an institution striving to meet the needs of the Province and expanding rapidly, chief emphasis in the field of science is placed on subjects more immediately utilitarian. Not until these had been taken care of would the claims of a pure science like astronomy be considered.

The interest in the subject in recent years has been much increased by the spectacular discoveries, which have greatly extended our knowledge of the universe, and which have appealed to the imagination. Astronomy owes much to the great body of amateurs whose interest has strengthened the desire that a large telescope might be situated within the Province. David Alexander Dunlap was one of these. He was a member of the Royal Astronomical Society of Canada and attended the meetings of the Toronto centre. Dr. Chant in all his lectures before the Society and throughout the country emphasized the observational side of astronomy and the need of an observatory. It was his hope that aid in this project would be received from Mr. Dunlap, but the latter's death in 1924 prevented this. When, some time later, Professor Chant suggested to Mrs. Dunlap that she should provide

[1] Journal of the Royal Astronomical Society of Canada, September, 1935.

the observatory as a memorial to her husband, the suggestion met with a sympathetic response. Indeed, Mrs. Dunlap shared her husband's interest in astronomy.

General Plans and Location

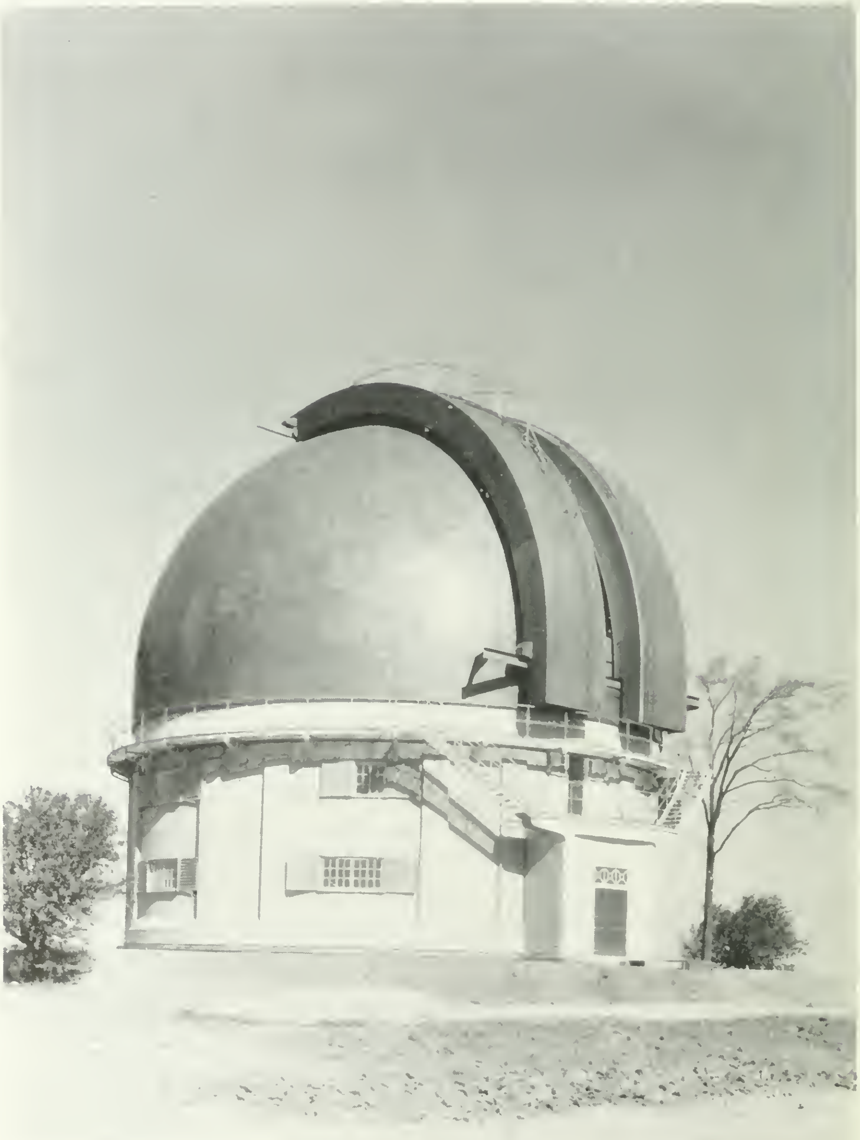
In 1927 Mrs. Dunlap expressed her willingness to provide the observatory but it was not until June of 1928 that we were in a position to call for estimates. The choice of instruments was an important point to decide. From the first, it was felt that a large reflector would be the most useful and economical instrument to push research in stellar astronomy, partly because the reflector is, size for size, cheaper than a refractor, but largely also because the writer's experience had been mostly in astronomical spectroscopy and the great light-gathering power of the reflector makes it a very suitable instrument in this field of astronomy. Former experience at the observatory at Ottawa as well as tests with smaller telescopes made us aware that we could not expect the best seeing conditions and it was necessary to plan programmes of work which did not require the finest definition. All these considerations led us to adopt the large reflector as a choice for the main instrument of research. Two buildings were planned: one, a steel structure to house the large telescope; the other, an administration building for office work and the reduction of observations. There was no haste about the construction of the latter building since it offered no particular difficulties, but the telescope was ordered as soon as possible because the time required for its construction was somewhat uncertain, this being especially true of the large mirror which forms the main optical part of the large telescope.

The location of the observatory was an important point to decide. It was almost essential from the standpoint of economy that it be located near Toronto. There can be no doubt that the output of the telescope would be much larger if it were placed nearer the equator. However, this would require a larger staff to carry on the courses of instruction at the University, and the research work at the observatory as well. Dr. Chant and the writer spent many afternoons inspecting maps of the neighbourhood of Toronto and visiting possible sites. It was not thought advisable to go more than twenty-five miles away from the city, and locations north or north-west were much preferable to those east of the city.

Most of our clear weather comes with west or north-west winds, and at these times the smoke of the city is blown east, or south-east A considerable amount of experimenting was carried on to determine the transparency of the air and the sky-illumination from the city lights, at thirty, fifteen, and four miles from the city. In this regard the stations thirty and fifteen miles away proved far superior to that near the city, especially in the amount of sky-illumination. The gain between thirty and fifteen miles did not seem to warrant placing the observatory at the more distant station. The site finally chosen is about twelve miles north of the city limits and is situated on a rise of ground about one hundred feet above the surrounding country which slopes gently away on all sides giving a good view. (Plate I). The elevation is eight hundred feet above sea-level. At present the land around the observatory is quite open, with a few trees and shrubs scattered here and there. From an astronomical point of view, it would be better if the land were more heavily wooded. It is hoped to be able to plant trees and shrubs on the one hundred and seventy-nine acres in the middle of which the observatory is situated. The approximate position of the observatory as taken from large scale maps, one mile to the inch, is, longitude $5^h\ 17^m\ 41^s.3$ W., latitude $43° 51' 46''$ N.

Awarding the Contracts

Comparatively few firms possess machinery large enough to handle the massive castings of a great telescope, and there are still fewer with experience in telescope building. The tentative specifications were sent to four firms: Carl Zeiss in Germany; Sir Howard Grubb, Parsons & Company in England; Warner & Swasey Company of Cleveland; and J. W. Fecker of Pittsburgh. The Warner & Swasey Company did not submit a tender, and the design of the Carl Zeiss firm was considered less satisfactory than the one selected. There was not much difference in the design or price of the other two, but after due consideration it was decided to accept the tender of the English company. This was a very fortunate choice because the decrease in the pound sterling and advance in the American dollar made the cost much less than it would have been had the contract been let in the United States. It was very satisfactory to be able to let the contract to a firm that could contract for the complete structure, dome, telescope



Dome from the south-west

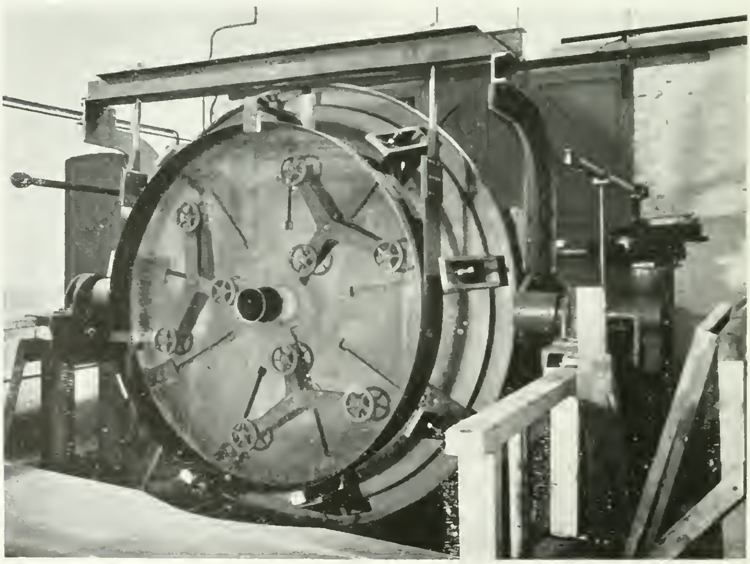
and optical parts, for this ensured the finished equipment would assemble without difficulty and it also saved a tremendous amount of time in correspondence and travel. In the description of the telescope and building which follow, the aim has been to describe the various points of construction, so that prospective observatories may obtain some ideas that may be of service in their own problems.

The Circular Steel Building and Dome

The building to house the telescope (Plate II) was ordered in November, 1931, and it was received in Toronto on July 31, 1933. The foundation for the building and the cement piers had previously been constructed and were in readiness to receive the building.

The foundation of the walls of the building is of cement and is extended below frost level. Preliminary borings were made before the location was selected to determine the nature of the ground under the piers. It is hard clay. The piers (Plate III (a)) go down to a depth of twenty-five feet and are hollow, with walls eighteen inches thick, heavily reinforced with steel. The hollow pier is more satisfactory than a solid one. They are amply strong and much lighter, with a correspondingly less tendency to subside. The space inside is very convenient for use. Below ground there are four rooms, six feet by eight feet, two in each pier, and above ground there are three more rooms, one in the south pier and two in the north. One of these, the upper room in the north pier, is very convenient as a dark room for loading and unloading plate holders. Another is utilized as a battery room for the low-voltage system about the telescope. So far the other rooms have not been used. They will be very useful, especially the underground rooms, for mounting instruments that require stability. We have experienced no difficulty from moisture in these rooms.

The circular building is sixty feet in outside diameter, sheathed inside and out with steel sheeting carried by twenty-four stanchions which bear upon their tops a strong annular girder. The entrance is on the ground level on the south side through a small porch with two pairs of steel doors. This gives access to the lower floor. The lower story is thirteen feet high and on this floor is placed a motor-generator set for supplying direct current to all the motors of the telescope, the dome-turning gear and the electric control



(a) The cement piers and base for 61-ft. dome
(b) Mirror on edge, ready for testing

panels and fuse boards, and a part is enclosed as a silvering room. A steel stairway leads to the upper floor which is of reinforced concrete, supported in steel I-beams. It has stood three winters without showing any tendency to develop cracks due to extremes of temperature. A doorway on this floor leads outside to the top of the porch over the entrance and thence a short stairway gives access to a gallery running around the outside of the building at a height of twenty-three feet above the ground level.

The hemispherical dome is sixty-one feet in outside and fifty-seven feet in inside diameter, the walls being double. The inside and outside covering are of "agasote", a hard paper product. The outside cover is one-half inch thick and the inside covering one-quarter inch. In addition, the outside has a sheeting of copper. The opening in the dome is fifteen feet wide and extends from the horizontal to seven feet beyond the zenith. It is covered by two parallel-moving shutters running on rails at the top and bottom of the dome. These shutters are operated by steel cables which are wound on a drum operated by a motor. The motor is of nine-tenths horse-power and the shutters can be opened in one minute. Some difficulty was experienced at first in getting the shutters to open and close parallel. This was due, for the most part, to a differential stretch in the cables between the bottom of the shutters and the top. As this stretch has gradually worked itself out and also because the guiding rollers were freed to some extent, the difficulty has disappeared. It is quite possible that a chain or gear system might be better. Two wind screens made of sail-cloth are mounted in the opening. One rises from the bottom and the other descends from the top. They are motor-operated and can be made to approach each other, so as to allow just enough room for the beam of light to reach the main mirror.

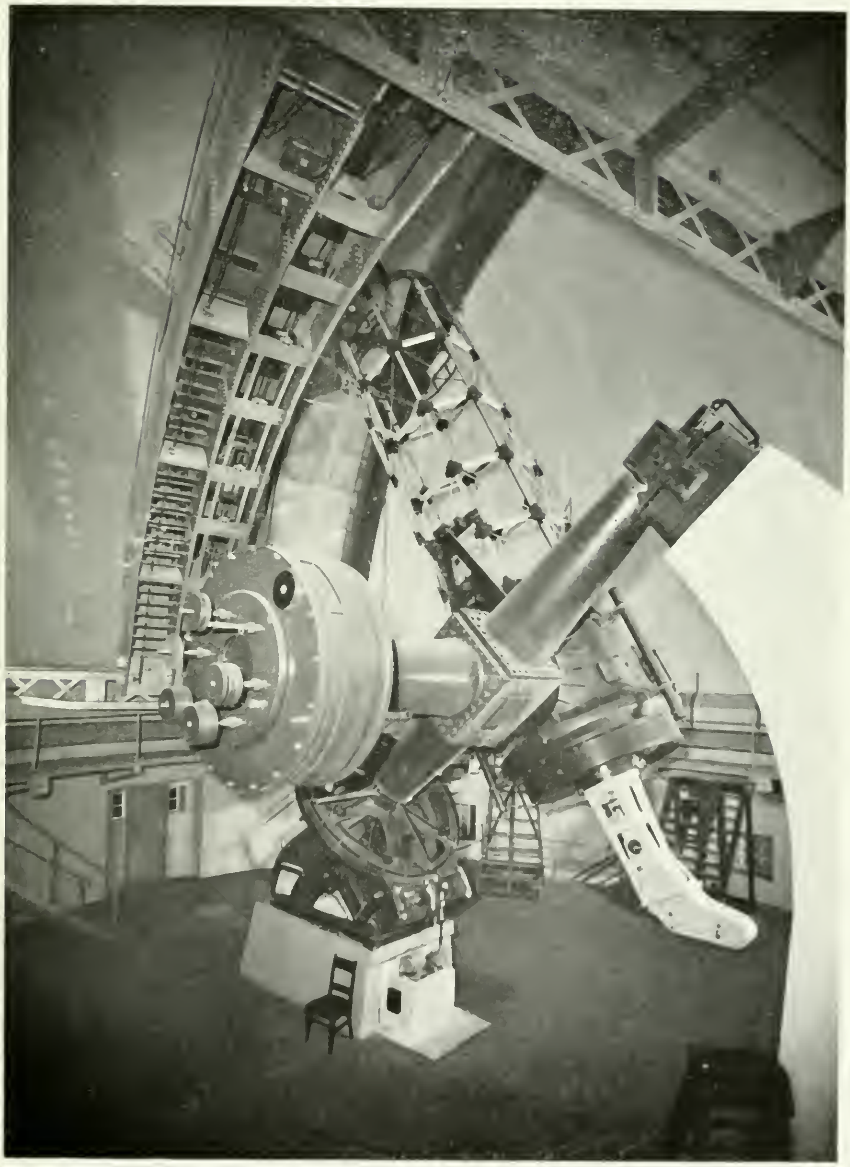
The dome is supported on twenty-four steel rollers, twenty-seven inches in diameter, mounted in self-aligning ball bearings and the rollers run on a flat annular rail. Sixteen pairs of lateral rollers keep the dome centred. The dome is rotated by a seven and one-half horse-power motor which actuates a driving sheave. An endless steel cable passes around the dome and down to the driving sheave. There are two grooves in the driving sheave and the cable passes twice around the turning sheave and tension pulley. Fifteen hundred pounds tension is used. The cable has never slipped on the sheave. It is inclined to slip on the dome in a

PLATE IV

The bridge and observing platform erected in the workshop at Newcastle-on-Tyne high wind. To prevent this, V-brackets were placed on the channel which carries the cable around the dome. A more efficient arrangement will probably consist in lining this channel with wood, to give the cable something to "bite into". The dome makes one revolution in eight minutes.

Probably no feature of the dome for a large reflector is more difficult to design than the means for observing conveniently at the Newtonian focus. One has only to examine the various methods that have been tried to realize that each new architect has been dissatisfied with former models. When the designs for the seventy-four-inch telescope and dome were being drawn, I suggested that a bridge might be supported on platforms and the engineers of the Messrs. Grubb-Parsons worked out the design which we have adopted (Plate IV). The illustration shows the bridge in the workshop in England. Owing to the confined quarters in the dome, it is difficult to obtain a satisfactory picture there. It can however be seen in Plates V, VI. Two segmental platforms, one at the base of the opening and one at the back and sixteen feet higher, carry a bridge which spans the two. The size of these platforms is such that their inside chords are 35 and 45 feet. The bridge is supported on rails along the inner edges of the platforms and can be moved laterally from one side of the dome to the other. The horizontal distance between the platforms is thirty feet and the bridge, which is in the form of an arc, is five feet, six inches wide. On the right-hand side of the bridge is a stairway for the observer and on the left-hand side a truck carrying a movable platform can run from the top to the bottom of the bridge. The observer on the platform can raise or lower the platform, move the bridge from left to right or *vice versa* or rotate the dome. In addition the special platform for the observer can be turned about a vertical pivot by means of a hand wheel. In practically all positions of the telescope the observer can obtain a very convenient position. We have been using the telescope at the Newtonian focus for the observation of clusters. These are mostly in the southern sky and the bridge and the platform are very satisfactory. If one had a varied programme involving reversals of the telescope and pointings in widely different parts of the sky, there would be considerable time lost in obtaining the best positions for work. However, this trouble is almost inevitable at the Newtonian focus and we have been well satisfied with the way the bridge and platform has worked

Telescope from the west, tube on west side of piers



Telescope from the east, tube on west side of piers out. As stated before, the dome and circular building arrived in Toronto on July 31, 1933, and it was erected on the site by the Dominion Bridge Company of Toronto, the work being supervised by the foremen of the maker's shop. The erection of the building and the telescope took about four months, though there were a great many details for the astronomers to put into final shape before observation could be begun.

The Telescope Mounting

The order for the telescope was placed in May, 1930, and the finished mounting was received in October, 1933. A very excellent description of the instrument has appeared in "Engineering" for March 9, 30 and April 20, 1934, to whom we are indebted for permission to reproduce a number of illustrations. It consequently seems unnecessary to enter into all the details of construction. Those who desire to see these may consult the article mentioned above. Only those features will be mentioned which may be novel or may serve in future designs.

The telescope has now been used for about eighteen months in the most rigorous climate in which it has ever been attempted to operate a large reflector. This has presented a number of problems and difficulties which had to be overcome and a record of these may also be useful. The general plan of the mounting may be seen in Plates V and VI. The design is based to a considerable extent on that of the Victoria telescope which has performed so well for many years. Only in certain details have alternative designs been used in an endeavour to improve results.

The main mirror cell is shown in half section in figure 1. The back supports consist of nine circular pads in groups of three each. This is a simple support compared to that in the seventy-two inch telescope at Victoria or in the sixty inch at Mount Wilson. We have no reason to believe that it is not adequate. The back supports are also shown in Plate III (b). This picture was taken in the optical shop in England. The back supports which may be seen through the glass are the same as used in the telescope. The lateral support consists of eighteen weighted levers which operate on a flexible band. This kind of support has been used in other large telescopes and some such arrangement is essential.

The surface of the mirror is covered by a large iris diaphragm, shown in Plate VII. It closes down to a circle twelve inches in diameter at which time the leaves close around a central core. In practice all the sides of the mirror are loosely packed with absorbent cotton so that the chamber of which the silvered surface forms the bottom has a very small volume and is nearly air tight. This is an important feature with us, because the very changeable climate, cold and then warm, leads to conditions which cause the telescope to sweat. A hothouse heater cable, drawing five amperes at one hundred and ten volts, has been clipped to the inside of the cell and this small amount of heat is sufficient under ordinary conditions to keep the chamber dry and preserve the silver coat. If the heat is left on for a day or more, a noticeable distortion of the

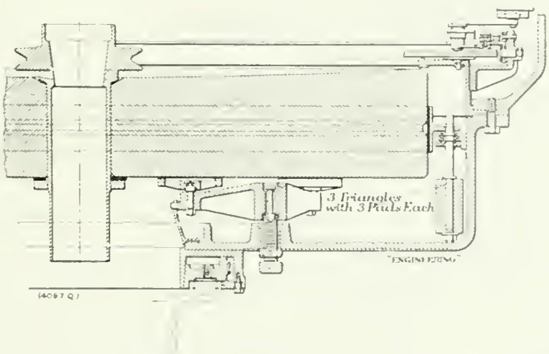
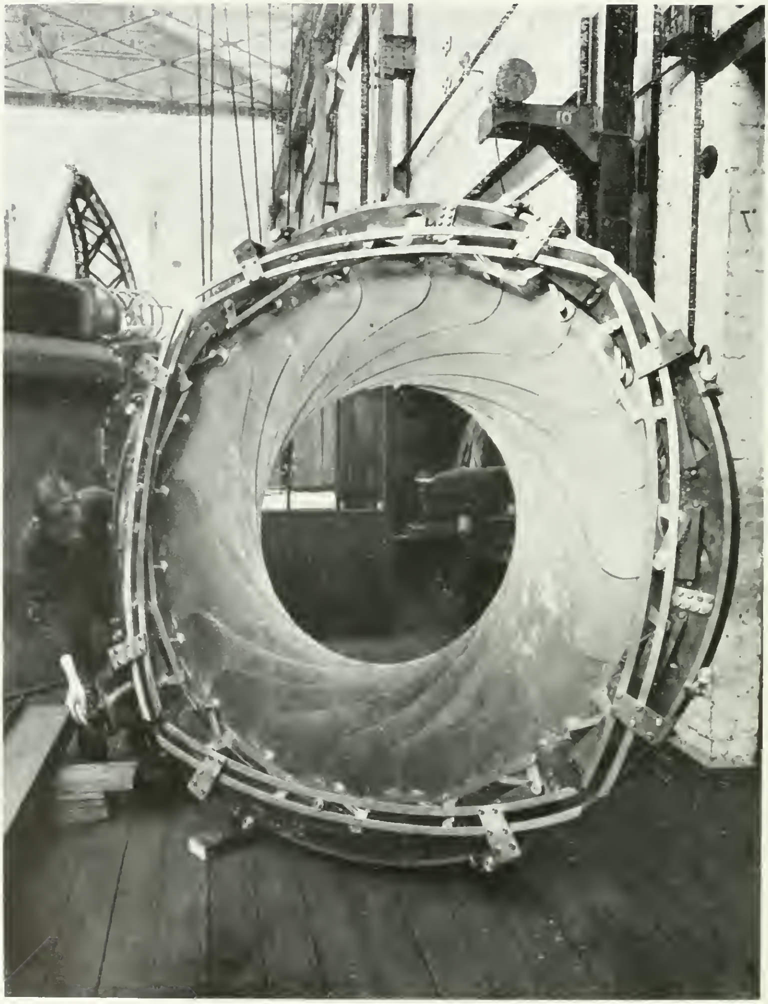


Figure 1
Half section of mirror and cell

surface is observed, though nothing very bad, and by taking the heat off as soon as the humidity outside shows signs of dropping, the figure of the mirror at night is quite satisfactory. We have found the iris diaphragm a very convenient method for covering the mirror. Some care has to be taken in the design of the central plug, which is left permanently in position. In order that it may resist the acids and solutions used in silvering the mirror, it is built of pressed paper impregnated with shellac. Care has to be taken that the holes in the plug through which the silvering solution drains out through the centre do not impede the flow of the spent solutions or prevent the surface becoming free from one solution before another is added in the process of cleaning the surface for silvering.



Iris diapragm at half aperture

Another feature in connection with the telescope tube is the method of focusing the Cassegrain mirror. This is shown in cross-section in figure 2 (b). It will be noted that a small motor has been used to push the Cassegrain focus forward or backward by a screw feed. The observer at the Cassegrain focus watches the

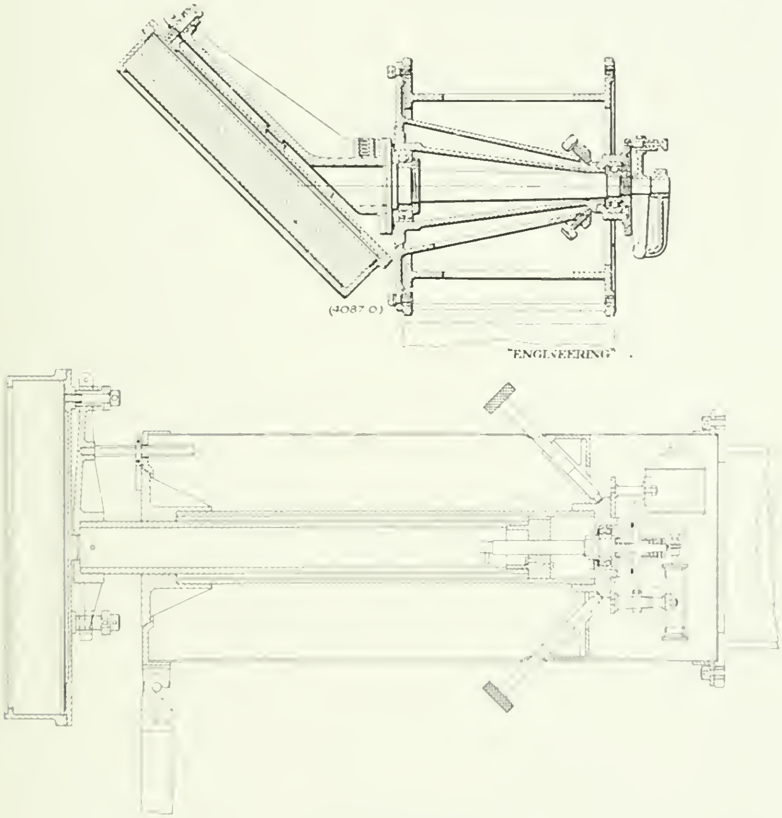


Figure 2 (a, b)
(a) Newtonian mirror mounting
(b) Casegrain mirror mounting

images and presses a button to operate this motor. It functions very well. Some apprehension was felt, in adopting this design, that the motor would vibrate the telescope unduly. However, while the effect can be seen on the image it is not sufficient to prevent the observer ascertaining the correct focus and the vibration subsides in a second when the motor is stopped.

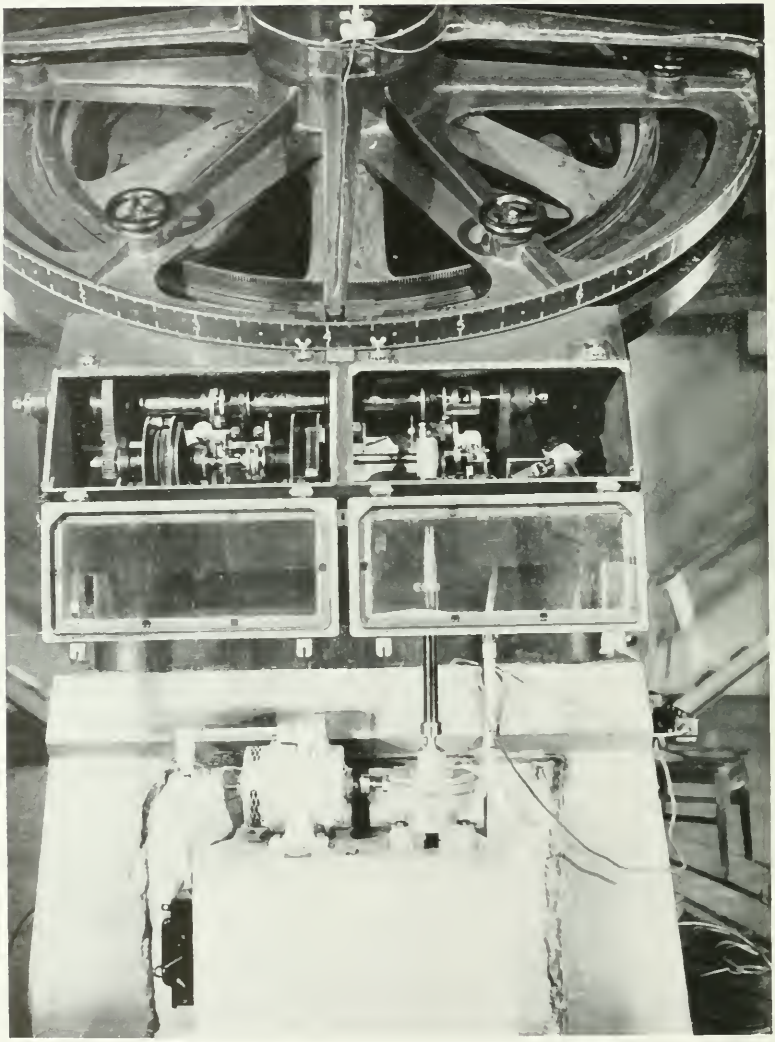
The telescope tube is built in three parts. The lower part consists of the mirror cell which is fastened to the central casting by 24 bolts around a flange on its edge. The central section is a steel casting 7 feet in diameter and weighs 6 tons. It is formed with a heavy boss on one side to which the declination axis is bolted. The upper part of the tube is of skeleton construction being built of duralumin I-beams with steel gusset plates and braced with duralumin cross-braces. These latter are threaded right-and-left-hand and tightened so that they are under tension in all positions of the tube. Tests made in the laboratory show that the differential flexure in the tube at the upper end between a vertical and a horizontal position amounts to 1/16 inch only.

The declination axis is a steel forging 13 feet in length and weighs $3\frac{1}{2}$ tons. It is formed with a flange 3 feet 5 inches in diameter on its inner end where it is bolted to the telescope tube. In order to reduce the flow of heat between the massive declination and polar axis to the central piece of the tube, this flange was cut away so as to leave a ring contact only. The writer's experience with the telescope at Victoria indicated that this flow of heat might be a source of astigmatism in the mirror. If the temperature is changing rapidly, the tube takes up the temperature of the surroundings more quickly than the declination and polar axis so that there is a temperature gradient between the two. The mirror at Victoria occasionally showed astigmatism in the meridian plane.

The polar axis is shown in Plate IX as assembled in the workshop of the makers with all the circles fitted to the lower end. The axis is 22 feet long and weighs 9 tons. It is built in three sections, a central cubical steel box and two tubular tapered steel sleeves bolted to the central box and having steel pivots shrunk into the ends. It turns on self-aligning ball-bearings and a thrust bearing at the lower end. On one side of the central cubical box is bolted a tapered steel sleeve which has a cylindrical hollow drum at its outer end. This sleeve serves to support the declination axis and the drum houses the motors for turning the telescope in declination. It also carried all the necessary counterweights to balance the telescope and the declination circle. The latter is fitted with two small geared drums which enable the telescope to be set in declination to the nearest minute of arc.

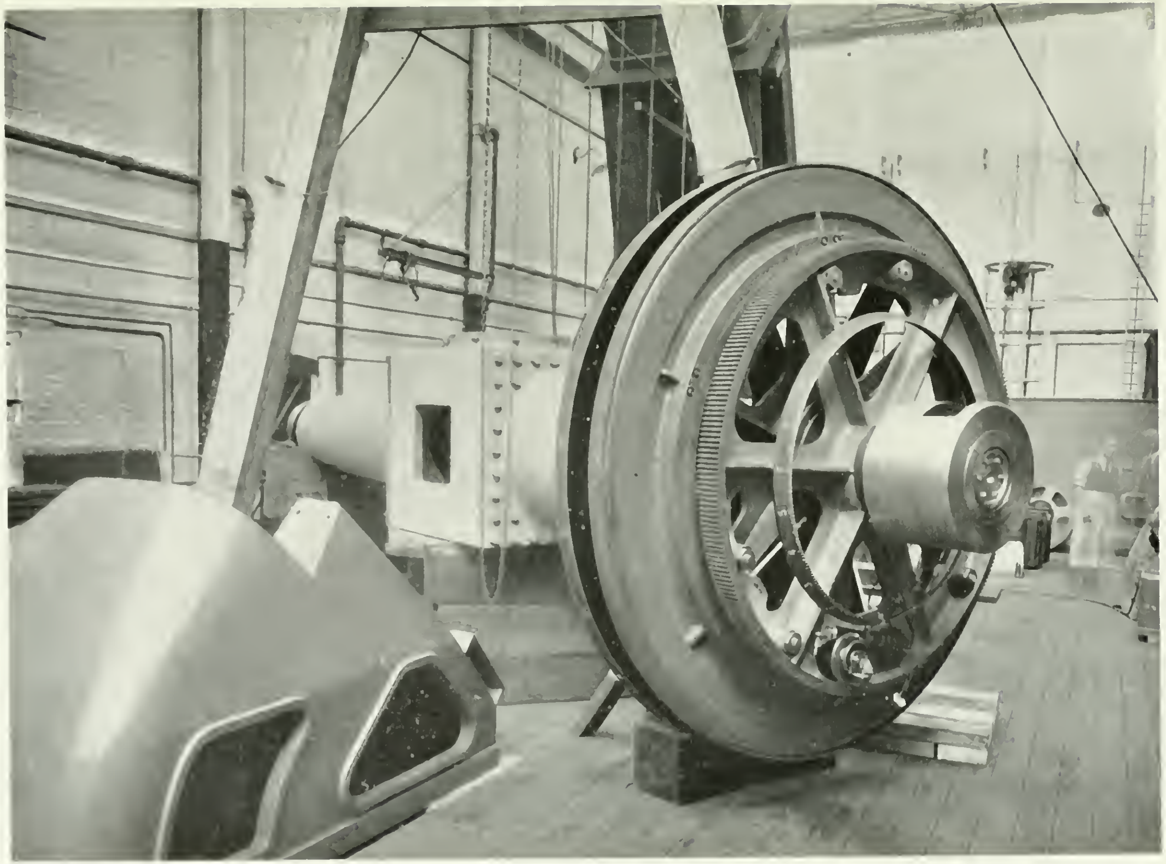
The method by which the telescope is driven to counteract the rotation of the earth is an important item in a telescope design.

The system used on the seventy-four inch is shown in Plate VIII. The first element in the system is a synchronous motor with appropriate gearing to give the sidereal rate from the mean time. When the telescope first arrived it had a gravity-driven conical pendulum but at our request Messrs. Grubb-Parsons furnished us with the synchronous motor which we have found very superior. The shaft from this gearing turns eighty revolutions per sidereal minute and connects with a worm gear which drives the lower shaft. The upper shaft is the driving worm for the telescope. If the synchronous motor is running at the correct speed the rate is transmitted to the driving worm and the telescope moves at the right speed. If the synchronous motor changes its rate, due to a change in the cycle, correcting gears are fitted on the lower shaft to adjust the rate before being transmitted to the worm. The manner in which the lower shaft functions is described as follows in "Engineering": "The lower shaft is made in five parts, of which the first part reading from left to right in Plate VIII carries the pinion driving the upper shaft, and this and the next two sections are connected through epicyclic-differential gearing. The third, fourth and fifth sections are also connected through epicyclic-differential gearing. On the centre section of the shaft is mounted, friction tight, a disk having twenty-four notches on the periphery, and opposite this disk is an electromagnet connected to the observatory seconds pendulum. This magnet, which is thus energized once per second, is provided with an armature of special shape, and this enters each of the notches in the disk, which is intended to make one revolution in twenty-four seconds. When the speed is correct, the entry of the armature into the notches has no effect, but if it should be fast or slow the disc is turned one way or the other relatively to the lower shaft. This relative motion operates a trigger connected to a spindle which passes longitudinally through the shaft and tilts a two-way mercury switch at the right end of the lower shaft; the effect of tilting this switch is to energize one of the two electromagnets, the armatures of which are arranged to hold one of the disks carrying the planet wheels of the epicyclic-differential gear, and in this way the lower shaft is slowed down or speeded up, as required." The second epicyclic-differential gear, viz., that on the left, is controlled by hand and is used for setting or shifting the image slightly in the field of view. The synchronous motor runs so well that we do not ordinarily need to use the seconds-



Synchronous motor drive and differential control

PLATE IX



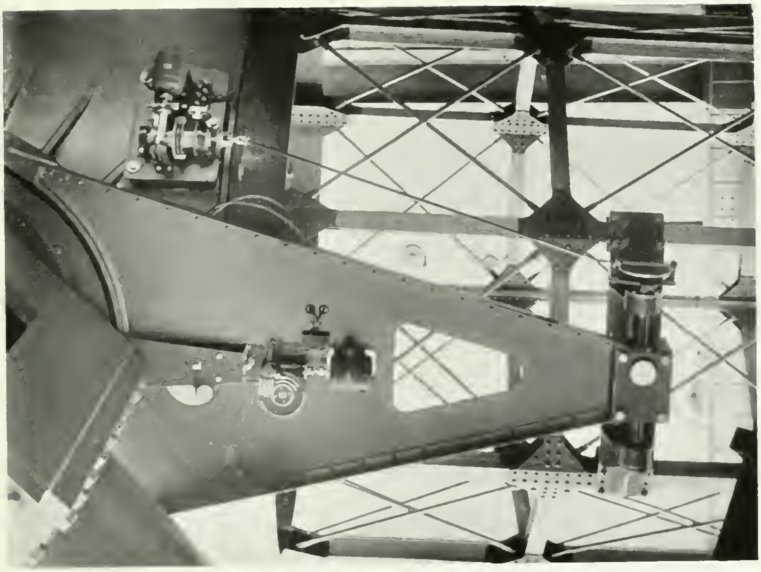
The Polar axis ready for mounting

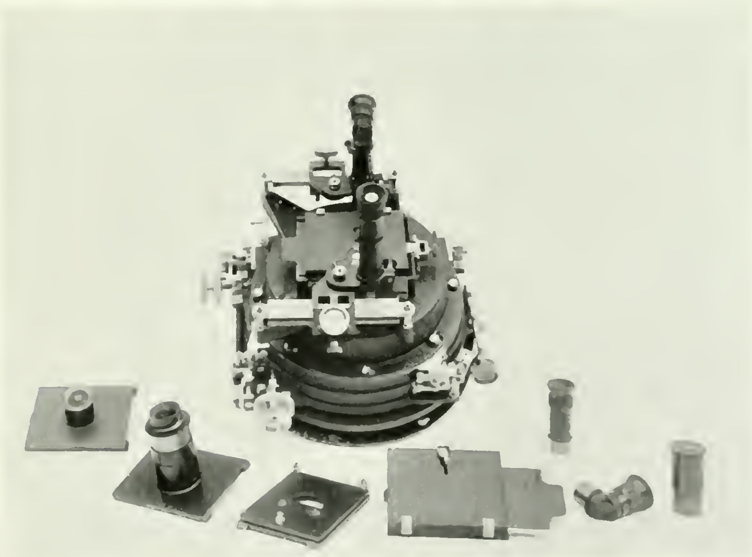
pendulum corrector. At times, however, the image will not move sufficiently on the slit and by weighting the pendulum, we introduce an arbitrary error to allow the image to drift more rapidly. The differential gearing is capable of taking care of rather wide variations in the driving speed but the Hydro-Electric Commission rate is so constant that for any telescope, except the very largest, it would seem sufficient to rely on the motor only. Plates X to XII show the instrument in various stages of construction in the manufacturer's shops at Newcastle-on-Tyne.

The Pyrex Mirror

When the telescope was ordered in 1930, we knew that the portion which would probably take the longest to complete was the big mirror. At that time, the Grubb-Parsons Company controlled the Parsons Optical Glass Works at Derby; and Sir Charles Parsons, the head of C. A. Parsons & Company, of which these other companies were subsidiaries, was confident that they could manufacture a suitable disk of glass for the telescope mirror. (Incidentally, Sir Charles Parsons was the youngest son of the Earl of Rosse, who completed a six-foot reflector in 1845.) But Sir Charles was in his seventy-sixth year when the order for our telescope was placed, and unfortunately he did not live to see the disk made. Had he lived, I have no doubt that his active interest and ingenuity would have solved the difficulties and pushed the task to completion. But in 1932, after his death, the disk had not yet been cast, and it seemed that the project for our observatory might be unduly delayed.

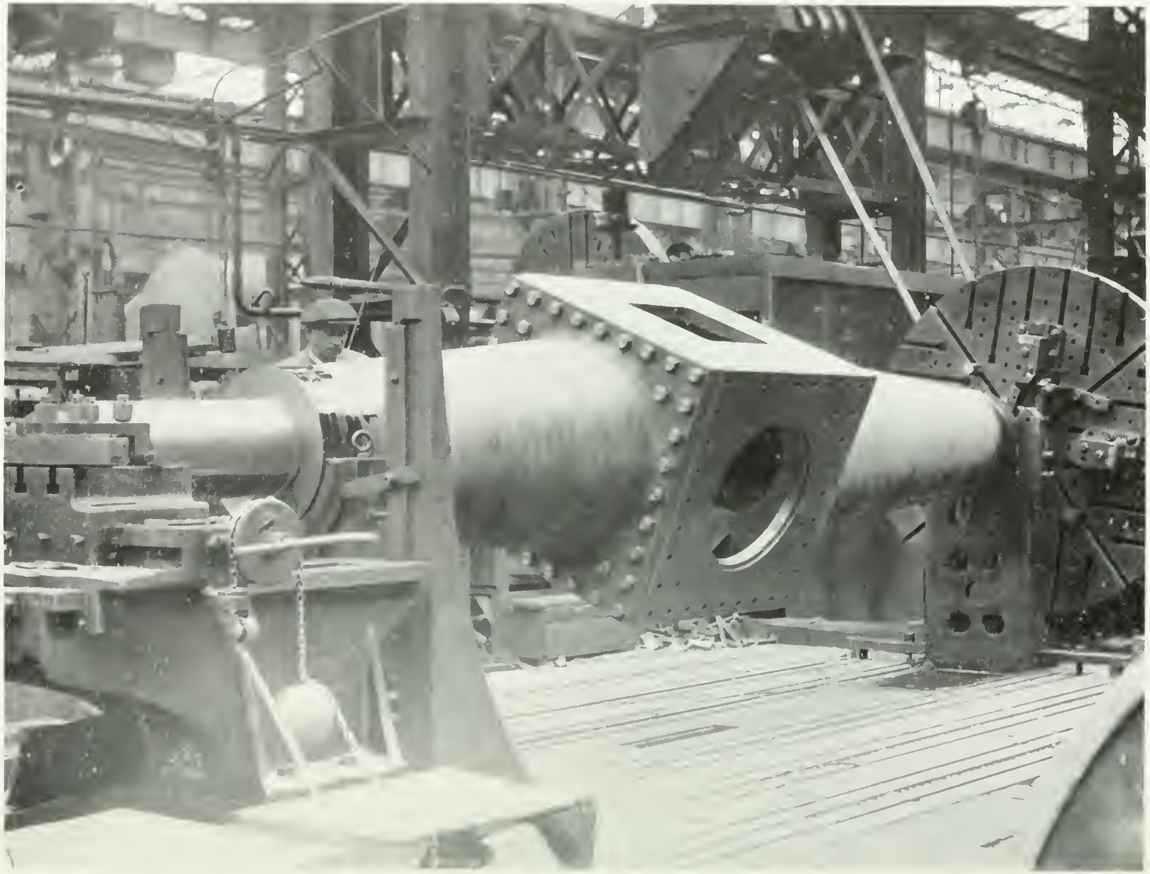
However, in 1932 unexpected help arrived in connection with the manufacture of telescope mirrors, which was not available in 1930. In the latter year the only firms which would undertake the manufacture of large disks were Carl Zeiss in Germany, and the Glass Works at Derby in England. On the American continent the Corning Glass Works, of Corning, N.Y., had made some small "Pyrex" disks of glass which were superior to any that had been previously made, but this firm was extensively engaged in the commercial manufacture of pyrex articles and was not prepared to undertake the expensive experimenting necessary to manufacture so large a disk as we required. Between 1930 and 1932, conditions changed. Plans had been put forward for the manufacture of a



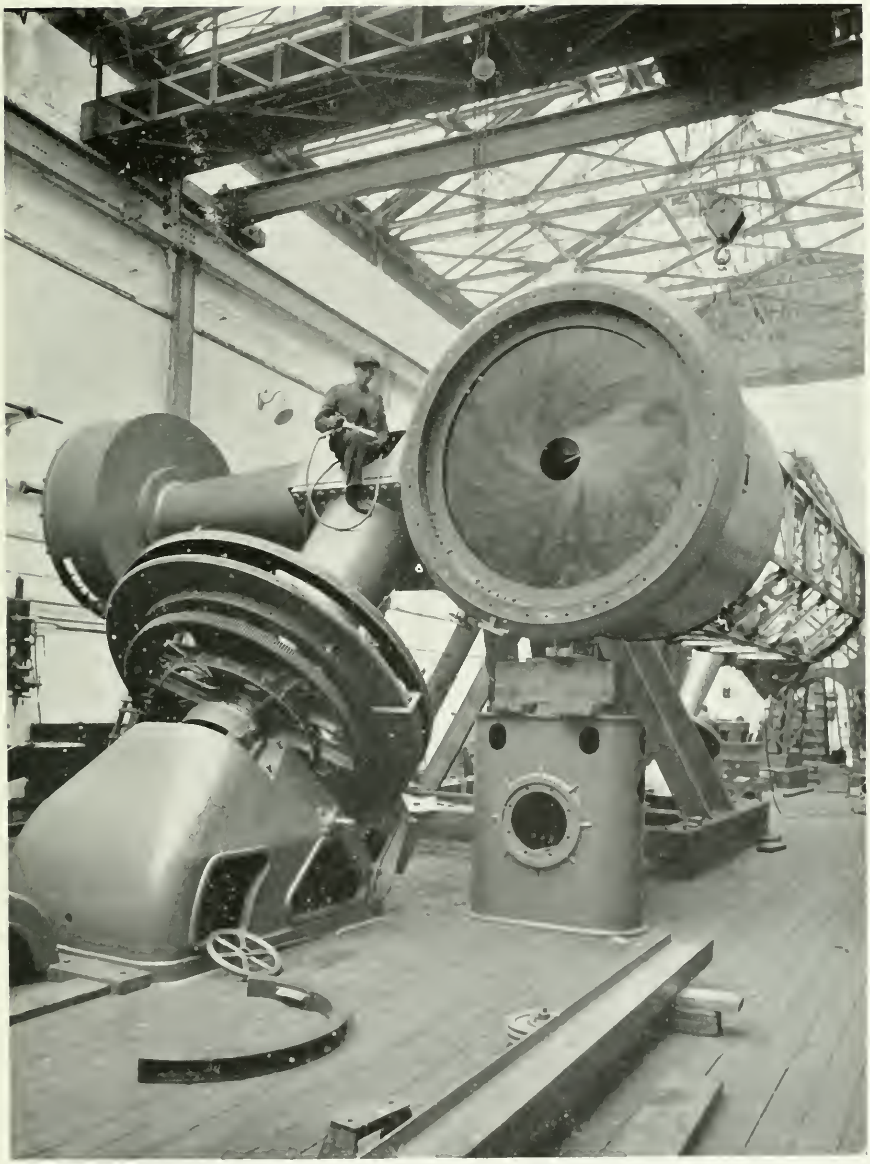


(a) Declination clamp and slow motion
(b) Newtonian double slide plate holder

Plate XI



Trueing up the polar axis



Telescope in the workshop at Newcastle

disk for a two-hundred inch telescope and time and money spent in finding out the most suitable material. In the end it was decided that pyrex glass offered the best hope of success for this disk. The Corning Glass Works was prevailed upon to install the necessary furnaces and annealing ovens for the task. We were informed late in 1932 that they were prepared within six months to cast our disk. From the first we should have chosen this material for the large mirror had it been available at that time. The Grubb-Parsons Company gave the contract for the manufacture of the raw disk of glass, which was to be shipped to England to be ground and polished into the final mirror.

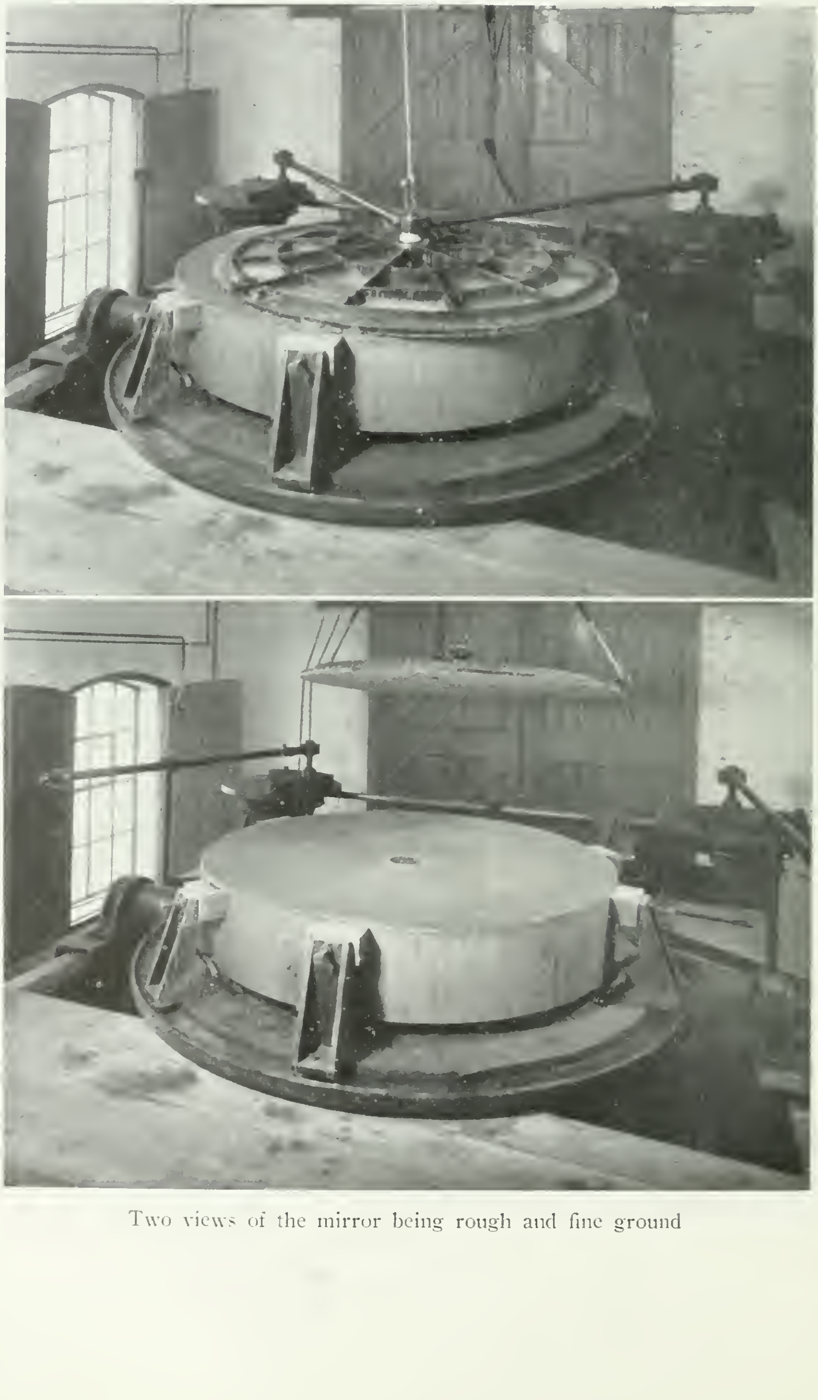
The mirror was cast on June 21, 1933, and came out of the annealing oven in September. It arrived in England in November. Plates XIII and XIV.) The disk at that time was fourteen inches thick and about two inches had to be taken off before it could be accommodated in the cell which had already been made. In spite of this delay the grinding and figuring was pushed forward with such dispatch that the makers reported the mirror as completed in February, 1935. Thus from the time the disk was cast till the mirror was completed, less than twenty months elapsed.

We think this constitutes a record in the grinding of large mirrors and great credit is due to the makers of the disk and to Messrs. Grubb-Parsons for the expedition with which they completed the task. It also speaks very highly of their facilities for handling such difficult problems and we are certain that any prospective purchaser may have every confidence in the ability of these firms to construct the mirror in as short a time as it is possible to have it done.

On March 9, 1935, the writer left for a trip to England to check the tests that had been made on the figure and to make further tests. These tests were carried out photographically in the laboratory of the Grubb-Parsons Company by the method suggested by Hartmann.

In this investigation the mirror was turned on edge and an artificial star placed near the centre of curvature. The surface of the mirror was then covered with a diaphragm having holes two inches in diameter cut at various distances from the centre along six diameters, the holes in each diameter, so arranged that on each two-inch zone of the mirror from eight inches from the centre to thirty-six inches from the centre there were four holes on two

(above): The desk on its arrival in England
(below): Grinding the central hole



Two views of the mirror being rough and fine ground diameters at right angles. (Plate XV.) The light from the artificial star reflected from the uncovered spots in the surface of the mirror was photographed on a plate, first a few inches inside the focus and then outside. Figure 3 shows a reproduction of a pair of such photographs. If the distance between two dots on one zone for a plate taken inside the focus is d_1 and the distance between the corresponding dots on the plate taken outside the focus is d_2, and a is the total separation between the plate taken inside the focus from that taken outside, then the focus of that zone is given by

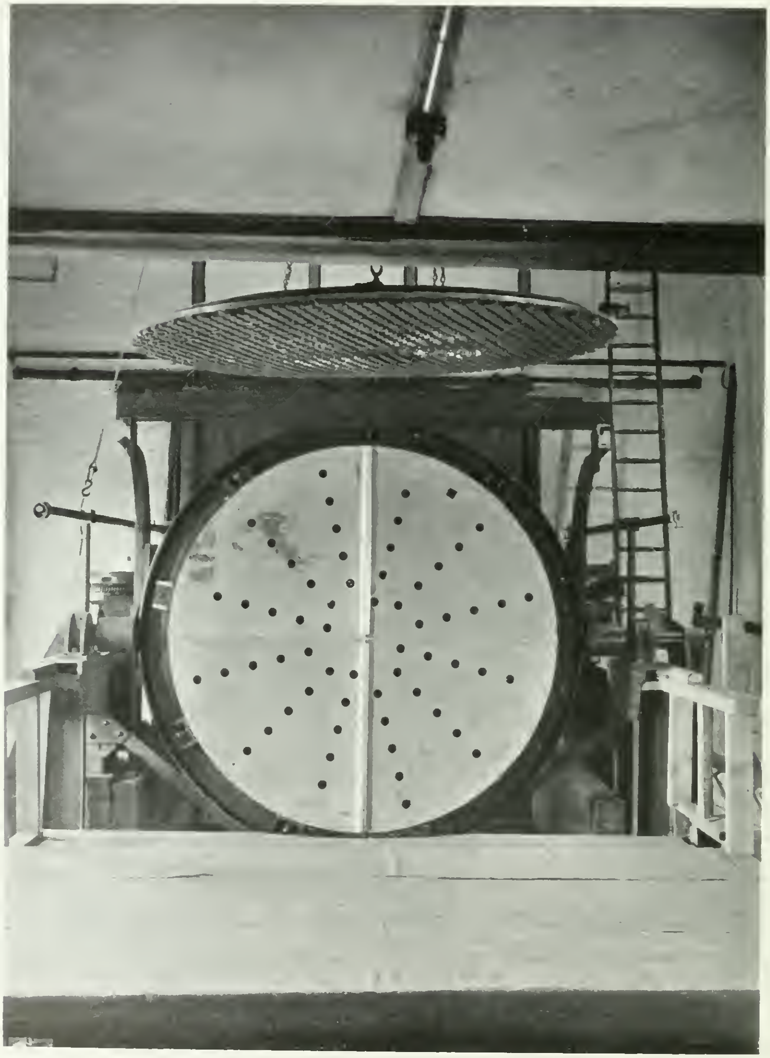
$$x = \frac{ad_1}{d_1 + d_2}$$

where x is the distance of the focal plane from the position of the

Figure 3
A pair of Hartmann photographs, both taken inside the focus

plate taken inside the focus. Both plates may also be taken on the same side of the focus in which case d_2 is negative in the above formula.

A great many plates were taken only a small fraction of which were suitable for measurement. The difficulty of getting good plates arises from vibrations and air currents within the testing tunnel and opportunity had to be seized when conditions led to steady images. In all, nine pairs of plates were measured. The results of these measures are shown in Table I.



Diaphragm over the mirror for the Hartmann test

TABLE I

Zone inches	Jan. 21 (1)	Jan. 21 (2)	Feb. 4 (1)	Feb. 4 (2)	Mar. 18 (1)	Mar. 18 (2)	Mar. 18 (3)	Mar. 22 (1)	Mar. 22 (2)
8	−0027	+0130	+0219	−0250	+0229	+0262	+0328	+0135	+0194
10	−0375	−0376	−0196	−0213	−0195	−0120	−0140	−0198	−0255
12	−0380	−0188	−0142	−0111	−0181	−0078	−0098	−0160	−0154
14	−0164	−0395	−0060	+0020	−0076	−0031	+0009	−0048	−0024
16	−0082	−0098	+0042	+0025	−0030	+0035	+0002	−0005	0000
18	−0093	−0050	−0053	−0055	−0198	−0160	−0053	−0093	−0106
20	+0024	−0040	−0054	−0144	−0188	−0170	−0136	−0096	−0090
22	+0002	+0026	−0056	−0014	−0094	−0058	−0139	−0055	−0076
24	+0010	+0029	+0068	+0009	−0016	0000	+0059	+0018	+0015
26	+0049	+0078	+0041	+0078	+0072	+0112	+0125	+0071	+0036
28	+0106	+0035	+0025	+0059	−0078	−0057	−0058	+0029	+0006
30	+0039	+0055	+0052	−0003	+0073	0000	+0071	+0021	+0014
32	+0052	+0022	−0011	+0060	+0055	+0065	+0101	−0001	−0004
34	+0001	−0024	−0141	−0066	−0166	−0160	−0090	−0042	−0041
36	−0021	−0043	+0086	−0046	+0204	+0207	+0033	+0114	+0119
T	Mean of Four....			0.24	0.15	0.40	0.32	0.21	0.20

Column one gives the distance of the zone from the centre in inches and the following columns are the aberrations as measured and reduced to the Newtonian focus as shown by the various plates. The first four pairs were taken before the writer's arrival in England and were measured in duplicate; once by Mr. Manville of the Grubb-Parsons Company, and also by Professor Know-Shaw at the Radcliffe Observatory, Oxford. The remaining five were taken and measured by the writer. The aberrations are expressed in inches. It is customary, in order to be able to quote a number as representing the degree of perfection of a finished surface, to compute the mean circle of confusion in the image expressed in hundred-thousandths of the focal length which Hartman calls T.

$$T = \frac{200000 \times \Sigma r^2\ (aberration)}{F^2 \times 2r}$$

The focal plane having been chosen to make $\Sigma r^2 \times$ (*aberration*) a minimum. The value of T is shown at the bottom of the Table.

An inspection of the aberrations of the various zones shows that they are gratifyingly small and that they shift from plate to plate, this shift being for the most part as large as the aberrations themselves.

The original measures showed some signs of astigmatism in a horizontal and a vertical plane which if real would have been objectionable. In order to test if this really was the case, the mirror was rotated through various angles and always the measures showed the same planes of astigmatism. It is difficult to say whether it arose from stratification in the air tunnel or deformation of the mirror when set on edge. However, the stationary plane of this effect under rotation of the mirror was satisfactory evidence that the trouble lay in the method of testing and not in the mirror.

The tests in the laboratory are always made under better temperature conditions than obtained at the telescope. Nevertheless it was decided to make some tests after the mirror was in position. I was particularly anxious to do this, after the telescope had been in use some months because a visual inspection of the image convinced me that the pyrex disk was holding its figure remarkably well under very trying temperature variations. Accordingly a mask was made for the mirrors from cardboard and exposures made inside and outside the Newtonian focus, using α Cygni as a source on the evening of July 31, 1935. The temperature had risen from 68.5 F. at 6.00 a.m. to a maximum of 82.0 F. at 6.00 p.m. and by midnight had dropped to 72 F. The exposures were made at 11 p.m. and the test of the mirror was made consequently under rather extreme conditions. The openings in the diaphragm were arranged so that the aberrations could be measured in two directions at right angles to each other as in the laboratory tests. The plates were measured by Miss R. J. Northcott and the results shown in Table II. The results are given for each quadrant separately. Column one gives the distance of the zone from the centre. Columns two and three give the aberrations as deduced from the I, III quadrants and II, IV respectively and the last column the mean. The aberrations are expressed in inches.

TABLE II

Distance inches	Aberrations I & III	Aberrations II & IV	Mean
10.5	+0087	+0228	+0158
12.5	+0008	+0114	+0061
14.5	+0102	+0228	+0165
16.5	+0024	+0248	+0136
18.5	+0055	−0028	+0014
20.5	−0122	+0012	−0055
12.5	−0028	+0110	−0041
24.5	+0020	+0004	+0012
26.5	+0043	+0043	+0043
28.5	−0091	+0035	−0028
30.5	−0071	−0165	−0118
32.5	−0169	−0087	−0128
34.5	−0169	−0098	−0134
36.5	−0260	−0189	−0225

It will be seen that the figure was very good. The outside curled forward making the outside zones have too short a focus. This effect is not marked, considering the great temperature variation. The regularity of the residuals shows that the surface was very smooth. The mean aberrations in the last column make $T=0.37$. Quadrants I & III give on the average a focus 0.0033 inches shorter than the mean and quadrants II & IV a focus longer by the same amount. Apart from the results of this test our experience during the eighteen months in which we have used the telescope has been that the mirror suffers very little from distortion and that whenever the seeing is good the image is satisfactory.

THE METHOD OF SILVERING

The extreme changes in the temperature, especially during the winter, makes it difficult to preserve the silvered surface. Then, too, the process of silvering is more difficult in cold weather. It is essential that the mirror be removed from the telescope into a room which can be heated. The removal of the mirror involves a considerable amount of labour and always a little risk, and it is necessary to have things so arranged that both these are kept to a minimum.

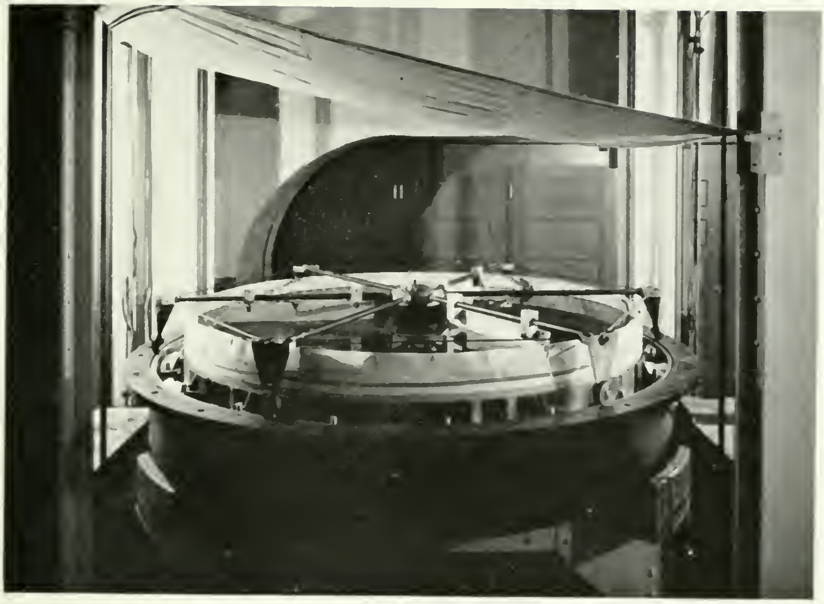
When the telescope is turned to the zenith the base of the mirror cell is nine feet above the upper floor and twenty-two feet above the basement floor. The silvering room is on the lower floor and the mirror in its cell has to be brought down into it. We accomplish this by a very inexpensive but efficient method. An elevator built of angle iron runs on vertical I-beams and is counterbalanced by heavy cast-iron weights which are carried on steel ropes. These ropes pass over sheaves just below the level of the observing floor; and a worm and worm-wheel, hand-operated, can move the elevator up and down without any particular effort. After the telescope has been placed upright and lashed in position a trap door in the floor permits the elevator to be raised to support the mirror. As the elevator is raised the counterweights go to the bottom of the elevator pit. Those weights necessary to balance the elevator are strung on long eye-bolts. The ends of these eye-bolts pass through holes in extra counterweights when the elevator is in its highest position and by simply screwing on retaining nuts the necessary additional counterweights are attached to balance the extra weight of the mirror and cell. There is no difficulty experienced in turning the hand wheel to lower the extra four tons on the carriage. Plate XVI shows the manner in which this hoist functions. It is much less expensive than a hydraulic elevator and we think more safe and easier to operate than any drum-operated hoisting gear would be. When the mirror has been lowered into the silvering room the trap door is closed and, as an added precaution, a heavy canvas is stretched about three feet above the mirror to protect the surface from accident. The room can be warmed by electric heaters. The silvering process we use functions best at a temperature of from 40° to 50°F.

The number of formulae for silvering mirrors is very numerous. We have used a method that has many merits over anything I have previously employed. A description of it may be worth while. During my visit to England I had the privilege of watching the mirror being silvered in the laboratory there. The Grubb-Parsons Company are extensive manufacturers of search-light mirrors and have had a great deal of experience in silvering. I was particularly impressed with the small amount of silver they found it necessary to use. Their method was carefully explained to me and I saw it applied. We have never been able to make it work correctly. We have, however, adopted certain features of it and the method we use requires only about one quarter as much silver nitrate as is customary in the Brashear process. Our thanks are due to Messrs.

The hoist for removing the mirror for silvering

Grubb-Parsons for permission to publish this method, which we think may be of some service.

Before any band is placed on the mirror, the old coat is lightly rubbed with a flannelette cloth, soaked in water, to remove dust. The coat is then taken off with concentrated nitric acid. We use swabs made of soft flannelette, fastened to a pine base with a handle, and much prefer these to absorbent cotton, as the latter is liable to leave lint on the surface. This operation is best done before the band is put on, because there always is the small ledge where the bevel of the mirror meets the wall that can serve as a pocket for the acid, which is very difficult to remove from this recess later. When the surface has been thoroughly rubbed, the acid is rinsed off with ordinary tap water. It is then cleaned with tepid water and soap. We use swabs similar to those used for the acid and work the surface into a lather. The bulk of this soap is rinsed off and the band placed around the edge. We have found that a retaining band of oilcloth is better than waxed paper. There is always a danger of bits of paraffin coming off the waxed paper and paraffin will smear over the surface and prevent a bright coat near the edge. In order to make the band perfectly solution-tight, we cut large elastics from the inner tube of an automobile tire, cutting the tire in the plane of rotation of the wheel. These are about one and one-half inches wide and four people can stretch them over the oilcloth band. They produce a remarkably tight seal. Two bands are usually put on, one near the top edge of the mirror and one near the bottom overlapping the oilcloth so that the bottom half of the elastic band rests on the edge of the mirror-disc. When this has been done a hose is used to rinse the mirror very completely and get rid of all traces of soap. It is then rinsed in distilled water and enough distilled water left on the mirror to fill the concavity. The centre hole of the mirror is closed by inserting a wooden plug covered with rubber inside the centre hub. No provision is made on the silvering hoist for rocking the mirror but instead we have a stirring device to agitate the silvering solutions. This can be seen in Plate XVII. It consists of a spoked wheel, which turns on the central hub and the periphery runs on rollers around the edge of the mirror cell. Wooden vanes are attached to three of the spokes and adjusted to within three sixteenths of an inch from the surface of the mirror. This device is put on after the distilled water is on the mirror.



(above): The stirring device on the mirror
(below): The freshly silvered mirror being returned to the telescope

It usually takes about one-half an hour to mix the silvering solutions, and this operation is commenced about this interval by estimation before the completion of the cleaning of the surface. The solution for silvering the seventy-four inch mirror is as follows.

Silvering Solutions:

(A)	Water	320 oz.
	Silver Nitrate	226 grams
(B)	Water	40 oz.
	Caustic Potash	135 grams

Reducing Solution:

Water	16 oz.
Dextrose	37 grams

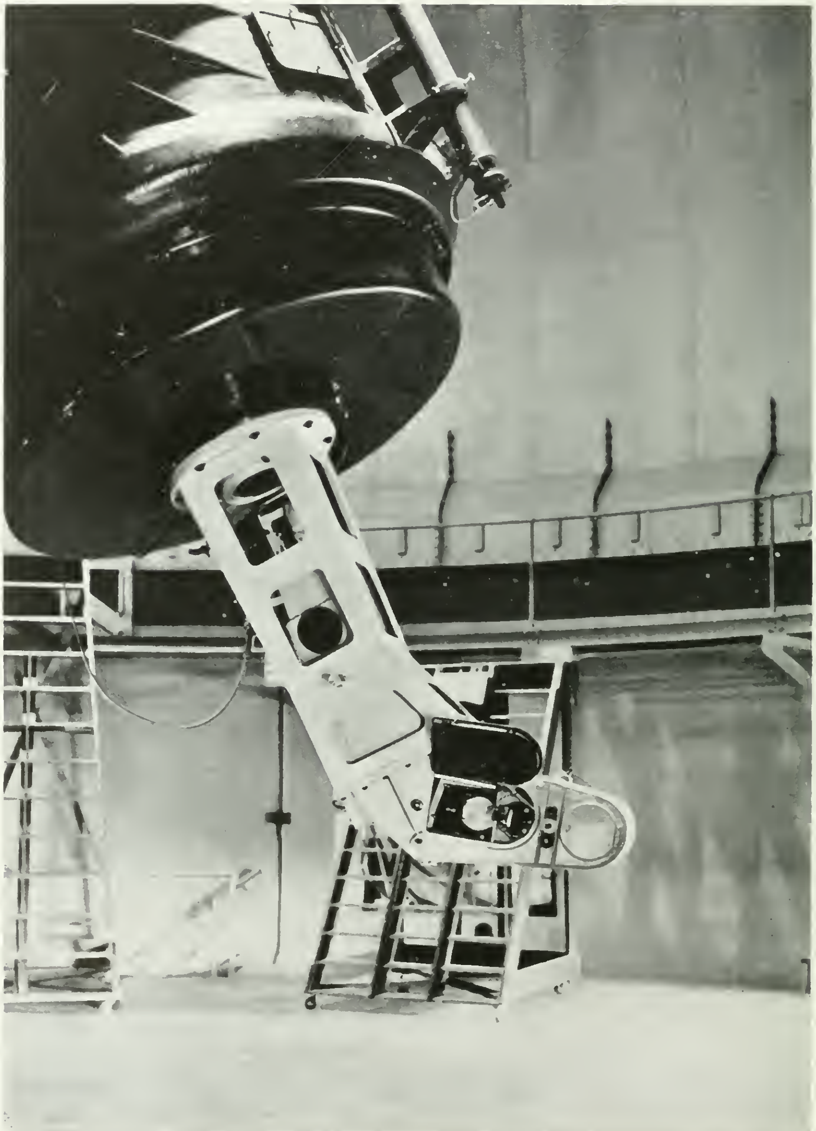
The process is carried out as in the Brashear method. Ammonia is added to (A) till the precipitate formed is re-dissolved, and then (B) is added. More ammonia is then added until the precipitate is again dissolved. It usually happens that there are some particles of matter left at this stage which have to be filtered out. When this has been done, a reserve silver nitrate solution is added until, on looking through a depth of three inches of the liquid, an opalescent straw colour is obtained. Twelve hundred ounces of distilled water are on the mirror and the reducing solution is added to the silvering solution immediately before being poured on the mirror. As mentioned before, the process works best at fairly low temperatures, 40° to 50°F., and at these temperatures will take from ten to fifteen minutes to deposit.

The Spectrograph

The initial gift to the observatory provided for a single spectrograph. A one-prism instrument was chosen for use at the Cassegrain focus as being the most useful. Spectrographic work requires a wide variety of dispersions and of range of wave-lengths, but it is impossible to include in one instrument complete flexibility in this regard without sacrificing rigidity. Most early designs of spectrographs which were used on telescopes were of the so-called universal type and could be adapted for various dispersions and regions of the spectrum. These instruments suffered from the defect of flexure and recently observatories engaged in extensive radial velocity measures, have generally adopted the design worked out by Campbell and Wright at the Lick Observatory in 1905 and incorporated in the Mills spectrograph. The main feature of this design is that the spectrograph proper is of the box pattern cradled on a two-point support in a frame which is attached to the telescope. A return to the universal character was attempted in the spectrograph attached to the 72-inch telescope at Victoria, with very successful results. Nevertheless, the writer's experience with this instrument showed that more flexure was present than desirable. The extra loading necessary to make provision for one, two or three prisms and difficulties in introducing internal webbing in the box for the same reason prevent the spectrograph box being built as rigidly as it can be for a simpler instrument. While the idea of having the various dispersions incorporated in one instrument is very attractive, I decided against it, on account of the impossibility of getting rid of flexure and also because it was not anticipated that we should have much occasion for large dispersion. It is eminently desirable that spectrograms of the brighter stars be so observed, but if this is done the dispersion should be greater than is possible with prisms, unless used with very long cameras such as are possible with the Coudé form of mounting. No such arrangement was contemplated for the 74-inch telescope and consequently it seemed best to design a low-dispersion spectrograph for use on the faint stars and of great rigidity to render it suitable for radial velocity measures. The general form of the instrument can be seen in Plates V and XVIII. It was built by the Adam Hilger firm of London, England.

The Optical Parts

The optical parts of the spectrograph consist of the collimating lens of two and three-quarters inches clear aperture, a single sixty-three degree prism made from a light flint glass with high transmission in the violet region of the spectrum and alternately two camera lenses of approximately twenty-five inches and twelve inches focal length. The latter are cemented triplets, the glasses being chosen to be as transparent as possible in the region of shorter wave-lengths.



The Hilger spectrograph

The glass of the prism approximates Parsons' glass DF3, as given in their catalogue, and has the following refractive indices:

λ	Refraction	λ	Refraction
6563	1.61347	4861	1.63037
5893	1.61830	4340	1.64063

The makers have furnished us with the absorption curve of specimens of the glass as shown in figure 4. From these I have derived the following transmissions in per cent. through a thickness of one centimetre and through the prism.

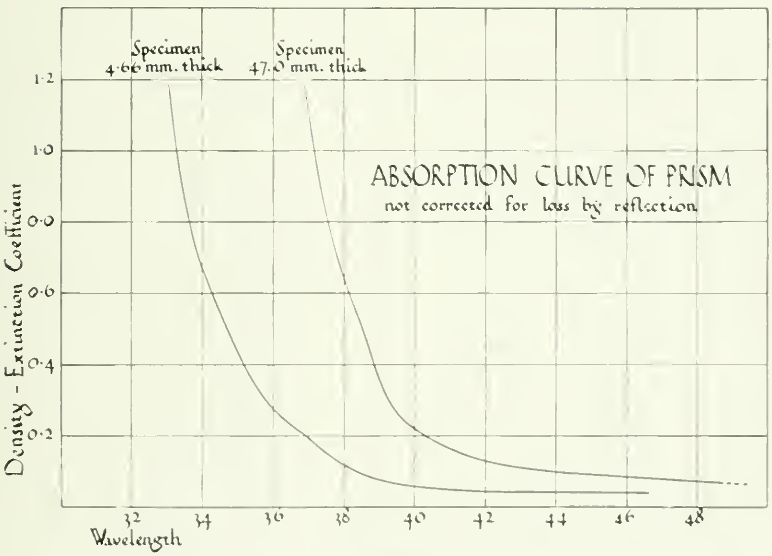


Figure 4

λ	Transmitted by 1 cm.	Transmitted by Prism
3700	61%	20%
3900	86	59
4100	94	76
4300	96	87
4500	97	89

All the surfaces have been figured by the interferometer method of compensating for internal strains and, as will be seen later from a discussion of the tests, the instrument gives excellent definition.

The Mounting

The general construction of the mounting and the relation of the various parts will be understood from figure 5. The spectrograph proper is of the box form heavily ribbed. It is made from a silicon aluminum casting. There is no collimator nor camera tube in the usual sense, the box itself serving this purpose. This form has the advantage that the internal bracing may be made stronger. The box is cradled in a frame so designed that in whatever position

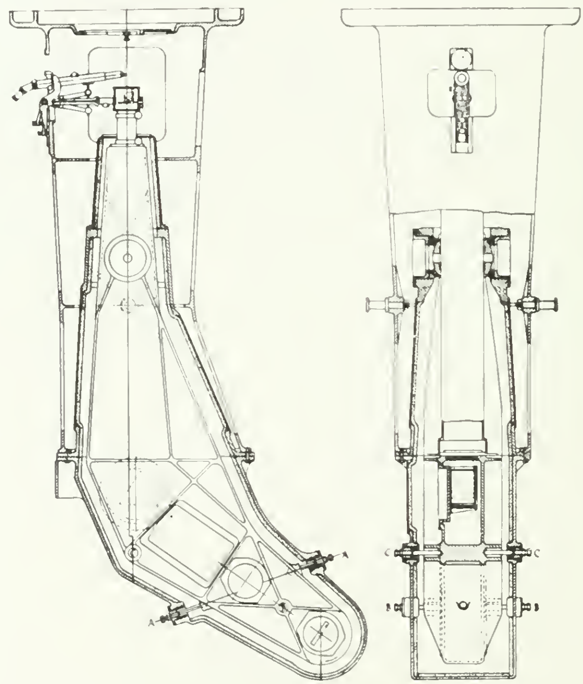


Figure 5

Longitudinal sections of the Hilger spectrograph

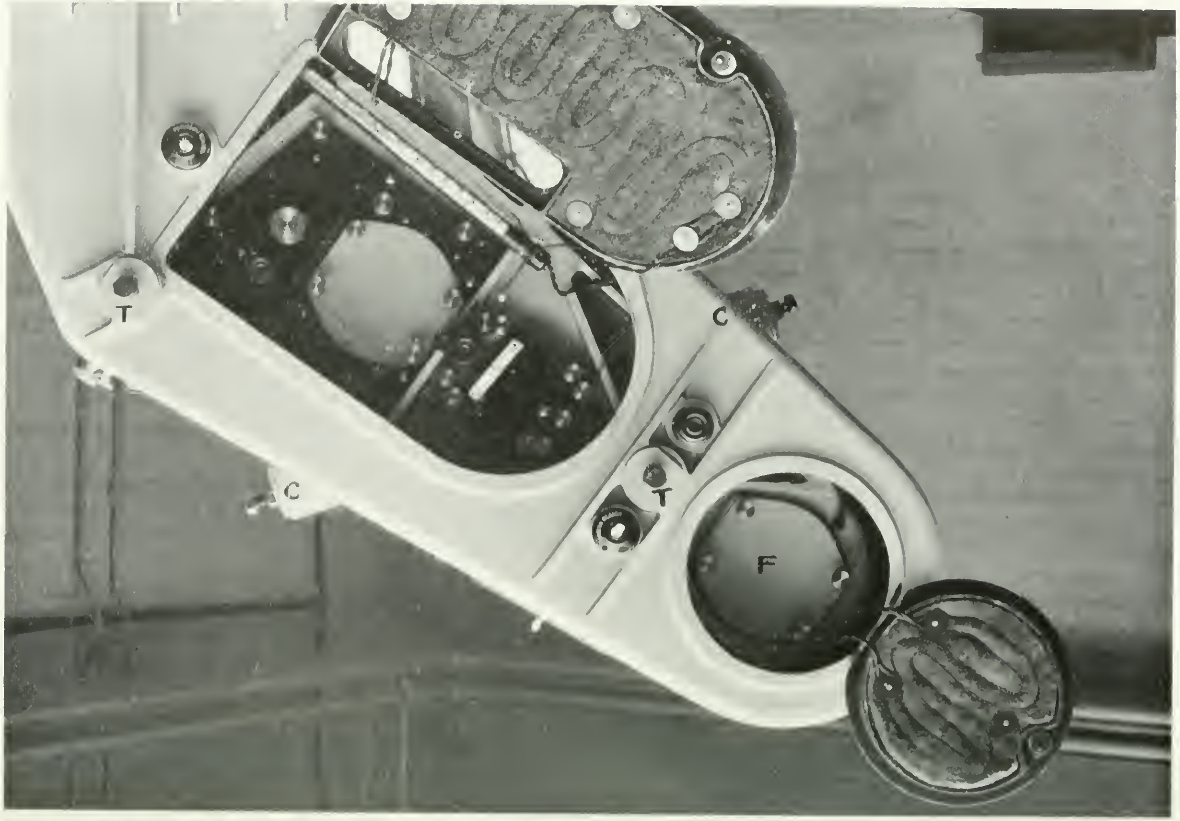
the telescope is pointing, the strains in the frame will not be transmitted to the box. A spherical bearing supports the upper end and permits freedom of motion in any direction. When the telescope is on the meridian the weight of the lower part of the box is taken by a pair of floating pins shown at *A,A* in figure 5. Motion in a direction at right angles to the meridian is prevented by two other pairs of floating pins *B,B* and *C,C*. As the telescop is moved away from the meridian the pins *B,B* and *C,C* assume part of the load but it will be observed that deformation in the frame is not transmitted to the box proper. All the floating pins are provided with adjusting screws to allow the spectrograph box to be set so that it is collimated with respect to the axis of the telescope tube.

The frame which supports the spectrograph is made in two parts. The upper part is a long box-like casting of silicon aluminum. A flange at its upper end attaches it to a ring at the back of the mirror cell. This ring is in the form of a worm-wheel and can be rotated to any desired position angle. A flange at the lower end of the box permits the lower half of the frame to be attached, which serves to support the lower end of the spectrograph and forms the heating case as well. Doors in the lower half of the frame, shown in Plate XIX, permit access to the spectrograph box. The inside of the frame is lined with felt about one-half an inch thick and the heating wires are distributed on the inside of this lining. The temperature is controlled by a mercury thermometer relay. The thermometer bulb is such that a rise of one degree centigrade produces an elevation of the mercury one-twelfth inch. It is placed close to the prism. This ensures that if stratification or inequalities in the temperature exist throughout the case, the index of refraction, air to glass, will remain unchanged.

The design of the camera holder and the manner in which the spectrograph can be adjusted to take a range of camera lenses is very neat. The camera holder consists of a cylindrical mounting shown in figure 6. It is attached by four knurled cap screws, and may be placed in any one of three positions. Adjustment for tilt is provided by the simple rotation of the cylinder. The plate holder is carried in a slide and can be shifted laterally, so as to permit a number of exposures on the same plate. The objective mount, shown in Plate XIX, is attached by knurled cap screws and carries also the gear for focusing, which is done by moving the objective. We have found that it is quite possible to change from one camera length to another and re-focus in fifteen minutes.

A drawing of the slit mechanism is shown in figure 7. This is very similar to that used on the spectrograph of the Dominion Astrophysical Observatory at Victoria. The slit jaws are of polished nickel, closed by spring pressure up to an adjustable stop,

Plate XIX



Lower half of the Hilger spectrograph

which prevents the jaws coming in contact. Micrometer screw threads, fifty to the inch, with a drum divided into one hundred parts, permits the opening to be read to the ten-thousandth part of an inch. Light from the comparison arc is reflected into the slit by two small right angled prisms which are covered on their lower side by masks. Holes in these masks limit the length and position of the comparison lines. The prisms may be separated by means of a right-and-left-hand thread and the inner edges of the prisms are bevelled, so as to permit the passage of the light from the star. The length of the opening in the slit, which the light from the star may reach, increases near the apex of the prisms and these are mounted on a slide and by moving them backward or forward, the width of the spectrum may be varied. A spring catch with three notches locates three definite widths. The

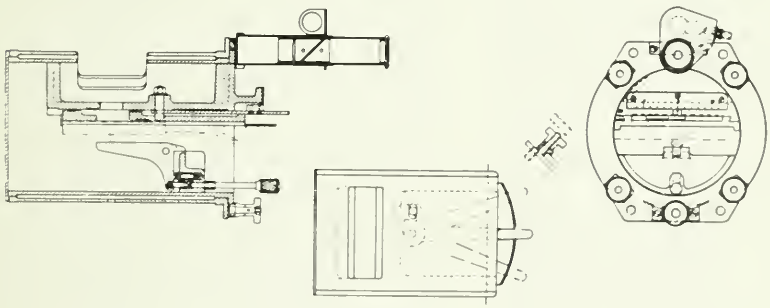


Figure 6

opening in the mask below the prism, shown at *D* in figure 7, permits the comparison to be substituted for the star spectrum, when the prisms are slid back, so that this opening is over the slit. This is very convenient for use in conjunction with the Hartmann method of focusing. To facilitate further the use of the method, the spectrograph is provided with shutters, shown at *D* in Plate XVIII, which can be adjusted on push rods to limit the beam of light to the apex half of the prism or to the base half at will. Guiding is done by a telescope which views the star image in the slit.

Constants and Tests of the Spectrograph

The internal adjustments of the position of the prism to minimum deviation at λ4150 and correct location with respect to the collimating and camera lenses had already been carried out before the instrument arrived and it was only necessary to check these. The collimation of the instrument to the axis of the telescope was effected by placing a small electric light bulb in the axis of the tube near the upper end and adjusting the spectrograph box until the light could be seen through a peep hole in the centre of the collimating lens, the rays having passed through the slit.

Determination of the focal properties of the lenses was carried

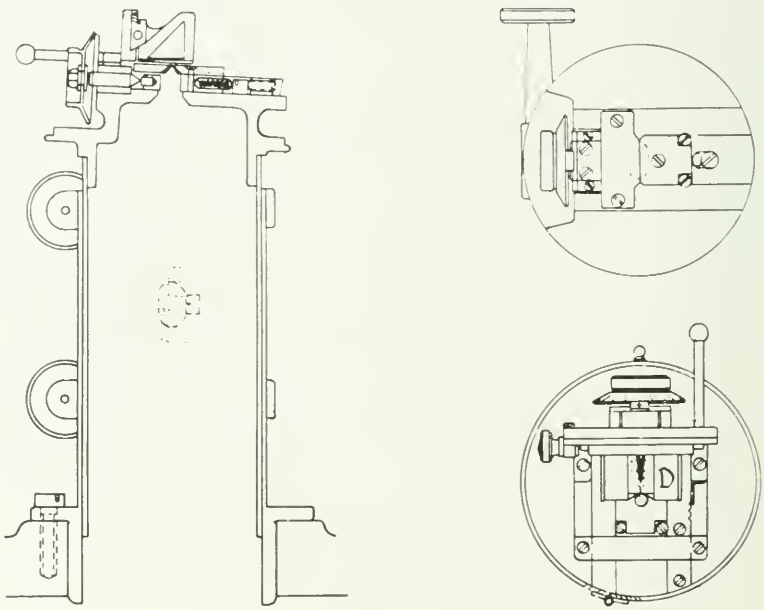
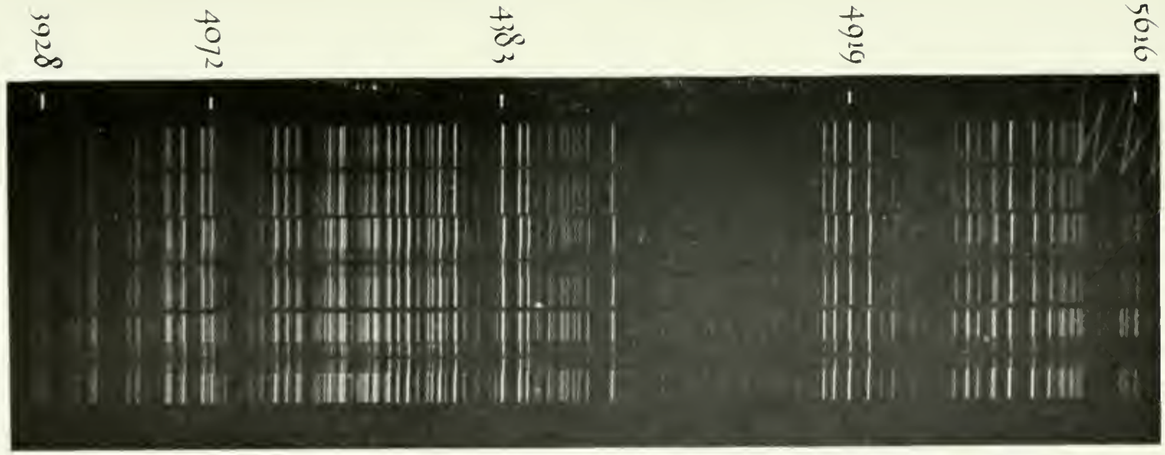


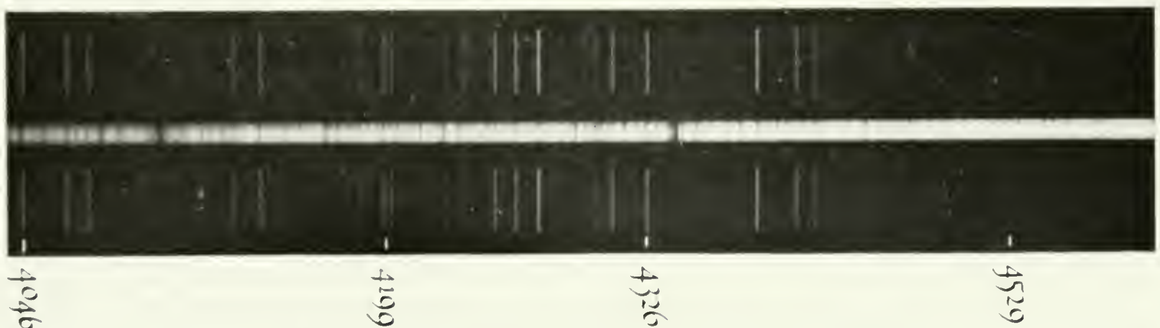
Figure 7

The slit mechanism

out by the Hartmann method. Plate XX(a) is a reproduction of a Hartmann focus test of the 25-inch camera, made at settings 23.0, 24.0, 23.5. The measurement of this plate is shown in figure 8 and the same figure also shows the focal curve for the short camera. For both cameras a wide range of spectrum is in focus to within $^1/_{10}$ mm. Plate XX(b) is a reproduction of HD 198726. The pair of lines λλ4199 are resolved in both the comparison and star. The instrument gives a computed resolving power at λ4200 of 40,000 and with ordinary plates and the normal slit width of 0.002

PLATE XX—(a, b)





(a) (above): The Hartmann focus test at settings 23.0, 24.0, 23.5

(b) (below): The spectrum of HD 198726

inch, a purity of about 10,000. Spectra of seventh magnitude stars may be obtained with the twenty-five inch camera under average seeing conditions and state of the silver coat on the main mirror in about seventy minutes. Good spectra have been obtained of an 8.0 magnitude star in one hour under good conditions. The dispersion with the twenty-five inch camera is 33A at Hγ and about half this with the shorter camera.

An investigation of the curvature correction has been carried out by Dr. Heard for the twenty-five inch camera. Spectrograms were taken of the iron arc and the sky, using the longest slit

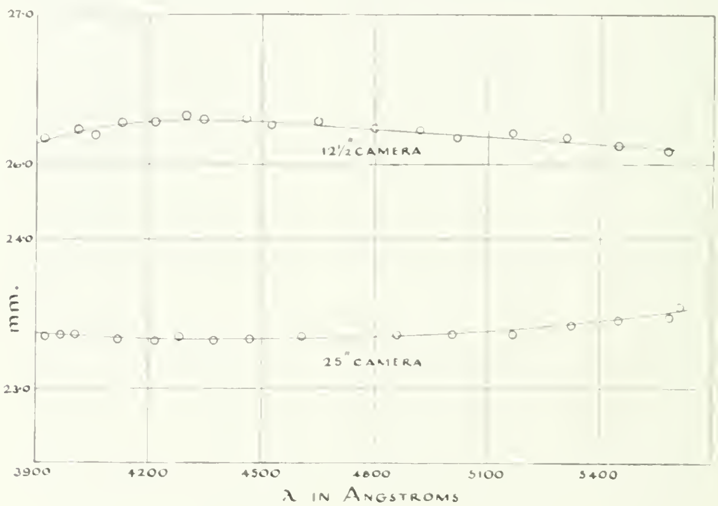


Figure 8

The focal curves of the 25-inch and 12½-inch cameras

possible. On the plates the equation of the lines is well represented by the parabola,

$$x = 0.00097y^2$$

where x is the distance along the dispersion and y the distance along the line, both expressed in half-millimetre. The exact magnitude of the correction to radial velocity which must be introduced depends on the point where the measurer bisects the comparison line. Assuming that this bisection is made at a distance from the tip of the line of about one-seventh its length, the curvature correction runs from about -1.5 km. at λ3959, to -2.9 km. at λ4900.

Since the opening of the observatory in 1935, the instrument has been in continuous use in radial velocity work, and about 1600 spectra have been secured. Most of these spectra are of stars in and near the Kapteyn areas in the northern hemisphere and brighter than magnitude 7.5. These spectra are of stars for which no results have been published. In order to check the consistency of the instrument, spectra have been secured of the standard velocity stars and bright stars observed at other observatories. The results of a comparison show a very satisfactory agreement and the probable error of a single plate with the twenty-five inch camera for a good-line star is about 1.5 km. per second.

The Administration Building

A general view of the location and ground immediately surrounding the 61-foot dome and Administration Building is shown in Plate I. The front view of the Administration Building is shown in Plate XXI. The plans for this building were prepared by the architects, Mathers and Haldenby. It is ninety-one feet long and forty-nine feet wide. The walls are constructed of Credit Valley limestone with trimmings of Queenston stone. The square entrance hall and stairway are finished in travertine.

The chief functions of the Administration Building are to provide a suitable place for studying the plates taken with the telescope, office space for the staff, and other rooms for laboratory work. In designing the building, however, we had to bear in mind not only the present contemplated programmes of work of the observatory but also the possible future needs.

Prior to the project of the 74-inch telescope, the writer had constructed a 19-inch telescope but, for lack of a suitable building or space for mounting, it had rested in storage. It seemed that this instrument would be a useful adjunct to the equipment. The disposition of numerous small domes about the grounds to house special pieces of apparatus is difficult to arrange and is costly. Consequently, we made provision on the roof for three domes. These look quite small in the photographs, but the centre dome is twenty-two feet clear inside and the other two, eighteen feet. The 19-inch reflecting telescope is housed in the south dome. The

Front view of Administration Building from the west other domes are vacant. We contemplate a refractor in the middle dome of 10 to 12-inch aperture and a battery of photographic lenses in the remaining dome. The piers inside these domes are carried on separate stringers entirely free from the floor and are carried by the main supporting walls of the building. We have not had sufficient observing time to draw any conclusions as to the suitability of this method of support. So far as can be judged from the visual image, the support is steady in ordinary weather, though not perfectly steady in a high wind. It has the advantage over the piers in this case of leaving the rooms below free from obstruction.

A fairly well-equipped workshop seemed a necessary part of the equipment. Modern astrophysics is continually requiring pieces of apparatus. Principal instruments are usually advantageously purchased from those who make a specialty of this type of apparatus. The smaller pieces, which have to be designed to meet the special requirements are best made under the eye of the user, because as the work proceeds ideas present themselves in the way of improvements, which can be embodied in the design, without additional cost, which is not the case when drawings are sent to a machine shop for completion.

The basement of the building is comprised of the machine shop, 31 x 16 feet, in which are located a milling machine, a lathe, drill press, shaper and grinder; the heating plant and the water tank; the library stack room, 26 x 19 feet; the clock room, 17 x 16 feet with piers for the sidereal and mean time clocks; the woodworking shop, 22 x 19 feet, and wash rooms. The main floor is given over to the office space, the main room of the library and a lecture hall. The library comprises about 600 monographs on Astronomy, Physics and Mathematics and 2500 volumes of Observatory Publications and Journals. A large fraction of the latter is on loan from the Royal Astronomical Society of Canada.

The second floor provides two additional offices, two laboratories, 31 x 16 feet and 20 x 19 feet, which accommodate the measuring engines, computing machines and photometers. The dark room and photographic room are also located on this floor. A special room is set aside for the donor of the observatory as a reception room.

Plate XXII

Library of the David Dunlap Observatory

The Staff and Work of the Observatory

The staff of the observatory is also the teaching staff at the University. The lecture session is carried on from the end of September till May and summer sessions are offered also. The courses of instruction include general courses and laboratory work for those taking Astronomy as a part of a liberal education, and more advanced courses in Astrophysics, Theoretical Astronomy, and Celestial Mechanics for those more deeply interested in the subject or who may desire to pursue Astronomy as a vocation.

The personnel of the observatory staff is as follows:

C. A. Chant, M.A., Ph.D., LL.D., F.R.S.C., *Professor Emeritus of Astrophysics and Director Emeritus of the David Dunlap Observatory.*
R. K. Young, B.A., Ph.D., F.R.S.C., *Professor and Director of the David Dunlap Observatory.*
F. S. Hogg, M.A., Ph.D., *Assistant Professor*
P. M. Millman, M.A., Ph.D., *Lecturer.*
J. F. Heard, M.A., Ph.D., *Lecturer.*
Mrs. H. S. Hogg, M.A., Ph.D., *Research Associate.*
Miss R. J. Northcott, M.A., *Computer.*
Miss F. S. Patterson, M.A., *Assistant Computer.*
Miss E. M. Fuller, B.A., *Librarian and Secretary.*
G. F. Longworth, *Night Assistant and Machinist.*

During the year and a half since the opening of the observatory work has been continued on a general programme of radial velocity determination for stars in and near the Kapteyn areas. 1600 spectrograms have been secured, of which about two-thirds have been measured and the results tabulated for publication. Observation of a number of eclipsing and spectroscopic binaries has been started. A list of these stars appears in the annual report of the council of the Royal Astronomical Society. (M.N. Vol. 97, No. 4.) Observations have been made at the Newtonian focus for the variables in globular star clusters and 178 photographs secured. The 19-inch telescope has been adapted for photography and will be used in photometric programmes.

In closing this brief description of the observatory, its equipment and work, thanks are due to the many firms and individuals who have contributed to its completion: to Sir Howard Grubb, Parsons and Company for the perfection of the mechanical details; to the Corning Glass Works for the construction of the "pyrex" disk; to Mr. Armstrong for the accuracy of the optical surfaces; to Adam

Main entrance Hall of the Administration Building

19-inch telescope

Hilger and Company for the excellent definition of the spectrograph; to the Superintendent of the University, Col. A. D. LePan and his assistants for their continual supervision of the installation; to the Dominion Bridge Company for the erection of the dome and telescope; to Mathers and Haldenby, architects, for the beautiful design of the Administration Building; lastly, to the enthusiasm and energy of the staff who have laboured to get the observatory under way.

David Dunlap Observatory,
March, 1937.

PUBLICATIONS OF
THE DAVID DUNLAP OBSERVATORY
UNIVERSITY OF TORONTO

VOLUME I NUMBER 2

THE LIGHT CURVES OF TWO VARIABLE STARS IN THE GLOBULAR CLUSTERS NGC 6218 AND NGC 6254

BY

HELEN B. SAWYER

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THE LIGHT CURVES OF TWO VARIABLE STARS IN THE GLOBULAR CLUSTERS NGC 6218 AND NGC 6254

BY HELEN B. SAWYER

Introduction. The two clusters NGC 6218 and NGC 6254, known also as Messier 12 and Messier 10 respectively, form a rather unusual pair in the sky. They are quite similar in appearance, with an arrangement of the brighter stars which is relatively loose for a globular cluster. Situated in the constellation of Ophiuchus near the celestial equator, they are only about three degrees apart in the sky. These clusters belong to a group which has a relative scarcity of bright stars. The luminosity curve of NGC 6218, as plotted from the data of Küstner's catalogue, is shown in Figure 1. There are fewer than two hundred stars of absolute magnitude brighter than zero.

The writer began photographing these clusters with the 72-inch reflector during her first season at the Dominion Astrophysical Observatory in 1931. The clusters were observed at that observatory each season through 1934, and since then observation has been continued with the 74-inch telescope of the David Dunlap Observatory. A number of Mount Wilson plates are available taken by F. G. Pease, H. Shapley and P. Th. Oosterhoff, to whom the writer is much indebted. Something of an astronomical record has been attained in that plates from the three largest existing telescopes have been available to study these clusters.

The writer has hunted both clusters intensively for variables as reported in a paper "One Hundred and Thirty-Two New Variable Stars in Globular Clusters", now in press.[1] The clusters are exceedingly poor in variable stars as in Messier 12 only one variable was found, and in Messier 10, only two. Plates giving the identification of the variables and comparison stars appear in the paper just mentioned. The variables, though scarce, are interesting objects however, as in each cluster the outstanding variable is practically the brightest star in the cluster. It is curious that the variability of these bright objects should have escaped detection for so long, but it may be recalled that a similar thing happened in the case of the brightest variable, which is also the brightest star, in the globular cluster Messier 2.[2] There Prof. Bailey found eleven fainter variables from an inspection of photographs, but failed to notice the variability of the brightest star in the cluster.

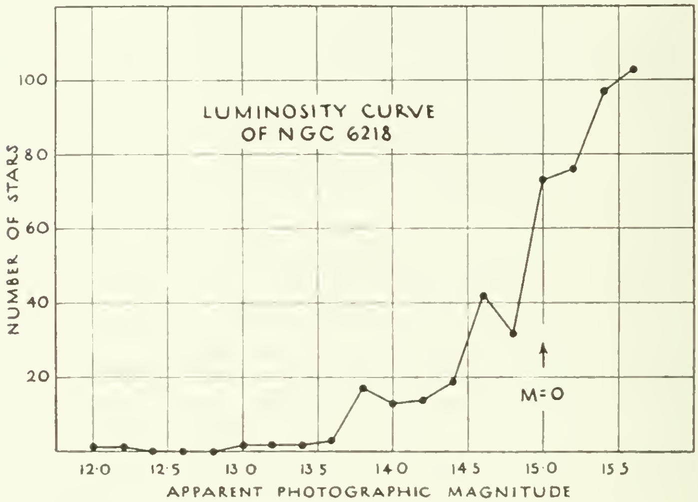

Figure 1

The luminosity curve of NGC 6218 as plotted from Küstner's Catalogue, Bonn Veröff. 26, 1933. The stars are grouped in intervals of 0.2 magnitude. There are 482 stars represented in the diagram; a few brighter stars (doubtless field stars) are omitted. The variable is the brightest star definitely attributable to the cluster, as at maximum it reaches 12.0. To give an idea of the absolute magnitudes, the line for absolute magnitude zero, based on the distance determined in this paper, is indicated.

1. NGC 6218 = Messier 12

This cluster is at R.A. $16^h\ 42^m.0$, Dec. $-1°\ 46'$ (1900), galactic longitude 344°, latitude +25°. The writer has photographed it for six seasons, and obtained observations on 33 nights. In addition, 14 Mount Wilson plates taken by Dr. Pease and Dr. Shapley in the years 1912-1919, and 7 by Dr. Oosterhoff in 1935 bring the total number of nights up to 50 and of observations to 59.

A sequence has been determined from two plates of ten and fifteen minutes exposure respectively on Kapteyn Area 108. As the variable is the brightest star in the region of the cluster a satisfactory sequence cannot be selected on reflector plates. But the sequence has been sufficient to estimate the variable and determine the period. Dr. Oosterhoff has communicated to the writer that he finds star *e* of the sequence to be variable. This star is a double star, and is resolved on his plates, though not on the writer's. The blending of the images apparently masks the variation on the writer's plates. The magnitudes used for the sequence stars are: *a*, 11.6; *b*, 11.9; *c*, 12.2; *d*, 13.2; *e*, 13.7.

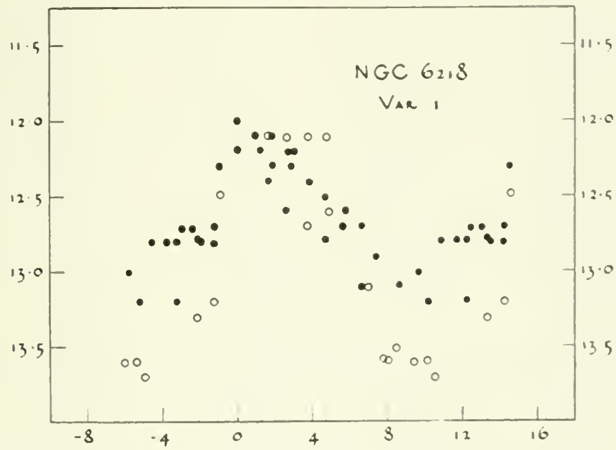

Figure 2

The Light Curve of Variable No. 1 in NGC 6218. Abscissae are days; ordinates, apparent photographic magnitudes. The open circles represent Mount Wilson plates, on which the two components of the variable are usually better resolved.

Variable No. 1 is a double star. Apparently the brighter component of the double varies, while the fainter is constant in light at approximately magnitude 14.0. This makes the estimation of magnitude exceedingly difficult. On the Canadian plates the variables are never separated at maximum, and only rarely toward minimum; while on the Mount Wilson plates they are usually separated toward minimum, and are occasionally resolved near maximum. The variable appears to be a long period Cepheid. The adopted elements are

$$\text{Maximum} = \text{J.D. } 2427306.708 + 15^{d}.508E$$

A period of 15.475 days represents slightly better the observations from some years, but throws others badly out of phase. It is

TABLE I

OBSERVATIONS OF VARIABLE NO. 1 IN N.G.C. 6218

Julian Day 2,400,000.+	Mag.	Phase	Plate No.	Obs.
19535.872	12.5	14.68	100	W
20952.878	12.1	4.86	2981	W
952.946	12.0	4.93	2985	W
953.006	12.1	4.99	2989	W
980.924	12.7	1.89	3058	W
980.989	12.1	1.95	3062	W
981.829	12.1	2.79	3068	W
981.899	12.1	2.86	3071	W
981.982	12.1	2.95	3075	W
982.955	12.1	3.92	3077	W
21435.781	13.1	6.98	3850	W
454.774	13.7	10.47	3872	W
22105.883	13.6	10.20	4945	W
134.704	13.6	8.00	4958	W
26607.689	12.8	14.39	19969	V
607.732	12.8	14.44	19971	V
915.756	12.9	12.28	20541	V
915.775	12.7	12.30	20542	V
921.725	12.4	2.74	20555	V
921.804	12.1	2.82	20558	V
923.758	12.5	4.77	20570	V
924.771	12.6	5.79	20585	V
925.733	12.7	6.75	20595	V
944.715	13.2	10.22	20642	V
944.723	13.2	10.23	20643	V
946.693	13.2	12.20	20671	V
946.701	13.3	12.21	20672	V
27273.761	12.8	13.58	21385	V
274.739	12.3	14.56	21397	V
275.740	12.2	0.05	21410	V
306.708	12.0	0.00	21510	V
307.722	12.1	1.01	21533	V
308.701	12.1	1.99	21551	V
309.718	12.2	3.01	21570	V
639.765	12.9	7.39	23177	V
658.790	12.8	10.88	23239	V
659.714	12.8	11.80	23250	V
664.705	12.2	1.29	23303	V
872.98	13.6	7.95	.....	W
888.95	13.5	8.41	.....	W
889.90	13.6	9.36	.....	W
930.96	12.7	3.89	.....	W

Julian Day 2,400,000.+	Mag.	Phase	Plate No.	Obs.
931.93	12.6	4.86	.....	W
955.88	13.3	13.30	.....	W
956.90	13.2	14.32	.....	W
28688.653	12.4	1.64	1977	T
689.653	12.6	2.64	1991	T
692.642	12.7	5.63	*2006	T
693.706	13.1	6.70	2010	T
695.726	13.1	8.72	2019	T
696.644	13.0	9.64	2031	T
715.642	12.5	13.12	2109	T
29071.668	12.7	12.44	3247	T
072.643	12.8	13.42	3257	T
073.612	12.7	14.39	3270	T
076.632	12.3	1.90	3287	T
077.641	12.3	2.91	3300	T
078.640	12.4	3.91	3314	T
079.449	12.8	4.71	3328	T

NOTE TO TABLE I. On plate 3058, the components of the variable were resolved, but they were not on the subsequent plate.

possible that in the future a period may be obtained to represent better all the observations, or it may be that the star is slightly irregular around a mean period.

Table I gives the observations on this star, indicating in successive columns the Julian Day, magnitude, phase, plate number, and the initial of the observatory where the plate was taken, W standing for Mount Wilson, V for the Dominion Astrophysical, and T for the David Dunlap Observatory. Figure 2 shows the light curve as obtained from the adopted elements. The open circles represent the Mount Wilson observations which fall systematically below those of Victoria and Toronto, due to the better resolution of the double star.

2. NGC 6254 = MESSIER 10

This cluster is at R.A. $16^h\ 51^m.9$, Dec. $-3°\ 57'$ (1900), galactic longitude 343°, latitude +22°. It has been observed for eight consecutive seasons, first at the Dominion Astrophysical and later at the David Dunlap Observatory, on a total of 42 nights. In addition, 14 Mount Wilson plates from the collection of Dr. Pease and Dr. Shapley have given observations on 9 additional nights between the years 1912 and 1919.

Two variables were found in this cluster by the writer. In a paper by E. C. Pickering[3] in 1897 there is one previous reference to a variable in this cluster, when he mentions that Professor Bailey has found a variable in it. However, the cluster and variable were not included in Bailey's comprehensive work on variables in globular clusters published in 1902.[4] An attempt has been made to see whether any unpublished records at the Harvard Observatory would identify the variable announced in 1897 and

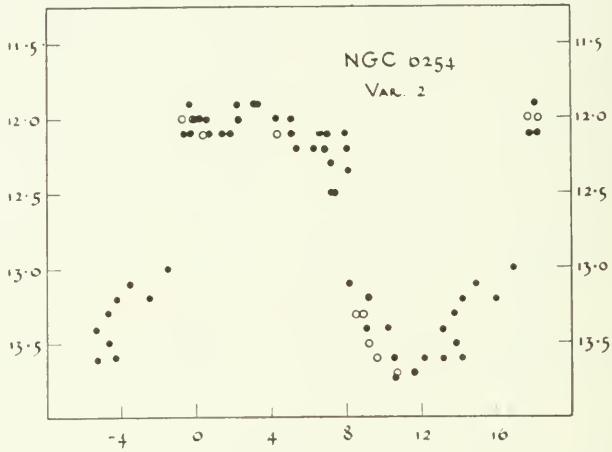

Figure 3

The Light Curve of Variable No. 2 in NGC 6254. Abscissae are days; ordinates, apparent photographic magnitudes. The open circles represent observations from Mount Wilson plates, which for this star show no systematic difference from the Canadian plates.

indicate if it were dropped from the lists because it was not a genuine variable. Miss Walker has located Prof. Bailey's records of a variable star search in this cluster, in which four suspected variables are identified. This search, however, judging from internal evidence, was made about 1917, and there is no mention in these papers of the variable announced earlier. On the plates available to the writer, none of Bailey's suspected variables appears to be a genuine variable.

A magnitude sequence has been obtained from three plates, one of fifteen minutes exposure and two of ten, on Kapteyn Area 108. The magnitude sequence is very unsatisfactory as there is a gap of 1.15 magnitudes between sequence stars in the very interval in which the variable is most frequently found. The magnitudes of the sequence stars are: *a*, 12.35; *b*, 13.5; *c*, 13.85; *d*, 14.1; *e*, 14.3; *f*, 14.65; *g*, 15.3; *h*, 15.6.

The writer has not yet made a serious attempt to find a period for Variable No. 1 in this cluster. It is a bright object in a congested region, with a range of only half a magnitude.

A satisfactory period has been obtained for Variable No. 2, however. It is found that this star, which is the brightest object in the cluster, strongly resembles in period the bright variable in NGC 6218 and also the brightest variable in NGC 6402.[5] The adopted elements are

$$\text{Maximum} = \text{J. D. } 2426607.712 + 18^{d}.754\text{E}$$

Table II contains the observations of this variable in the same form used in Table I. Figure 3 gives the light curve of the star from the adopted elements. The gaps in the light curve are probably accounted for by the magnitude sequence, which is poor because of the scarcity of bright stars in the vicinity of the cluster. The magnitude estimates appear sufficient however to define the period well. The Mount Wilson observations are indicated by open circles.

3. The Distances of NGC 6218 and NGC 6254

Since no variables were known in either of these clusters when their distances were last determined, it is interesting to make a new determination of their distances from the period-luminosity relation, although for each cluster it depends on only one star. For NGC 6218, the median apparent magnitude of the variable is 12.8 (subtracting the brightness of the companion star); the absolute magnitude from the period luminosity curve is -2.2, giving a modulus of 15.0, and a distance of 10.0 kiloparsecs. For NGC 6254, the median apparent magnitude of the variable is 12.7, the absolute magnitude -2.3, giving the same modulus as for NGC 6218. We find that the determination of distance from the new data is essentially the same as that found earlier. Table III gives a summary of the recent distance determinations. The adopted, uncorrected, distance is taken as the mean of the distance determined from the Cepheid variable and van de Kamp's distance.

Table IIIb shows that the true distance of the cluster is affected

TABLE II

Observations of Variables in NGC 6254

Julian Day 2,400,000.+	Var. No. 1 Mag.	Var. No. 2 Mag.	Var. No. 2 Phase	Plate No.	Obs.
19564.753	13.8	13.3	8.55	113	W
564.861	13.7	13.4	8.66	114	W
565.772	13.5	13.6	9.56	117	W
565.869	13.4	13.6	9.66	119	W
566.819	13.6	13.7	10.61	123	W
566.835	13.5	13.7	10.63	124	W
20952.891	13.6	13.3	8.89	2982	W
980.936	13.7	12.0	18.18	3059	W
981.839	13.6	12.0	0.33	3069	W
981.908	13.8	12.1	0.40	3072	W
981.992	13.6	12.1	0.48	3076	W
21454.747	13.4	12.1	4.38	3869	W
22105.874	13.3	12.0	17.88	4944	W
22134.714	13.6	13.5	9.21	4960	W
26607.712	13.7	12.0	0.00	19970	V
915.796	13.7	12.1	8.02	20543	V
921.742	13.5	13.5	13.97	20556	V
921.758	13.6	13.6	13.98	20557	V
923.804	13.6	13.2	16.03	20572	V
924.739	13.4	13.0	16.97	20583	V
925.746	13.5	12.1	17.97	20596	V
944.735	13.5	12.1	18.20	20644	V
944.744	13.5	12.1	18.21	20645	V
946.713	13.6	12.1	1.43	20673	V
946.722	13.7	12.0	1.44	20674	V
27274.752	13.4	13.7	10.65	21398	V
275.751	13.5	13.7	11.65	21411	V
306.756	13.3	12.0	5.15	21514	V
307.754	13.3	12.1	6.64	21536	V
308.712	13.4	12.1	7.10	21552	V
309.695	13.4	12.2	8.08	21569	V
309.746	13.4	12.3	8.14	21571	V
639.738	13.5	12.0	0.56	23176	V
658.724	13.5	12.1	0.69	23236	V
659.776	13.5	12.1	1.84	23253	V
664.783	13.5	12.2	6.85	23307	V
28016.589	13.7	12.0	2.33	99	T
038.508	13.8	12.2	5.49	184	T
043.555	13.7	13.6	10.54	216	T
308.796	13.6	13.6	13.22	822	T
309.741	13.4	13.6	14.17	835	T

Julian Day 2,400,000.+	Var. No. 1 Mag.	Var. No. 2 Mag.	Var. No. 2 Phase	Plate No.	Obs.
365.617	13.5	13.3	13.78	1108	T
366.671	13.4	13.1	14.84	1125	T
391.569	13.3	11.9	2.23	1225	T
392.635	13.3	11.9	3.29	1242	T
398.622	13.4	13.2	9.28	1269	T
399.606	13.2	13.4	10.26	1286	T
688.672	13.8	11.9	18.02	1978	T
689.689	13.8	12.0	0.28	1993	T
692.654	13.3	11.9	3.25	2007	T
693.715	13.4	12.0	4.31	2011	T
695.736	13.3	12.2	6.33	2020	T
696.655	13.3	12.3	7.25	2032	T
715.652	13.7	12.5	7.49	2110	T
29071.687	13.8	12.5	7.20	3248	T
072.670	13.5	13.1	8.18	3258	T
073.621	13.5	13.4	9.14	3271	T
076.695	13.3	13.6	12.21	3288	T
077.648	13.6	13.4	13.16	3301	T
078.647	13.4	13.2	14.16	3315	T

far more by the value of the absorption coefficient one adopts than by the different ways of determining an uncorrected distance of the cluster. If the mean of the three corrected distances is taken, it is very close to the distances given by van de Kamp for these clusters in 1933, 6.9 kiloparsecs for NGC 6218, and 6.7 for NGC 6254. It should be noted that Stebbins and Whitford[11] find the field of NGC 6254 (measured colour excess $E+0.19$) considerably more reddened than that of NGC 6218 ($E+0.13$); this is further confirmed by the counts of nebulae in these fields by Baade.[11] The number of nebulae is normal in the field of NGC 6218, but there are no nebulae in the field of NGC 6254 and the star field is partially obscured. At the mean corrected distance the linear separation of the two clusters is about 500 parsecs.

Now that these two clusters are known to possess such bright variables, photographs may be obtained with smaller, larger-field telescopes which would permit of more sequence stars and lead to better magnitude estimates and a well-defined light curve. There is no reason for assuming that these variables are not physically connected with the cluster in which they appear, and because of the high galactic latitude, we may assume that the variables are

TABLE III

DISTANCES OF NGC 6218 AND NGC 6254

(a) UNCORRECTED FOR ABSORPTION

Source	*NGC 6218*	*NGC 6254*	*Basis*
Shapley and Sawyer,[7] 1929	11.0 kpc	11.2 kpc	Int. mag., diam., bright stars
van de Kamp,[8] 1932	10.6	10.9	Int. mag., bright stars
Sawyer, 1938	10.0	10.0	One long period Cepheid
Uncorrected Mean	*10.3*	*10.4*	Mean of 1932 and 1938

(b) MEAN DISTANCES CORRECTED FOR ABSORPTION

Absorption coefficient of	*NGC 6218*	*NGC 6254*	
van de Kamp[9]	6.7 kpc	6.5 kpc	$\log f = -0.08 \lvert\text{cosec } b\rvert$
Hubble[10]	7.8	7.6	$\log f = -0.05 \lvert\text{cosec } b\rvert$
Stebbins and Whitford[11]	5.7	4.3	$\log \mathrm{f} = -2.0\,E$
Mean	*6.7*	*6.1*	

actual members. Because of their apparent brightness, which is greater than that of the variable in Messier 3 already studied spectroscopically by Joy,[12] these variables are especially commended to observers with fast spectrographs.

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Richmond Hill, Ontario,
October 25, 1938.

PUBLICATIONS OF
THE DAVID DUNLAP OBSERVATORY
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VOLUME I NUMBER 3

THE RADIAL VELOCITIES OF 500 STARS

R. K. YOUNG
DIRECTOR

1939
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THE RADIAL VELOCITIES OF 500 STARS

THE radial velocities of the 500 stars contained in this publication include all the stars in the Kapteyn areas from the north pole down to declination +15 degrees and to the photographic magnitude limit 7.59 as well as those stars in the immediate neighbourhood for an area 4 x 4 degrees square with the exception of a few stars whose velocities had already been determined. The programme as originally made out included an area 6 x 6 degrees square and some of the stars in this larger area have been included. Observation of the remainder of the stars in the larger areas is being continued. The observations have been made with the one-prism spectrograph attached to the 74-inch telescope. Observations were begun in June 1935 and completed in March 1939. Two cameras of 25 inch and 12½ inch focal length were available. The dispersion of the former is 33 A per mm. at Hγ and of the latter about half this. In the earlier months of the work, the 25-inch camera was used almost entirely. With this dispersion the spectra can be measured more accurately than with the lower dispersion. Owing to the number of nights when seeing conditions were poor and broken by clouds, it was soon realized that more rapid progress could be made with the shorter camera, and we have obtained nearly all the spectra with this camera. The results are adequately accurate for statistical studies or for the determination of binary orbits with medium range. The detection of the binary character of those stars with small range, less than 20 km., is uncertain and doubtless some of these have been included as of constant velocity.

The iron arc was used for comparison spectra using the wave-lengths recommended in the Transactions of the I.A.U., v. III, 1928. For the stellar wave-lengths of the O-B types and the A types, we have used the values given in the Transactions of the I.A.U., v. IV, 1932. For the later types two systems have been recommended based on the work of Adams and Harper respectively. The difficulty of compiling satisfactory wave-lengths for the late type stars increases as the dispersion decreases. The system given by the I.A.U. is quoted as being suitable for dispersions approximating 40 A per mm. Although our dispersion is only about two thirds of this it seemed best to use the published values. We have adhered fairly closely to the system given by Adams. The wave-lengths we have used are given in Table I.

TABLE I

λ	Auth.	Type	λ	Auth.	Type
3933.684	x A *	F-M	4325.652	x H	G-K
61.537	o A *	K-M	37.057	o A *	M
68.494	x A *	F-M	40.477	x A *	F-M
70.078	x A *	F	51.848	o A *B	G-K
4005.256	x A *	F-M	79.240	o A *	K-M
24.670	*B	F-M	83.559	x A *	F-G
35.683	o H	G-K	4404.763	x A *	F-M
45.827	x A *	F-M	07.694	*B	F-M
63.635	x H	F-M	08.368	x A	M
71.751	x A *	F-M	15.153	x H	F-M
77.726	x A *	F	27.258	x A *B	G-M
92.478	o H	G-K	35.226	o A	K-M
4101.750	x A *	F-G	43.814	*	F-M
18.681	o H	G-K	61.809	o A	G-M
27.840	o H	G-K	66.564	*	F-M
32.069	x A *	F-G	68.502	*	F-M
43.740	x A	F-M	82.214	o A *B	M
91.555	o H	G-K	94.575	o A *	F-M
4202.042	x A *	G-K	96.862	o A *	M
15.638	x A-H	F	4501.280	*	F-M
26.829	Y	F-G	08.293	o A *	F-M
35.951	x A *	F-G	15.345	*	F-M
46.838	*	F-M	22.707	o A	G
50.465	x A *B	F-M	22.809	o A *	K-M
54.348	x A *	G-M	28.629	*	F-M
60.415	x H	F-M	31.040	o A	G
71.545	x A	G	31.084	o A	K-M
71.586	x H	K-M	33.974	*	F-M
74.761	o A	K-M	49.597	*B	F-M
82.622	o A	K-M	54.038	*	F-M
89.632	x A-H	G-M	58.652	*	F-M
4307.914	x A	G-K	63.768	*	F-M
14.635	x A	M	71.982	o A *	M
14.668	x A	G-K	83.841	*	F-M
18.660	o A *	K-M	4629.344	*	F-M
20.816	x A	G-K	4861.344	o A *	F-M
4320.884	x A	M			

* Wave length in Sun
B blend
x I.A.U. Primary Standard
o I.A.U. Secondary Standard

A = Adams
H = Harper
Y = Young

The observation and measurement have been carried out by the various members of the staff as a joint programme. The following numbers of stars were assigned to the permanent members of the staff who were responsible for seeing that sufficient spectra were secured to obtain satisfactory velocities and for collating the results; F. S. Hogg, 151; P. M. Millman, 136; J. F. Heard, 127; R. K. Young, 86. The observing at the telescope was done by the astronomers mentioned above with the assistance of Mr. Longworth, night assistant and machinist, Mr. Tidy and Mr. MacRae, the last three observers taking nearly all the latter part of the nights. The measuring has been shared by various members also. In all 3387 measures were made. Of these Miss Patterson made 1218; Miss Northcott, 829; Mr. Tidy, 470; Mr. MacRae, 445; Dr. Heard, 190; Mr. Bunker, 119; Dr. Millman, 102.

For 61 of the stars, velocities published at other observatories are available for a study of systematic differences. Two of these seem to be variable and yield large differences. These have been omitted. The 59 remaining stars were divided into groups according to the types, B, A, F, G, K, M, and the average residual and its probable error computed as shown in Table II. Before taking these residuals the published velocities were reduced to the system of Moore's catalogue by applying the correction given by Moore.

TABLE II

Type	No. Stars	Alg. Residual	p.e.
B	5	−2.9	±0.8
A	9	−0.4	±1.3
F	14	+0.3	±0.5
G	10	+2.3	±0.7
K	17	+0.2	±0.3
M	4	+2.5	±0.2

For the whole 59 stars the average algebraic residual is $+0.40 \pm 0.03$. For the individual types the numbers are probably too small to give very reliable results but there seems to be an indication that the systematic error is more negative in the B and A type than in the later types. Some measures of standard velocity stars not included in the present table and not published tend to confirm this result. It is noteworthy that the systematic corrections given by Moore for the Mount Wilson velocities run from 0.0 in the A type to -0.8 in the M type. This is in the same direction as we find for the correction to our velocities.

The results for all the stars are included in Table III in which the headings of the various columns have the following meanings.

1. The serial number in the Henry Draper Catalogue.

2-3. The right ascension and declination for the epoch 1900.0.

4. The visual magnitude from Henry Draper Catalogue.

5. The Harvard type.

6. The type as estimated from our spectra. The criteria for estimating the type have been made as simple as possible and agree in general with the Harvard system and more particularly with the system adopted at Victoria.

   For the A-type—Ao, K 0.1 times Hδ; A2, K 0.4 times Hδ; A5, K 1.2 times Hδ; A9, K 2.0 times Hδ. In the F-type attention was centered on the line 4227; F3, 4227, 0.1 times Hγ; F7, 4227, 0.8 times Hγ; F8, 4227 = Hγ; Go, 4227, 3 times Hγ. For the later types the absolute intensity of 4227 was compared with typical spectra from G0 − K8 and for the M-type the strength of the titatium oxide bands was used as a criterion.

7. The velocity of the star, i.e., the weighted mean velocity from all the plates if the velocity seemed constant or variation not reasonably certain. Those stars which showed definite variation are indicated by "Var" or, if the variation was probable only, by "Var?"

8. The probable error of the mean velocity computed by the formula

$$P.\,E. = 0.845\,\frac{\Sigma v\sqrt{p}}{n\sqrt{\Sigma p}}$$

9. The number of plates.

10. The minimum and maximum number of lines measured on the plates.

11. The average probable error of a plate as judged from the agreement of the lines.

12. The observer responsible for the collation of the results and the progress of observing. H, Hogg; M, Millman; Hd, Heard; Y, Young.

13. Velocities published at other observatories. In this column, M refers to Moore's general catalogue; W, the Mount Wilson

list of stars in Ap. J., v. 88, p. 34; V, the Victoria list, D.A.O. Pub., v. VI, no. 10.

14. References—R refers to notes to Table III; IV indicates that the individual velocities are found in Table IV. In this column also reference is made to a number of stars which showed a somewhat larger range than the agreement of the lines would lead one to suspect. Such stars are indicated by an * followed by a number showing the extreme range which the velocities indicated.

The individual velocities for all those stars in which a velocity variation has been definitely established or for which a velocity variation is probable are shown in Table IV. There are 85 of these stars—that is a proportion of 1:4 which show variable velocity. This ratio is somewhat lower than ordinarily accepted since the low dispersion has prevented the detection of the binaries with small range. For most of these stars we have attempted to estimate a velocity which could be used in statistical work. Those who use these results can be guided in this regard by the probable error attached which has been computed in the usual way on the assumption that the variations in the velocities shown were of a purely accidental nature. Column 1, gives the H.D. number and the Julian day of the observation and the fractional part of the day; 2, the measured velocity; 3, the number of lines measured; 4, the probable error computed as in column 11 of Table II; 5, the weight assigned to the plate; 6, the camera used; 7, measurer—N, Miss R. J. Northcott; MR, D. A. MacRae; P, Miss F. S. Patterson; T, G. H. Tidy; B, A. F. Bunker; M, P. M. Millman; Hd, J. F. Heard; S, Helen B. Sawyer.

TABLE III

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	ē	Obs.	Pub. Velocity	Ref.
	h m	° ′											
3	00 00.0	+44 40	6.51	A0	A1n	−18.5	4.4	6	3–7	5.3	M		
370	03.3	73 41	7.42	A0	A0s	+04.7	1.4	5	4–7	4.5	H		
874	08.0	16 22	6.62	G5	G5	+10.6	0.8	4	14–24	1.9	Hd		
886	08.1	14 38	2.87	B2	B2s	+00.4	1.4	8	10–15	2.8	Hd	+05.0±0.5 M	R
1243	11.6	13 22	7.50	A3	A3	−01.8	2.8	8	5–12	3.9	M		
1375	00 12.8	+12 13	6.63	G5	G5	+03.6	1.2	4	19–25	1.8	Y		
1439	13.4	30 58	5.80	A0	A0s	−07.2	1.7	5	4–10	2.8	Hd		
1606	15.2	30 23	5.82	B8	B5	+03.8	2.0	9	3–7	5.6	H		
1632	15.5	32 21	5.97	K5	K5	−34.6	1.6	5	12–23	2.2	H		
1641	15.6	32 25	6.98	F5	F4	−03.0	1.7	5	7–11	2.0	H		
1662	00 15.8	+12 13	7.43	A3	A5	−19.7	1.4	4	9–15	2.9	Hd		
1826	17.6	28 55	6.89	A3	A5	Var.		5	15–29	2.8	Y		IV
2019	19.4	30 49	6.80	B9	B9	Var.		7	2–7	6.3	M		IV
2358	22.3	15 29	6.57	A5	A5n	+02.1	1.7	5	3–8	3.5	M		
2411	22.8	17 21	5.33	Mb	M6	+07.7	0.8	4	10–22	2.0	M	+05.2±0.8 M	
2436	00 23.0	+15 54	6.46	K2	K3	−11.1	2.6	4	17–22	1.8	Y	−02.0±0.6 M	*19
2453	23.2	31 53	6.71	A0p	A0sp	Var.?		5	13–21	3.1	Hd		IV
2628	24.8	29 12	5.26	F0	A9s	−08.0	1.0	4	19–39	1.7	Hd	−10.8±0.3 M	
2666	25.2	31 38	7.57	F5	F3	−08.0	2.7	6	8–16	3.1	H		*37
2767	26.1	33 02	6.08	K0	K0	Var.?		7	5–26	1.8	H		IV

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	ē	Obs.	Pub. Velocity	Ref.
	h m	° ′											
2942	00 27.6	+27 44	6.38	G5	G5	−08.5	0.5	5	10–23	1.8	Hd	−14.2±0.8 M	
3291	30.9	44 06	7.33	B8	B8	−10.1	1.9	6	3–12	5.8	Y		R
3369	31.5	33 10	4.44	B3	B4	Var.		4	4–11	4.5	Hd		IV
3546	33.3	28 46	4.52	G5	G7	−81.8	1.4	4	11–25	1.4	Hd	−83.6±0.2 M	
3627	34.0	30 19	3.49	K2	K1	−08.2	0.4	4	19–23	1.4	Hd	−07.1±0.3 M	
4335	00 40.7	+44 18	5.99	B8	B9s	+04.5	2.6	5	5–9	3.9	Y		*17R
4701	44.0	47 13	6.97	A2	A5n	−14.6	2.3	6	5–11	6.8	M		
4817	45.2	61 16	6.36	K2	K2	−19.7	1.0	5	13–22	3.0	H		
5394	50.7	60 11	2.25	B0p	Bepv	Var.		4	4–10	1.9	Hd		R
5459	51.3	60 53	6.62	G5	G6	−07.6	1.8	5	18–26	1.8	H		*20
5914	00 55.6	+88 29	6.48	A2	A2	−11.0	1.7	5	4–11	3.8	H		
6130	57.4	60 32	5.94	F0	A9s	−01.1	1.1	5	8–27	2.0	H	−01.8±1.6 W	
6210	58.1	61 04	5.88	F8	F7	−14.8	0.7	6	12–17	2.2	H		
6175	01 00.7	59 20	6.78	A0	A0n	Var.		5	3–5	6.4	H		IV
7157	06.8	61 10	6.29	B9	B9s	−03.4	2.8	6	4–9	4.3	M		R
7374	01 08.8	+15 36	5.85	B8	B7	−16.2	2.0	6	4–6	4.6	M	−16.1±0.7 W	
8126	15.6	28 13	5.60	K0	K2	−34.9	0.9	5	11–27	1.3	Hd	−35.1±1.0 M	
8112	18.5	17 17	6.81	F0	F2	−15.7	1.3	6	7–18	2.6	H		
8815	21.8	29 16	7.18	F2	F2	−06.2	1.4	4	6–17	4.8	Y		
8909	22.7	30 02	6.87	F5	F6	−14.5	1.4	4	11–15	1.8	Y		

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	$\bar{c}$	Obs.	Pub. Velocity	Ref.
	h m	° ′											
8941	01 23.0	+16 34	6.75	F5	F7	+08.2	0.6	6	9–16	2.3	H	+08.5±0.2 W	
9100	24.5	17 51	5.96	A2	A3	+02.7	3.3	6	4–9	5.7	M		
9270	26.1	14 50	3.72	G5	G5	+15.1	1.1	6	16–36	1.8	H	+14.4±0.2 M	
9312	26.6	16 28	6.81	G5	G5	Var.		19	18–30	1.8	Hd		IV
9616	29.2	32 37	6.57	G0	G0	−25.2	0.8	5	15–24	2.2	H		
9709	01 30.0	+16 36	7.02	B9	B8ne	Var.?		9	2–4	3.8	Hd		IV
9996	32.5	44 54	6.34	A0	A0	+05.0	3.3	6	5–13	3.7	M		*31
10086	33.5	45 23	6.66	G5	G4	+06.8	1.1	4	21–27	1.9	H	±01.8±1.1 W	
10363	36.1	43 08	7.03	A0	A0n	−01.0	2.7	5	4–6	6.5	Y		
10407	36.4	29 01	7.38	A2	A1	+06.3	3.2	6	3–7	4.9	M		
10588	01 38.2	+31 43	6.42	G5	G5	Var.		6	22–27	1.9	Y		IV
10638	38.7	32 01	6.78	A3	A6	−00.9	0.5	5	8–20	3.1	Hd		
10681	39.2	27 58	7.31	A0	B9	−01.8	2.4	6	3–5	6.7	M		
10773	40.3	43 13	7.40	A0	B9n	−14.5	3.7	6	3–6	4.7	M		*21
10874	41.6	45 44	6.32	F5	F4	−03.6	1.0	5	9–15	2.5	Y		
11188	01 44.9	+46 58	7.14	B8	B8	Var.		6	4–8	4.3	M		IV
11336	46.4	44 19	7.48	B8	B9	−20.8	3.8	6	3–6	5.0	M		R
13596	02 07.6	14 48	5.99	K5	K5	+20.2	2.1	6	8–19	2.2	Y	+26.2±1.7 M	*21
14688	17.1	16 25	6.78	A0	A1s	Var.		4	8–23	2.0	M		IV
15227	22.1	16 12	7.26	F0	F0	+14.0	0.4	4	13–19	2.3	Hd		

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	$\bar{\epsilon}$	Obs.	Pub. Velocity	Ref.
	h m	° ′											
15992	02 29.1	+44 12	7.42	B9	B9	−01.0	2.6	6	5–7	3.9	M		R
16111	30.2	28 58	7.10	B8	B9n	+02.8	2.5	11	2–5	7.3	H		
16187	30.8	31 10	6.16	K0	G8	+03.7	1.1	4	14–27	1.6	Y		
16220	31.1	32 37	6.29	F5	F5	−01.6	1.4	6	12–18	2.4	H	−00.6 V	
16245	31.3	29 59	7.41	A0	A0	+04.7	2.7	6	4–6	4.4	M		R
16545	02 34.1	+43 40	7.25	A0p	A0p	+04.4	3.4	6	3–7	5.1	M		R
16580	34.4	29 21	7.45	B9	A0	+13.4	3.3	6	4–11	5.1	M		R
16594	34.5	31 53	7.50	A2	A2n	+01.3	3.2	7	3–5	5.5	M		
16933	37.8	46 26	6.98	F5	F4	+24.2	1.6	5	8–18	2.1	H		*13
17007	38.6	29 03	7.06	F0	F0	−08.0	1.0	6	7–23	3.3	Hd		R
17316	02 41.7	+43 13	7.35	B9	A2	−30.4	2.5	4	4–5	7.0	Y		
17656	45.0	46 25	5.97	G5	G7	−10.0	0.9	4	16–28	1.8	Y		
17891	47.3	46 44	6.73	B9	B9	+04.6	1.6	6	4–7	5.3	M		
18173N	53.1	59 17	7.35	A0	A0	Var.		6	3–8	6.0	M		IV
19536	03 03.5	60 15	7.26	A0	A1s	Var.		6	5–15	4.0	H		IV
19896	03 06.8	+16 07	7.32	A2	A4s	−06.5	2.3	5	13–27	2.2	Hd		*15
20134	09.1	59 41	7.51	B3	B4e	−15.1	3.8	6	3–9	3.2	M		*31
20158	12.4	13 29	7.42	A0	A0n	+01.7	5.1	6	2–7	5.7	M		
20536	13.1	61 38	6.65	B8	B8n	−08.3	1.8	7	2–5	8.4	H		
21062	18.8	28 18	6.99	A0	A3	+06.4	1.6	6	5–8	4.8	Y		

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	c̄	Obs.	Pub. Velocity	Ref.
	h m	° ′											
21242	03 20.5	+28 23	6.51	G5	G5e	+16.9	1.7	8	7–32		H		R
21379	21.8	12 23	6.20	A0	A0	+16.0	2.6	6	3–10	4.4	M		
21611	24.2	29 12	7.51	A0	A0n	+13.2	3.2	6	3–6	6.2	M		
22124	28.8	31 41	6.62	F0	F2	Var.		30	11–27	2.3	Y		IV
22136	28.9	46 46	6.76	B9	B8sp	+10.7	2.4	6	3–10	4.1	Hd		R
22195	03 29.4	+31 21	6.83	F0	F2	+21.8	1.4	6	7–24	4.0	H		
22317	30.5	28 54	6.63	A5	A7	+20.0	1.1	4	15–19	2.9	Y		
22418	31.3	30 48	7.01	F5	F4	−38.3	1.7	5	9–13	3.2	Hd		
22963	36.1	32 38	6.67	F8	F7	−33.0	1.7	4	9–15	2.0	Hd		
23139	37.7	45 48	6.09	A5	A5	+10.2	1.1	4	9–22	3.1	Y		
23477	03 40.4	+43 46	7.07	B9	A0s	+06.8	1.5	4	4–6	4.5	M		R
23728	42.3	43 39	5.86	F0	F0	−15.9	2.3	4	6–20	3.6	Hd		
23838	43.1	44 40	5.79	G0	G0	Var.		12	9–29	2.0	H		IV
25473	57.7	73 18	6.88	F5	F4	−29.0	1.2	5	12–18	2.2	H		
26015	04 02.0	14 54	5.94	F0	F2	Var.?		5	17–27	2.0	H		IV
26039	02.3	+16 16	7.52	B9	B9	+15.4	4.4	6	3–6	7.1	M		
26171	03.4	13 08	6.02	B9	B9	−26.3	4.3	6	4–8	5.6	M		*47
26398	05.4	16 22	7.02	B8	B6e	+32.3	4.4	7	3–9	7.9	M		R
26546	06.8	17 02	6.30	G5	G5	+29.4	1.6	4	17–37	1.3	Y		
26703	08.3	12 30	6.49	K0	K0	+48.9	1.0	4	7–26	3.5	H		

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	ē	Obs.	Pub. Velocity	Ref.
	h m	° ′											
26911	04 10.1	+15 09	6.35	F5	F5	+37.3	1.7	6	6–14	5.1	Hd		
27319	13.9	31 44	6.35	K5	K5	−16.2	0.8	4	13–28	2.2	Y		
27483	15.2	13 38	6.14	F2	F4	Var.		4	9–21		Y		IV
27561	15.9	14 11	6.71	F0	F3	+36.7	1.1	5	16–22	2.1	Hd		
27579	16.1	13 21	7.34	A5	A4	+09.6	2.0	5	7–17	4.5	Hd		
28150	04 21.3	+17 58	6.74	A0	A1	+18.5	0.7	6	4–9	6.9	M		
28271	22.5	30 09	6.26	F5	F5	Var.?		7	9–20	2.3	H		IV
29329	32.1	76 25	6.51	F5	F5	−05.7	1.9	5	7–13	2.4	H		*17
29487	33.5	43 55	7.32	B9	B8	+06.9	4.1	6	4–15	5.4	M		*52
29678	35.4	75 46	6.04	F0	F0	−01.4	1.6	5	4–14	4.6	H		
30090	04 39.4	+42 09	6.65	G0	G0	+29.3	1.9	5	16–20	1.8	H		*14
30736	45.1	45 46	6.69	F8	F8	+23.6	1.3	4	9–21	2.0	Y		
31069	47.7	43 54	5.98	B9	B9n	−00.2	4.1	7	3–6	4.8	Y		*39
31662	52.6	60 56	6.12	F5	F4	+10.8	1.9	6	8–25	2.6	H		
32356	57.5	61 02	6.27	K0	K0	−39.0	1.3	4	21–35	1.8	H		
33266	05 03.9	+61 44	5.99	A0	A1	−05.4	1.9	7	9–20	3.3	Hd		*21
33336	04.5	13 25	6.73	F2	F3	−00.6	1.8	6	7–12	3.3	Hd		
33618	06.4	59 16	6.36	K0	G8	+04.2	1.6	5	23–29	1.3	H		*14
34054	09.5	14 56	7.29	B9	B9	+13.2	3.9	6	3–5	6.4	M		
34517	13.2	13 29	7.5	B9	cA0	+08.4	0.3	4	5–15	4.0	M		

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	$\bar{c}$	Obs.	Pub. Velocity	Ref.
	h m	° ′											
35035	05 16.7	+28 22	7.36	A3	A3	+44.7	2.0	4	16–25	3.8	M		R
35036	16.7	16 01	7.38	A0	A0s	+47.1	2.0	7	2–7	7.3	M		
35076	17.0	28 51	6.39	B9	B9k	Var.		6	3–9	4.5	H		IV
35173	17.8	15 55	6.94	B8	B4	+21.1	2.4	6	3–5	6.7	M		
35189	17.9	16 36	6.09	A2	A1s	Var.		6	5–29	3.2	M		IV
35238	05 18.2	+31 08	6.37	K0	K0	Var.?		6	12–33	2.0	Hd		IV
35239	18.2	31 03	5.93	B9	B9	+08.3	2.6	8	3–5	9.2	H		
25522	20.2	15 23	7.04	B9	B8	Var.?		8	2–8	4.8	M		IV
35533	20.3	15 35	7.48	A0	A0sp	+24.2	3.0	6	3–9	4.7	Hd		*26R
35607	20.9	60 11	6.85	A0	A1	+05.6	2.0	5	4–6	5.0	Hd		
35693	05 21.5	+15 11	6.13	A2	A1	+21.6	2.4	6	3–11	6.0	M		
35909	22.9	13 37	6.26	A2	A3n	+27.8	1.1	5	4–5	4.9	M		
35984	23.4	29 07	6.21	F5	F3	+13.5	1.0	6	11–24	1.9	H	+11.0±2.2 W	
36468	26.8	43 52	7.18	B9	B9	+38.7	2.8	6	3–5	4.4	Y		
36756	28.9	44 15	7.17	F5	F6	+21.6	1.2	4	12–19	2.3	Hd		
38817	05 43.4	+43 59	7.45	A2	A1s	+31.5	1.5	5	13–25	3.0	M		
43043	06 09.0	16 04	6.73	G5	G5	+32.5	0.8	5	15–24	2.2	Hd		
43044p	09.0	14 38	6.82	B9	B9	Var.?		7	2–5	6.4	M		IV
43044f	09.0	14 38	6.82	B9	Aon	+11.5	3.2	6	3–6	9.2	M		
43496	11.4	15 53	7.18	B9	B9	+11.0	0.9	5	4–6	3.4	M		R

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	ē	Obs.	Pub. Velocity	Ref.
	h m	° ′											
43583	06 11.9	14 05	6.48	B9	B9	+09.1	4.6	5	3–8	4.2	M		*46
43683	12.4	14 25	5.98	A0	A0n	+12.2	3.1	5	4–6	5.4	M		
43931	13.8	13 29	6.96	F5	F6	+47.0	1.0	5	10–22	2.3	Hd		
43947	13.9	16 03	6.53	G0	G0	+12.5	0.7	5	12–30	2.1	Hd		
44033	14.4	14 41	6.02	K5	K8	+33.8	1.1	5	13–44	1.6	H	+35.0±0.5 W	
44250	06 15.7	30 01	7.06	A0	A0	Var.?		5	3–6	4.6	M		IV
44738	18.3	14 10	7.3	A0p	A0p	+21.4	5.0	5	7–10	6.0	M		*37R
44766	18.5	29 46	6.52	B9	B7	+28.1	3.6	6	3–7	6.5	M		
44867	19.1	16 07	6.35	G5	G7	Var.?		5	16–39	1.9	Hd		IV
44904	19.3	17 03	6.82	B9	B8	+01.9	4.0	6	2–10	5.6	M		
45180	06 20.9	+15 35	6.71	B9	B9	+08.8	2.5	7	3–8	5.1	M		
45194	21.0	13 10	6.59	F8	F8	Var.		8	3–15	2.7	Hd		IV
45412	22.1	30 34	Var.	G0	F8	Var.		2	23–25	1.2	Y		IV
45506	22.7	16 19	6.33	G5	G6	+41.9	1.2	4	22–37	1.2	Hd		
45721	24.0	28 17	6.85	A2	A3n	−05.2	4.5	6	4–7	9.0	Hd		
46016	06 25.8	+16 34	6.78	B8	B8	−05.9	1.6	5	3–11	5.5	Hd		R
46031	25.9	15 58	6.37	A5	A5n	+19.9	2.0	9	4–28	5.3	H		
47050	31.6	30 58	7.23	A2	A2	−12.8	2.2	5	4–6	5.1	M		
47255	32.6	31 51	7.31	A0	A1	+05.4	2.9	5	4–18	4.6	M		
47270	32.7	44 06	6.51	K0	K0	Var.		7	12–32	1.7	H		IV

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	$\bar{c}$	Obs.	Pub. Velocity	Ref.
	h m	° ′											
47395	06 33.3	+28 21	5.84	B8	B7	Var.		6	5–7	4.6	M		IV
47914	35.8	44 38	5.17	K5	K4	−69.3	1.2	4	22–51	1.5	Y	−74.8±0.5 M	
49949	45.8	44 58	6.10	A5	A5n	+00.1	4.2	6	4–7	8.1	M		
50315	47.6	43 04	7.27	A3	A5	+02.1	2.5	5	6–19	3.5	Hd		
52708	57.2	59 57	6.54	K0	K0	+23.2	1.5	4	23–43	1.6	H		*12
55283N	07 07.2	+15 21	7.39	A0	A0	Var.		6	4–7	5.1	M		IV
55383	07.6	16 20	5.31	Mb	M4	−07.9	0.8	5	9–35	1.6	M	−9.8±0.5 W	
56200	11.0	16 18	6.83	F5	F5	+22.6	1.2	4	10–20	1.8	H		
56537	12.3	16 43	3.65	A2	A4	−10.2	2.6	4	4–8	5.0	Hd	−13.8±1.9 M	
57049	14.5	15 21	6.47	A0	A1n	+21.4	4.7	6	4–7	6.0	Hd		*44
57728	07 17.4	+15 33	6.71	G5	G5	+01.2	2.0	6	6–27	2.2	Hd		R
58729	21.8	15 30	7.02	B8	B9n	+24.1	3.6	6	3–7	5.3	M		
58746	21.9	29 37	7.41	A5	A6	+09.4	1.4	5	10–35	2.3	Hd	+13.4±0.3 W	
59059	23.2	15 20	6.07	A0	A0n	+32.3	3.5	6	3–5	4.9	M		
60204	28.3	28 55	6.74	G5	G8	−11.3	1.3	4	18–44	1.6	Hd		
60335	07 28.9	+43 15	6.30	F0	F2	+20.1	1.6	6	16–30	1.9	H		*14
60383	29.1	28 51	7.02	A3	A3	−08.5	2.1	5	6–12	4.6	Hd		
60800	31.2	31 50	7.60	B9	B8	−02.2	1.0	4	3–5	5.0	Hd		
63312	43.2	46 03	7.06	A2	A2	+02.7	2.5	6	8–21	3.6	M		R
63630	44.8	46 12	6.53	A3	A5	Var.		17	6–22	3.8	H		IV

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	ē	Obs.	Pub. Velocity	Ref.
	h m	° ′											
68461	08 07.4	+16 49	6.12	G5	G6	Var.		8	22–51	1.6	Y		IV
68776	08.8	13 22	6.48	K0	K0	Var.		8	14–25	2.5	Hd		IV
68903	09.4	16 23	7.18	B8	B9	+03.4	1.6	6	3–7	4.6	M		
69788	13.5	16 26	6.79	A0	A0n	+24.7	3.9	5	2–6	4.5	Y		
70338	16.3	13 57	7.08	A2	A6s	+24.6	1.2	5	19–26	2.2	M		
71555	08 23.0	+14 33	5.90	A2	A5	+ 9.8	1.4	6	7–19	4.5	M	−6.1±2.1 M	
73080	31.3	28 39	6.72	G5	G2	−27.2	1.0	4	12–20	2.0	Hd		
73190	32.0	73 31	6.93	A0	A0	+03.3	1.5	4	5–6	4.9	H		
73593	34.1	46 11	5.52	K0	G8	−34.6	0.7	4	31–43	0.7	Hd	−37.3±0.8 M	
73797	35.1	73 39	7.40	A2	A2	−14.7	1.6	5	4–10	6.3	H		
75523	08 45.1	+15 41	6.08	K0	K0	+13.7	1.4	6	11–29	1.4	H		*17
76216	49.7	58 36	6.90	A2	A2s	Var.?		6	8–19	2.8	H		IV
76238	49.8	46 09	6.93	F0	F0	−08.3	2.5	6	8–19	4.7	H		
77692	59.0	59 45	6.19	A0	A0	+09.5	2.1	5	4–6	6.1	H		
79554	09 09.7	15 22	5.57	K0	K0	+27.2	1.7	5	11–13	1.3	H	+25.0±0.1 W	
80613	09 15.7	+15 48	6.49	A0	A0n	+16.9	3.0	6	3–8	8.4	M	+17.8±0.4 M	
80654	15.9	13 33	6.58	F5	F5	−08.4	0.8	6	9–22	1.8	H		
82010	24.2	31 45	7.60	B8	B9	+30.8	3.5	6	2–6	8.3	Hd		
81737	42.1	46 29	5.20	G0	G1	+01.6	0.5	5	25–40	1.0	Hd	+05.4±0.3 M	
89993	10 18.1	30 07	6.46	K0	G8	−11.6	0.7	4	13–45	1.2	Hd		

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	ē	Obs.	Pub. Velocity	Ref.
	h m	° ′											
91181	10 26.5	+44 43	7.32	A5	A5	−01.9	1.7	6	13–20	3.5	M		R
93075	39.8	57 26	7.03	F0	A9	Var.		5	16–19	2.1	H		IV
94118	46.7	46 20	7.07	A2	A1	Var.		8	5–20	3.3	M		IV
94631	50.4	58 02	6.78	G5	G5	+11.2	1.9	5	25–34	1.7	Y		
96870	11 04.2	88 11	7.44	B8	B9	−23.8	1.0	4	5–6	6.5	H		
97889	11 10.5	+60 28	6.66	A3	A4	−06.0	3.8	6	5–16	5.3	M		
97938	10.8	13 09	6.73	A0	B9	+11.2	3.0	5	3–6	4.0	Hd		
98354	13.7	14 49	6.65	G0	F7	+24.9	1.3	7	12–30	2.0	H	+24.2±1.6 W	
98388	14.0	13 56	7.08	F8	F7	+06.2	2.5	4	12–15	3.1	Hd		
99267	20.3	30 32	6.88	F0	A8	Var.?		5	10–19	5.0	Y		IV
99832	11 24.0	+30 58	7.10	F2	F5s	−19.3	1.7	6	12–23	1.8	Hd		*18
99946	24.8	30 32	6.78	F0	A9n	−07.2	3.4	8	4–14	7.3	H		
100808	31.0	28 20	5.82	A3	A9n	+04.1	1.5	6	5–14	5.3	M		
100972	32.2	45 17	6.58	B9	B9n	+15.8	5.6	5	4–8	8.4	H		*31
105388	12 03.0	31 37	7.24	A0	A0	−08.5	1.5	7	4–13	8.1	Hd		
105678	12 04.9	+75 13	6.36	F5	F5	−18.1	1.5	4	15–21	2.1	H		
106022	06.9	29 06	6.40	F2	F2n	−16.5	1.2	7	11–20	3.1	H	−17.9±2.0 V	
106677	11.0	73 07	6.55	K0	K0	Var.		7	14–29	2.4	H		IV
106926	12.7	15 42	6.53	K0	K0	Var.		7	10–26	2.9	Hd		IV
107192	14.4	88 15	6.28	F0	F2	−05.7	2.2	4	15–18	2.9	H		

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	ē	Obs.	Pub. Velocity	Ref.
	h m	° ′											
107415	12 15.8	+16 05	6.51	K0	G6	−20.8	1.0	4	28-41	1.3	Y		
110834	39.8	41 39	6.31	F5	F5	−16.4	2.0	6	11-18	5.2	H		
112501	52.1	44 06	6.95	A0	A5	−9.8	1.2	6	11-25	2.9	M		R
112570	52.6	46 44	6.22	K0	G8	Var.		6	24-45	1.5	H		IV
112734	53.8	28 52	6.61	A5	A5	Var.		6	4-15	5.4	H		IV
112887	12 51.8	+28 37	7.09	F5	F4s	−08.2	0.6	4	13-25	2.7	Hd		
113021	55.7	32 18	6.72	G5	G5	+03.5	1.3	5	16-25	2.3	H		
113019	55.9	76 00	6.19	K0	K0	−14.0	0.9	5	21-35	1.5	H		
113817	13 01.4	45 48	5.72	K0	G9	−18.5	0.7	5	16-22	1.1	Hd	−19.2±1.5 W	
114092	03.2	28 04	6.40	K5	K6	−07.6	0.4	6	18-31	1.4	Y		
114446	13 05.5	+57 22	7.01	F8	F8	−34.2	1.5	4	14-18	2.0	H		
114723	07.3	32 39	6.66	F8	F7	−12.7	1.3	5	12-14	3.4	Y		R
116594	19.5	12 57	6.50	K0	G7	Var.		6	12-43	2.0	Hd		IV
119213	36.8	57 42	6.14	A2	A1s	−01.2	1.1	4	7-25	2.2	H		R
119842	40.5	60 39	7.06	A0	A1	−12.2	2.5	4	8-25	3.0	H		
120702	13 46.0	+43 02	6.90	F0	F4s	−18.2	1.7	4	14-21	2.1	Y		
121626	51.5	29 10	7.11	A0	A2n	−08.8	3.6	6	4-13	6.2	Hd		
126269-70	14 19.4	16 44	6.77	F5-A0		−19.8	1.4	5	7-38	2.3	M		R
130044	40.9	45 36	6.84	F0	F2s	−07.2	0.6	4	25-34	1.8	Hd		
130945	45.8	46 32	5.76	F5	F6s	−05.5	0.6	5	15-20	1.4	Hd	−05.4±1.7 W	

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	ē	Obs.	Pub. Velocity	Ref.
	h m	° ′											
131764	14 50.4	+30 28	6.84	F2	F4	−35.0	3.5	8	6–12	8.1	Y		R
132445	54.1	44 52	7.22	A2	A2n	−11.9	2.8	9	3–5	7.1	H		R
133330	58.8	28 40	6.90	A0	A3n	+15.4	6.1	6	2–5	9.6	M		R
133909	15 01.9	59 55	7.26	A2	A5n	−09.6	5.5	6	6–19	8.5	M		
134305	04.0	12 52	7.16	A3	A5	−33.8	2.0	5	11–20	3.4	M		R
134323	15 04.1	+13 37	6.07	K0	G8	−48.4	0.6	4	26–39	1.4	H	−47.1±1.7 W	
134792	06.7	29 37	7.11	F5	F5s	+15.0	1.0	4	17–21	2.0	Y		
135438	10.0	32 09	6.22	K5	K5	+05.1	2.3	4	17–24	2.9	H		
138265	25.9	61 01	6.08	K5	K5	−42.8	0.5	4	25–45	1.2	H		
140612	39.5	46 04	6.90	F0	F4	−27.1	1.7	7	13–35	2.7	Hd		*19
141930	15 46.6	+44 49	7.57	A0	A1	Var.?		6	5–12	6.5	Hd		IV
142926	52.2	42 51	5.61	B8	B9e	Var.		26	3–3	1.6	Hd		IV
145368	16 05.5	73 25	6.95	F5	F5	−14.4	1.1	4	15–19	2.2	H		
145891	08.3	13 04	6.96	A3	A3n	−25.5	4.5	6	3–11	6.2	Hd		*32
148132	23.0	76 22	6.90	A3	A3n	−05.5	1.2	5	3–5	6.1	H		
150030	16 33.3	+46 49	5.95	G5	G6	−11.7	0.3	4	23–25	1.6	Hd	−17.3±1.2 M	
150203	34.4	43 46	7.15	A2	A2n	Var.?		8	3–5	8.4	H		IV
151388	42.0	43 24	6.07	K2	K2	−08.6	1.2	5	13–29	1.7	H		
151732	44.1	42 26	6.15	Mb	M4	−05.9	1.4	4	17–30	2.2	H		
151746	44.2	74 05	6.76	A2	A2	Var.		7	11–26	3.2	H		IV

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	$\bar{e}$	Obs.	Pub. Velocity	Ref.
	h m	° ′											
152107	16 46.3	+46 10	4.86	A2p	A2p	−01.9	1.0	4	9–15	2.4	H	−01.4±0.4 M	R
152153	46.6	43 36	6.37	K0	K0	−18.8	0.8	4	27–31	1.3	H		
152812	50.6	47 31	6.30	K0	K0	−62.3	1.8	4	28–31	1.6	Y		
152877	51.0	28 17	7.12	F0	F2	−37.4	1.7	5	9–16	4.7	Hd		
152896	51.1	29 12	7.30	A5	A6	+01.1	1.0	4	19–26	2.6	Hd		
152951	16 51.5	+46 41	6.71	A2	A2	Var.		10	4–8	6.4	H		IV
153286	53.4	47 32	6.88	A2p	A4sp	−19.3	1.9	5	18–27	1.9	M		*14
153472	54.7	42 39	6.38	K2	K0	+32.0	1.1	4	22–29	1.5	Y	+22.7±0.7 V	
154160	58.7	14 41	6.52	K0	G7	−54.7	1.9	4	21–26	2.3	Hd		
154228	59.1	13 44	5.86	A0	A2	−28.7	1.9	5	5–8	4.8	Y	−37. ±1 M	
154278	16 59.4	+13 42	6.14	K2	K0	+47.1	1.9	4	16–27	2.1	Hd	+46.5±1.1 M	
154494	17 00.7	12 53	4.91	A3	A3n	−08.1	0.7	6	4–23	3.6	H	−01.5±0.9 M	
154713	02.0	43 57	6.36	A0	A4	−09.3	1.1	6	7–17	2.8	Y	−09.7±0.8 M	
154974	03.7	16 13	6.67	F8	F6	−26.9	0.6	5	10–21	1.8	Hd		
155092	04.4	28 23	6.99	F2	F3s	+03.0	1.2	6	7–16	2.5	Hd		
156341	17 11.9	+16 47	7.5	A0	A0n	−14.9	3.7	6	3–7	9.6	M		
156653	13.7	17 26	5.90	A0	A2	Var.?		6	4–16	3.6	Y		IV
157582	19.0	17 00	7.59	A0	A1	−22.4	4.7	6	2–9	6.3	M		
157741	20.0	15 43	6.25	B9	B9n	−26.2	4.4	5	3–5	10.9	Hd		
157935	21.2	16 29	6.69	F2	F2s	−49.3	1.2	3	12	3.2	Hd		

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	ē	Obs.	Pub. Velocity	Ref.
	h m	° ′											
158251	17 23.1	+16 32	7.16	F0	F0s	Var.?		5	8–26	2.5	Hd		IV
158485	24.5	58 44	6.52	A2	A2n	−31.5	2.9	6	4–7	6.8	H		
159330	29.1	57 57	6.50	K2	K2	Var.?		6	15–28	1.9	H		IV
160762	36.6	46 04	3.79	B3	B3s	−20.0	0.9	7	10–19	2.0	H	−18.1±0.6 M	
161569	41.2	45 05	6.61	B9	B9	−10.4	5.8	6	3–5	11.3	M		
161695	17 41.9	+31 33	6.25	B9	A0s	+02.4	2.0	5	6–13	1.9	Y		R
161797	42.5	27 47	3.18	G5	G5	−17.4	0.4	4	13–17	1.4	H	−16.1±0.2 M	
162555	46.5	29 21	5.61	K0	K0	−15.0	0.8	4	9–12	1.7	H	−11.2±0.4 M	
162668	47.1	30 01	6.68	A2	A3	−22.1	3.1	6	2–5	6.0	Y		
162880	48.2	44 56	7.22	F0	A6	Var.?		5	10–22	3.4	Y		IV
162936	17 48.5	+32 02	7.04	A0	A0	−16.9	1.6	8	5–12	6.0	H		R
163075	49.2	16 41	6.57	K0	K0	−27.3	0.8	5	13–21	2.1	Y		
163219	50.0	30 23	7.46	A3	A4	−39.4	1.5	5	5–11	6.0	M		R
163590	51.8	32 28	7.20	A0	A0n	−17.1	2.5	7	2–10	9.3	H		
163966	53.8	45 01	6.83	B9	B9	−31.6	1.8	6	3–4	4.9	Hd	−21.9±0.9 W	R
163993	17 53.9	+29 16	3.82	K0	K0	−01.5	0.5	4	15–37	1.4	H	−01.5±0.1 M	
164059	54.3	45 53	6.77	F5	F5	−27.6	1.2	4	13–17	1.9	Y		
164078	54.4	32 41	6.54	F5	F5n	Var.		7	5–11	3.8	Hd		IV
164136	54.7	30 11	4.48	F0	F0	−26.6	1.1	6	17–25	1.8	H	−22.0±0.3 M	
164429	56.0	45 28	6.22	B9	A0n	−15.6	2.6	7	3–8	5.2	H		*39R

TABLE III — *Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	ē	Obs.	Pub. Velocity	Ref.
	h m	° ′											
164506	17 56.4	+28 45	7.37	A2	A2	+01.2	1.8	6	5–6	5.2	Hd		
164898	58.3	45 21	7.44	B9	A0	Var.		7	4–18	4.6	H		IV
165008	58.8	30 33	6.76	F2	F4	−36.4	1.4	5	11–13	3.4	H		
165170	59.6	11 15	7.22	F2	F4	Var. ?		5	10–15	2.5	Hd		IV
165281	18 00.1	30 24	6.66	F5	F5	+02.3	1.9	4	14–17	2.6	H	+01.2±0.9 W	
165683	18 02.4	+32 11	5.92	K0	K1	+02.0	0.9	4	14–26	1.6	Y		
165908	03.2	30 33	5.21	F8	F8	+00.6	0.7	5	13–21	1.6	Y	+01.0±0.2 M	
166014	03.6	28 45	3.83	A0	B9	−30.2	1.2	11	3–7	5.6	M	−31.4±1.5 M	IV
166095	01.0	14 16	6.30	A2	A5s	−11.4	2.1	1	15–22	2.5	Y		
166180	01.4	30 59	7.32	A0	A0	−30.7	0.6	4	3–4	7.9	H		
166409	18 05.1	+11 06	6.64	F5	F5	−17.3	0.3	4	11–18	2.1	Y		
167131	08.8	16 14	6.72	F5	F6	−21.7	0.5	5	7–20	2.7	Hd		
168271	13.8	12 56	6.56	B9	B9	−13.1	2.8	5	1–5	5.4	H		
168431	14.5	12 09	6.93	B8	B3	−07.9	3.0	7	6–12	3.2	H		*40R
168481	14.8	15 47	7.00	A3	A5s	+00.3	2.3	1	8–23	3.9	M		R
169169	18 18.3	+11 57	7.31	A2	A3s	−15.8	5.4	6	2–7	6.6	M		*59
169223	18.6	16 38	6.38	K0	K0	Var.?		6	15–23	2.8	H		IV
169247	18.7	14 39	6.69	B9	B9	−16.6	5.0	6	3–4	6.5	M		*79
169491	19.8	15 36	7.40	B9	B5	−15.8	1.3	1	6–8	4.9	M		
169820	21.4	14 55	6.45	B9	B9	−25.4	5.5	6	3–8	6.0	M		*70R

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	$\bar{\epsilon}$	Obs.	Pub. Velocity	Ref.
	h m	° ′											
171654	18 31.0	+46 08	6.66	A0	A0	−10.9	3.9	5	4–6	4.2	H		*30
172187	33.7	43 08	6 26	A5	A5	Var.		13	5–12	6.3	H		IV
172976	38.0	44 10	7.32	A5	A6	−08.9	1.6	5	13–22	2.7	Hd		
174177	44.2	46 12	6.47	A0	A2	−04.8	1.2	4	8–18	3.8	Hd		
174504	45.7	45 09	6.84	F0	F2	−13.1	1.7	5	11–18	2.7	Hd	−15.5±1.2 W	
174621	18 46.3	+43 37	6.79	G5	G4	−25.7	2.0	7	17–26	2.0	Y		16
175785	51.9	30 11	7.31	A0	B9	−25.8	5.4	6	3–4	7.9	M		
175865	52.3	43 49	Var.	Mb	M5	Var.		4	18–39	2.0	Hd		IV
176003	53.0	44 05	6.94	A2	A2	−14.4	3.8	7	5–16	4.6	Y		*30R
176053	53.3	31 52	7.10	A3	A3	Var.		7	3–11	4.0	Y		IV
176131	18 53.7	+46 37	7.08	A2	A3n	−05.2	2.0	6	3–4	5.4	Hd		
176209	54.1	45 43	7.21	A0	A1	−20.2	2.9	6	5–13	4.7	M		
176377	54.9	30 02	6.55	G0	F8	−38.2	1.7	5	17–23	1.8	H		
176626	56.1	43 35	6.90	A2	A1	−26.5	1.0	4	2–8	3.0	Y		
176798	56.9	43 07	7.19	A3	A5	−29.4	1.2	5	13–25	1.9	Hd		
176938	18 57.5	+29 23	6.64	A0	A0	−20.6	1.9	4	4–8	7.4	M		
177829	19 01.2	43 43	6.78	B9	B9n	−23.5	1.7	4	2–4	6.3	Hd		
178568	04.0	14 17	6.74	B9	B9	−27.1	3.6	6	3–5	4.9	M		*40
178947	05.5	30 24	6.68	B9	B8	−29.5	3.4	6	3–6	5.7	M		
179218	06.6	15 37	7.15	B9	B9	−04.2	4.3	6	3–8	8.4	M		R

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	ē	Obs.	Pub. Velocity	Ref.
	h m	° ′											
179280	19 06.9	+31 28	7.14	F0	F0	−16.3	4.5	6	4–11	6.5	Y		R
179838	09.0	29 03	6.93	A0	A0n	−22.8	2.5	5	2–5	3.4	Hd		
180216	10.6	16 01	7.08	A2	A2n	−25.4	3.3	5	2–9	7.3	Hd		
180450	11.5	30 21	6.13	Ma	M1	−60.6	1.0	4	13–20	3.0	H	−65.5±0.6 V	
180451	11.5	15 59	7.04	F0	A9n	−51.0	1.4	4	10–13	4.6	Hd		
180583	19 12.0	+27 45	6.06	F8p	F6	−13.4	1.2	4	18–19	2.2	Y		
180778	12.8	59 31	7.46	A3	A2	−30.0	1.7	4	11–17	2.0	H		
181099	14.0	16 31	7.18	A3	A3	−36.8	1.3	4	10–18	3.5	M		R
181444	14.2	16 19	6.92	F5	F7	Var.		5	6–22	3.0	Hd		IV
181799	16.8	60 46	7.01	B9	B9	−19.3	1.7	5	4–7	4.1	H		
182239	19 18.6	+11 44	6.56	A3	A4	+12.2	1.3	4	12–23	3.5	Hd		
182381	19.3	15 49	7.42	A2	A0n	Var.?		5	3–6	7.3	M		IV
185955	36.6	45 43	6.34	G5	G5	−07.7	1.1	5	15–22	1.5	Y	−13.7±0.9 V	
186340	38.7	60 16	6.21	A2	A4	−01.2	1.2	5	5–12	5.0	Hd		
187160	19 43.4	44 05	7.03	G5	F8	+04.3	0.6	4	22–36	2.0	H		
187237	43.9	27 36	6.75	G5	G1	−35.9	2.4	6	12–25	2.2	Y		*21
187255	44.0	27 26	7.34	A0	B9	−23.5	3.9	6	2–5	7.0	Hd		
187613N	45.8	44 07	(7.7)	(B8)	B7	−12.8	2.5	6	2–6	6.8	M		
187613S	45.8	44 07	(8.2)	(B8)	B8	−15.0	3.6	6	2–7	5.7	M		
187981	47.8	30 53	6.94	A5	A5	+08.2	2.6	6	7–16	6.5	H		*21

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	$\bar{e}$	Obs.	Pub. Velocity	Ref.
	h m	° ′											
188170	19 48.8	+28 44	7.17	A0	B8	−12.4	2.6	5	3–11	5.3	M		R
188651	51.1	29 56	6.36	B9	B6	−13.9	2.4	6	3–7	6.6	M		
189013	52.9	46 50	6.84	A2	A4	Var.?		6	4–10	3.8	Y		IV
189086	53.2	30 30	6.88	A0	B9	−19.3	2.5	6	5–9	4.7	M		
189213	53.8	28 36	7.05	A2	A3	−05.8	4.3	6	3–8	6.3	Hd		*38
189613	19 55.8	+31 33	6.69	A0	A0n	−17.6	2.4	5	2–6	8.7	H		
189689	56.2	32 31	7.21	B9	B8e	+06.2	4.0	5	6–10	5.8	Hd		R
189706	56.3	29 32	6.50	A0	B9n	−00.1	1.2	4	3–4	10.9	Hd		
189847	57.0	30 57	6.71	B8	B8n	−16.5	2.9	8	2–6	9.2	H		
190047	58.0	30 50	6.60	B8	B7	−11.6	4.3	6	2–5	6.5	M		
190167	19 58.6	+28 14	6.79	B9	B9	−28.3	3.8	4	5–10	6.0	Hd		
190227	58.9	31 40	6.53	K0	K0	−18.8	1.9	4	22–27	1.8	Y		
190537	20 00.3	30 57	6.87	A2	A3s	−30.1	1.3	4	17–33	2.2	M		
190603	00.7	31 56	5.69	B0	B0se	+29.2	3.0	5	5–11	4.1	Hd	+18.0±1.8 M	R
191048	02.8	15 47	7.48	B9	B9	−22.9	3.8	6	3–7	6.4	M		
191671	20 06.0	+27 58	7.6	B5	B4n	−00.8	3.4	6	4–8	7.4	M		R
191745	06.4	29 04	7.44	B9	B7s	−04.1	1.2	5	6–12	4.7	Hd		
191879	07.0	14 21	7.48	A0	A1n	+12.3	2.9	6	3–5	11.2	M		
191918	07.2	32 00	7.07	A0	A0	−18.9	2.2	7	3–7	5.0	Y		
192715	11.2	15 00	6.91	F0	A8n	−32.9	1.7	5	4–9	9.5	Y		

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	$\bar{e}$	Obs.	Pub. Velocity	Ref.
	h m	° ′											
193349	20 14 7	+14 04	6.81	A0	A0sp	Var.?		6	7–14	5.7	M		IV
193472	15.3	13 11	5.96	A5	A5	−08.6	2.7	5	14–21	4.1	Hd		*20
193555	15.7	15 13	6.87	F8	F8	−27.2	1.0	5	7–13	3.8	Hd		
193556	15.7	14 16	6.34	G5	G5	+08.9	1.7	6	14–21	2.3	Hd		
193707	16.6	14 48	6.56	A0	A1	−23.3	1.2	4	4–10	4.5	M		
193819	20 17 2	+13 16	7.37	A0	B8	−10.5	3.1	6	3–9	3.3	M		*27
194012	18.2	14 13	6.22	F5	F7	+03.9	1.0	4	12–18	2.9	Hd	+3.5±0.7 V	
194115	18.7	15 03	7.09	A0	A0	−21.0	3.1	7	3–17	4.5	M		
194211	19.3	15 43	6.70	B9	B8n	−15.3	2.1	6	3–5	5.3	M		
197139	36.6	43 05	6.15	K0	K0	−17.9	1.1	4	22–25	2.3	Y		
197665	20 40 1	+76 29	7.07	F2	F3	−08.7	0.8	5	9–15	3.9	H		
197961	42.0	46 09	6.63	A0	A0	−04.6	2.0	5	5–9	4.7	M		
198151	43.3	46 10	6.26	A2	A3	−12.3	1.5	4	3–4	4.5	Y		
198414	45.1	45 05	7.47	A0	B9n	−21.4	5.1	6	2–5	7.5	M		
198626	46.5	30 32	6.75	A2	A5	−30.4	0.7	4	9–21	2.1	Y		
198726	20 47.2	+27 52	Var.	F8p	Var.	Var.		4	7–18	2.5	Hd		IV
198820	47.9	32 28	6.35	B5	B4s	−14.1	1.7	5	7–12	3.6	H		R
198915	48.5	46 21	7.30	B9	B7	−22.4	1.0	4	3–8	6.6	M		R
198976	48.9	29 17	6.40	K2	K0	−09.1	1.6	5	15–31	1.7	H		
199055	49.5	31 15	6.90	A5	A8n	−31.6	2.9	5	11–25	3.7	H		*24

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	c̄	Obs.	Pub. Velocity	Ref.
	h m	° ′											
199098	20 49.8	+44 48	5.59	K0	G7	−19.6	1.6	4	15–22	2.0	Y		
199101	49.8	33 03	5.68	K2	K3	−09.9	0.6	5	6–22	1.9	H	−07.5±1.5 W	
199102	49.8	29 07	7.56	B9	B9n	−03.3	2.5	6	3–4	8.7	H		
199140	50.1	28 08	6.44	B3	B2sk	Var.		9	7–23	3.8	H	−07±05 M	IV
199169	50.3	27 41	5.24	K5	K5	+09.2	0.8	4	17–29	1.7	Y	+08.1±0.9 M	
199206	20 50.6	+44 44	7.42	B9	B7	−22.2	4.1	6	3–15	4.6	M		*42
199311	51.3	45 51	6.66	A0	A2s	−40.9	0.8	4	11–19	2.5	Hd		
199479	52.4	43 59	6.71	B8	B8	Var.?		5	3–8	6.3	Hd		IV
199492	52.5	74 16	7.39	A3	A3n	−15.3	2.9	6	3–10	4.8	H		
199511	52.6	43 02	6.79	B8	B8s	−31.2	2.4	4	8–11	6.6	Hd		
199837	20 54.6	+31 15	7.17	B9	B9n	−09.4	1.9	6	2–4	3.6	H		
199986	55.5	45 52	7.03	A2	A5	−01.5	2.0	4	4–9	6.3	Y		
200102	56.3	44 36	6.79	G5	G5	−23.2	1.0	4	12–22	2.0	Hd		
200877	21 01.1	14 56	6.62	F5	F5	−21.2	2.0	5	12–17	2.3	H		*18
201078	02.3	30 47	5.86	F5	F5	Var.		3	15–21	2.2	H		IV
201194	21 02.9	+30 12	7.51	B8	B4s	−21.5	1.4	5	3–8	4.0	Hd	−15.6±0.4 W	R
201196	02.9	15 16	6.52	K0	K0	−33.1	1.3	5	15–29	2.2	H		
201433	04.4	29 48	5.57	A0	A0	Var.		5	3–8	4.5	Y		IV
201912	07.5	29 18	6.77	B5	B5s	−04.7	1.9	4	3–8	4.6	Hd	−02.8±0.4 M	R
201939	07.7	30 12	6.75	G5	G8	−18.6	1.3	4	18–25	1.5	H		

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	ē	Obs.	Pub. Velocity	Ref.
	h m	° ′											
202109	21 08.7	+29 49	3.40	K0	G9	+17.5	0.9	4	13–24	1.4	Hd	+16.9±0.4 M	R
202314	09.9	29 29	6.25	K0	K0	−03.5	0.6	7	16–35	2.1	Y		
202351	10.1	16 04	6.74	F0	F0n	−21.4	3.5	5	5–8	3.5	Y		
202644	12.1	13 32	7.42	B8	B3	−14.2	1.6	6	3–15	4.2	M		R
203551	17.8	60 15	6.74	F5	F5	−14.2	1.1	5	14–18	1.8	H		
203574	21 18.0	+60 21	6.24	K0	G8	−25.6	1.6	5	16–27	1.7	H		*15
204889	26.5	61 00	7.11	F5	F5	−13.2	1.5	5	11–20	2.0	H		
205939	33.6	44 14	6.11	A3	A6s	+06.3	1.2	4	8–28	1.9	Hd		
206280	36.0	43 59	6.70	B9	B9sk	−13.8	1.3	6	4–10	4.2	H		R
206330	36.3	42 49	5.35	K5	K8	−28.7	1.3	5	17–22	2.4	H	−27.7±0.2 M	
206842	21 39.7	+58 48	6.21	K2	K2	−00.9	1.6	4	20–28	1.5	H		
206963	40.6	46 24	6.62	F5	F4	+09.0	1.0	4	10–19	2.8	H		
207431	43.8	43 32	7.58	A0	A0	−06.6	3.4	6	4–9	7.3	M		
208174	49.4	27 53	6.71	A2	A5v	Var.?		6	11–29	2.9	M		IV
208394	50.9	47 11	7.35	A2	A5	−25.9	1.6	5	11–22	2.7	Hd		
208835	21 53.9	+46 23	7.39	A0	B8	Var.		6	3–7	5.5	M		IV
209193	56.4	30 57	7.04	F0	F2	−08.6	0.4	6	4–21	2.3	H		
209205	56.5	31 03	7.19	A0	B9n	Var.?		6	2–5	8.1	M		IV
209469	58.6	42 20	7.06	B9	B9	Var.?		6	3–4	6.3	Y		IV
209484	58.7	29 44	7.01	B9	B9	Var.?		6	4–11	2.9	M		IV

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	$\bar{e}$	Obs.	Pub. Velocity	Ref.
	h m	° ′											
209517	21 58.9	+29 33	7.39	B9	B8n	+01.1	3.5	8	2–5	7.2	H		
209679	22 00.1	43 52	6.57	A2	A1	+02.8	2.2	6	3–5	4.5	M		
209693	00.2	32 27	6.39	G5	G5	−19.7	1.1	6	19–30	1.8	H	−25.4±0.1 V	
209813	01.0	46 45	6.52	K0	K0	Var.		4	20–28	1.7	Y		IV
209833	01.1	28 28	5.58	A0	B9n	Var.		6	3–7	6.6	M		IV
210090	22 02.8	+17 32	6.43	Ma	M3	−08.2	2.1	4	8–22	2.6	M		
210130	03.1	12 34	7.56	A5	A5	−10.8	1.9	7	7–18	3.8	Hd		*29
210334	04.6	45 15	6.52	G5	G0	Var.		12	6–30		Y		IV
210387	05.0	44 22	6.72	A0	B9n	−10.3	1.4	7	3–5	6.3	Y		
210405	05.1	44 21	6.62	B9	B9	−05.8	1.4	6	2–4	3.5	Y		R
210461	22 05.5	+14 07	6.41	K0	K0	−40.7	1.8	5	22–36	2.0	H		*17
210594	06.3	30 04	6.38	A5	A5	+03.4	3.0	5	8–21	3.6	H		*21
210646	06.7	27 14	7.07	A0	A0s	+09.0	3.8	6	5–13	3.1	M		*29*R*
210661	06.8	28 45	7.44	A2	A1	−17.9	3.1	6	4–11	4.6	M		
211432	11.9	27 18	6.43	K0	K0	+16.7	1.2	6	15–25	1.8	H		
211733	22 14.1	+15 45	6.91	A0	A1	−24.1	1.0	4	4–14	3.6	M		
212075	16.6	13 52	6.94	A3	A3n	−05.2	2.3	5	2–7	4.3	Hd		
212186	17.3	15 08	6.69	A0	A0	−02.0	3.5	6	3–5	3.8	Y		*28
212442	19.2	14 46	6.73	A0	B8	Var.?		10	3–7	7.6	Hd		IV
212500	19.6	15 48	7.07	F2	F4	−37.6	1.6	4	10–16	4.2	Hd		

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	ē	Obs.	Pub. Velocity	Ref.
	h m	° ′											
213126	22 24.2	+87 34	7.37	A2	A2	Var.		6	4–7	6.3	H		IV
215242	38.7	46 38	6.42	B9	A0s	Var.		6	4–10	4.4	M		IV
215566	41.0	44 14	7.04	B9	B8	Var.?		6	3–5	6.7	M		IV
215664	41.7	44 01	5.84	F0	A9n	−12.8	1.8	4	5–8	4.4	Y		
216511	48.4	46 01	6.70	B9	B9nk	−16.2	1.8	9	3–5	4.0	H		
216608	22 49.2	+44 13	5.62	A0	A4	Var.		4	19–26	2.6	Y		IV
217477	55.9	30 33	6.52	A0	B9	−01.3	2.1	6	4–8	2.9	M		
217491	56.0	44 50	6.44	A2	A3	Var.?		7	11–19	3.4	H		IV
217587	56.7	43 39	7.25	A3	A7n	+04.7	0.5	4	3–9	4.4	M		
217731	57.6	44 02	6.51	K0	G7	−08.0	0.8	4	13–26	1.8	Y		
217754	22 57.8	+31 14	6.46	F0	F2	−16.1	1.0	6	21–34	2.1	H		
217906	58.9	27 32	2.61	Ma	M2	+12.4	0.2	4	31–49	1.8	H	+08.6±0.2 M	
218043	59.8	30 45	6.78	F2	F2	−05.5	1.5	4	13–20	2.5	Y	−08.9±1.9 W	
218097	23 00.2	32 50	7.28	A0	A0n	+04.3	3.4	5	3–4	7.2	M		R
218235	01.3	17 59	6.14	F2	F4	−10.4	1.1	5	8–21	2.3	H	−15.6±0.7 V	
218395	23 02.6	+32 18	5.97	A2	A3	−04.8	2.6	6	4–6	5.3	Y		R
218428	02.9	29 31	7.25	B9	A0	+00.1	1.6	6	3–5	4.8	M		R
218472	03.2	30 55	7.28	A2	A4	−03.2	1.6	6	9–21	3.9	M		
218538	03.7	28 39	7.50	A2	A5n	−08.8	1.8	6	4–6	6.2	Y		
218767	05.5	31 57	6.89	B9	B9n	−05.2	5.3	6	3–7	6.7	M		*47

TABLE III—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km.	P.E.	Plates	Lines	ē	Obs.	Pub. Velocity	Ref.
	h m	° ′											
218792	23 05.7	+17 03	5.94	K5	K5	+03.2	1.1	6	18–31	1.4	H	+00.7±0.9 W	
219110	08.3	28 54	6.34	K0	G7	+04.8	1.4	5	17–23	1.7	Hd		
219291	09.6	29 13	6.42	F5	F2	+08.0	2.0	5	6–12	5.7	Y		
219634	12.2	61 25	6.49	B8	B4nk	Var.		21	3–8	6.1	Hd		IV
219675	12.6	17 45	6.71	F0	A8	Var.?		5	12–22	2.3	Hd		IV
220091	23 15.9	+16 43	6.55	F0	A9	−19.6	2.2	5	7–18	3.5	Hd		
220102	16.0	59 44	6.66	F2	F2	−27.2	2.1	4	12–22	2.4	H	−21.9±1.0 W	*16
221114	24.1	15 28	6.98	A2	A2	Var.?		4	4–12	3.5	Y		IV
221115	24.1	12 13	4.67	K0	G6	−13.1	1.0	5	11–32	1.0	Hd	−15.1±0.3 M	
221237	25.2	58 01	7.06	A0	B9n	−05.0	3.6	6	3–8	7.8	H		
221671	23 29.0	+59 29	7.41	A0	A0s	−13.5	1.6	5	5–13	2.6	H		
222275	34.1	61 35	6.72	A2	A2	−34.5	3.0	5	5–13	3.6	H		*42
222386	35.0	74 43	6.04	A2	A2n	−04.0	1.6	5	3–5	4.0	H		
222387	35.0	73 25	6.08	G5	G5	+14.6	1.4	5	16–32	1.9	H		
222900	39.6	45 49	7.48	A0	B8	−09.4	2.4	5	3–7	3.5	Hd		
222922	23 39.8	+43 11	6.82	A0	A1n	+03.3	2.2	5	4–9	5.4	M		
224098	50.0	73 51	6.57	B9	B9	−14.1	3.5	6	2–5	8.1	H		
224166	50.6	45 48	6.84	B9	B9	−20.8	1.8	4	3–6	4.8	M		R
224720	55.1	46 23	7.25	A2	A2	−24.8	3.0	6	3–5	7.0	Y		
224801	55.7	44 42	6.25	A0p	A0p	Var.?		6	5–11	3.0	M		IV

NOTES TO TABLE III

H.D.

886 - 3933 is weak and diffuse, though all other lines are sharp; it is considered to be of stellar origin.

3291 - 3933 very sharp, other lines fair only, Si II present.

4335 - 3933 very narrow as if interstellar.

5394 - γ Cassiopeiae; the spectrum is peculiar, emission lines being the prominent feature; the measures are from the absorption lines; the velocity is variable; numerous other plates have been studied.

7157 - All lines sharp save H.

11336 - Si II present.

15992 - Si II visible on most plates.

16245 - Si II very faint; suspect He on some plates.

16545 - 3933 very faint; Si II very strong; Mg II present; other faint lines variable in appearance.

16580 - Suspect double lines in some cases; 4077 strong on last plate.

17007 - Double star, mag. 7.9–8.1, sep. $3''.2$; attempts made to guide on the brighter star but only satisfactory when the seeing was good.

21242 - H and K strongly reversed; velocity of H and K apparently variable; a number of stellar lines are double on three plates; none of the 12-inch camera plates show doubling; maximum separation of the double lines, 120 km.

22136 - Si II unusually strong; 3933, 4481 particularly sharp.

23477 - Presence of He doubtful; 3933 very sharp.

26398 - $H\beta$ shows emission core; strong emission at $H\alpha$; agreement of plates poor but measures probably unreliable because of the emission.

35035 - Many metallic lines visible; Cr, Ti II, Fe strong; relative intensity of metallic lines seems somewhat variable.

35533 - Si II particularly strong.

43496 - Spectrum may be composite; Fe II appears on some plates, also other faint metallic lines.

43583 - 3933 sharp.

44738 - Si II strong; Mg II weak; many diffuse metallic lines.

46016 - Si II present.

57728 - The velocity may be variable but one plate only gives discordant velocity.

63312 - Ionized lines prominent.

91181 - Fe and Fe II prominent.

112501 - Si II present.

114723 - Double star, mag. 6.9–7.1, sep. $1''.8$, observed as one.

119213 - Ionized Sr unusually strong.

126269-70 Composite spectrum; K line $= H\delta$; $4227 = 0.5\ H\gamma$.

131764 - Numerous fuzzy lines, a range of 26 km. is indicated but variation is doubtful.

132445 - Eight plates give fairly accordant results with a range of 20 km; one weak plate increases the range to 60 km.; variation is suspected.

133330 - Fe and Fe II show faintly; Si II on one plate; $H\delta$ looks double in one case.

134305 - Sr II, Fe II strong.
152107 - 52 Herculis; ionized Sr very strong; metallic lines abundant and sharp; B has measured about 200 lines on one plate in a study of Ap stars.
161695 - 3933 exceedingly sharp, Si II present.
162936 - Poor lines; ionized strontium variable?
163219 - Lines fuzzy; Fe II strong.
163966 - Si II present.
164429 - Ionized strontium and silicon strong; He absent.
168431 - Good lines; neutral helium spectrum very completely represented.
168481 - Sr II, Ti II, Fe II and Cr strong; lines around 4634, 40, 48, 73, strong on some plates.
169820 - Suspect double lines on two plates.
176003 - Double star, mag. 6.9 – 8.5, sep. 0″.5.
179218 - $H\beta$ probably emission.
179280 - Fuzzy line star; velocity may be variable.
181099 - Fe and Ti II strong.
188170 - Si II appears on some plates.
189689 - $H\beta$ and $H\gamma$ show central emission; the velocities from hydrogen lines are often not in accord with those from weaker lines, possibly due to emission.
190603 - Listed as an emission line star in Ap. J., v. 78, p. 87; the early B-type lines are sharp; $H\beta$ is weak—probably filled in by emission. The velocities from hydrogen lines are markedly different from other lines and have not been included. The mean hydrogen velocity is -09.1 ± 3.3. Calcium H and K are interstellar with a mean velocity -08.4 ± 1.5.
191671 - 3933 sharp, possibly interstellar; all other lines diffuse; Si III present.
198820 - He spectrum very sharp and strong.
198915 - Si II present; 3933 practically invisible.
201194 - 3933 seen on two plates only; from its appearance it may be interstellar.
201912 - 3933 sharp, but probably stellar; two measures give its velocity -08.9 km.
202109 - Very sharp lines; the velocity is known to vary over a small range.
202644 - Si II present on some plates.
206280 - Ionized silicon and calcium strong.
210405 - Star has a faint companion, 8.7 mag. 27″ dist.
210646 - Many faint sharp lines; Fe strong.
218097 - North and brighter component of close double; practically nothing but Ca II and H measurable. One plate of south component indicates it as an early A-type spectrum with many diffuse metallic lines.
218395 - Double star, mag. 6.8 – 8.0, sep. 8″.4.
218428 - No Ca II in this spectrum; faint metallic lines, Fe II and Sr II
224166 - Si II strong; He very faint and diffuse.

TABLE IV

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 1826							
8036.806	+22.8	20	2.5	1	12	N	A5. Mean velocity −1.1 km sec.; range 100 km; a preliminary orbit gives P=3.2832 days, velocity of system +2 km sec. Many fine lines. Y.
	+27.4	19	3.3			MR	
8379.865	−07.4	15	3.0	1	"	P	
8412.768	−32.0	19	2.4	1	"	P	
	−25.9	20	2.2		"	MR	
8776.806	+32.5	15	3.9	1	"	P	
9188.654	−26.6	29	1.9	1	"	T	
H.D. 2019							
8039.817	+11.5	3	2.9	1	12	P	B9. Mean velocity −16.6 ±7.1 km sec.; range 68 km. Si II visible; some faint unidentified lines suspected on some plates; lines possibly double on one plate. M.
8455.686	−52.2	4	9.3	1	"	P	
	−52.5	4	6.8			P	
8770.805	−18.5	2	10.8	1	"	P	
8811.662	+04.4	6	6.1	1	"	MR	
8881.538	+05.6	7	3.7	1	"	M	
9133.860	−10.1	5	2.6	1	"	P	
9168.761	−57.0	3	10.0	1	"	T	
H.D. 2453							
8029.850	−28.8	13	2.3	2	25	N	A0 sp. Velocity probably variable; mean velocity −19.2 km sec. The hydrogen lines have narrow cores; many sharp metallic lines; 4128, 4130 strong. Hd.
	−24.3	13	3.1		"	MR	
8382.851	−09.7	14	2.4	1	12	P	
	−13.4	17	2.8		"	MR	
8449.681	−05.7	20	2.6	1	"	P	
	−07.8	20	2.7		"	MR	
8799.747	−21.7	13	4.0	1	"	P	
8820.649	−20.8	21	1.5	2	25	P	
H.D. 2767							
8034.868	+07.9	15	1.1	1	25	N	K0. Velocity probably variable; mean velocity +11.6±1.3 km sec.; range 16 km. H.
	+04.1	15	1.8		"	MR	
8416.791	+11.8	22	2.5	1	12	N	
	+11.1	23	1.7		"	MR	
8526.543	+21.4	26	1.4	1	"	N	
	+20.3	25	1.9		"	MR	
8741.872	+09.4	17	2.6	1	"	N	
8751.849	+09.5	18	1.2	1	"	N	
8761.846	+09.1	19	1.5	1	"	N	
9255.459	+18.2	5	8.2	0	"	N	

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 3369							
8029.884	+32.2	9	1.1	2	25	N	B4. π Andromedae. These observations are in satisfactory agreement with Pearce's orbit (P.A.S.P. *48*, 215, 1936). Hd.
	+27.6	11	1.6		"	Hd	
8799.760	−08.6	4	6.9	1	12	Hd	
8821.712	−11.2	7	7.5	1	"	Hd	
	−12.8	5	5.7		"	Hd	
8835.667	−26.7	6	3.4	1	"	Hd	
H.D. 6475							
8389.878	−01.0	2	7.2	1	12	P	A0n. Mean velocity −00.5±4.8 km/sec.; range 53 km. Poor lines; only hydrogen and 3933 measurable. H.
	+05.0	3	3.8		"	MR	
8425.838	−26.3	4	4.6	1	"	P	
	−33.8	5	2.9		"	MR	
8503.617	−05.7	3	9.8	1	"	P	
	+00.3	4	6.7		"	P	
8751.878	+05.4	4	3.8	1	"	P	
8926.506	+21.9	3	9.8	1	"	P	
	+23.7	3	12.0		"	P	
H.D. 9312							
8063.788	+08.1	21	1.2	1	12	N	G5. From 19 plates, mean velocity +00.9 km/sec.; range 62 km. An orbit will be determined. Hd.
	+10.3	22	1.5		"	Hd	
8771.828	+18.4	18	2.2	1	"	Hd	
	+19.4	23	2.1		"	MR	
8786.804	−28.2	19	1.8	1	"	Hd	
	−29.0	30	1.8		"	MR	
8806.782	+23.4	22	1.5	1	"	Hd	
	+21.0	24	1.7		"	MR	
H.D. 9709							
8102.642	−23.2	3	4.2	½	12	Hd	B8 n e. Velocity probably variable; mean velocity −10.8 km/sec. Hβ shows double emission superposed on very broad absorption; the other hydrogen lines show evidence of similar structure; 4481 and helium lines too weak and diffuse for measurement; 3933 barely visible. Hd.
8131.629	−06.6	3	1.4	1	25	Hd	
8164.522	−05.8	3	3.9	1	"	Hd	
8370.862	−35.8	3	4.0	½	12	Hd	
8430.801	−23.4	3	3.4	1	25	Hd	
8437.712	+17.3	3	4.1	½	12	Hd	
8479.632	−16.5	2	3.0	½	"	Hd	
8491.620	+07.1	4	3.7	1	25	Hd	
9184.689	−25.0	4	6.5	½	12	Hd	

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 10588							
8412.820	−21.9	27	2.5	1	12	P	G5. Mean velocity −5.6
8763.842	+16.7	27	2.4	1	"	P	km/sec.; range 41 km.
8794.788	−15.6	26	1.8	1	"	P	Y.
8838.674	+19.1	23	1.8	1	"	P	
8894.490	−11.9	22	1.8	1	"	P	
9188.716	−19.8	25	1.3	1	"	B	
H.D. 11188							
8455.745	−33.8	8	6.9	1	12	P	B8. Mean velocity −10.1
	−21.1	6	4.0		"	MR	±6.6 km/sec.; range 53
8518.550	+01.4	5	1.9	1	"	P	km. Poor lines.
8804.776	+09.7	5	3.8	1/2	"	P	M.
8881.582	−43.6	8	5.1	1/2	"	M	
9144.903	+29.4	5	8.6	0	"	T	
9182.761	+02.5	4	5.6	1	"	T	
H.D. 14688							
8045.871	+69.4	11	1.6	1	12	N	A1s. Mean velocity
	+71.5	10	1.6		"	MR	+18.1±15.1 km/sec.;
8417.862	+42.8	23	2.2	1	"	N	range 95 km. Many
	+35.0	8	2.6		"	MR	strong metallic lines,
8479.675	−12.0	20	1.9	1	"	N	particularly Fe I, Sr II,
	−12.3	10	2.2		"	MR	Mg II; 4226 seems vari-
8934.496	−24.9	20	2.1	1	"	MR	able in intensity. M.
H.D. 18473N							
8441.783	+17.9	7	7.1	1	12	MR	A0. Mean velocity −1.6
8801.777	−25.8	4	7.5	1	"	M	±7.0 km/sec.; range
8815.750	+03.7	5	5.3	1	"	MR	63 km. Si II very strong;
8909.533	−39.1	8	7.5	1	"	MR	4077 and 4233 strong on
	−27.0	6	9.1		"	P	some plates. M.
9168.800	+29.7	3	5.1	1/2	"	T	
9200.736	+13.4	6	3.0	1	"	T	
H.D. 19536							
8114.769	+11.9	15	1.5	2	25	P	A1s. Velocity probably
8125.902	+01.7	5	5.7	1	12	P	variable, mean velocity
	−11.9	5	4.9		"	MR	+12.8±3.0 km/sec.;
8157.768	+33.4	8	4.8	1	"	P	range 40 km. All lines,
	+36.6	7	5.0		"	MR	especially 3933, 4481
8503.659	+15.0	5	5.7	1	"	P	and 4549 sharp. H.
8531.599	+04.5	5	3.4	1	"	P	
8879.660	+16.3	5	3.4	1	"	P	

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 22124							
8082.822	+51.1	17	1.2	1	25	N	F2. Mean velocity +31.6 km/sec.; a preliminary orbit gives P = 1.32638 days, range 120 km., velocity of system 0.0 km/sec. Y.
	+52.8	27	1.2		"	MR	
8432.830	+21.1	25	3.0	1	12	N	
8784.879	−00.7	11	3.0	1	"	N	
	+07.7	19	2.2		"	MR	
8838.765	+15.2	10	1.3	1	"	N	
9146.892	+38.5	22	2.4	1	"	T	
9167.863	+59.3	12	3.6	1	"	N	
H.D. 23838							
8160.614	+13.3	29	0.7	1	25	N	G0. From 12 plates, mean velocity + 11.7 ± 2.2 km/sec.; range 41 km. H.
	+12.5	17	1.1		"	MR	
8562.535	+27.2	22	2.2	1	12	N	
	+31.4	14	1.6		"	MR	
8778.899	+35.9	20	1.9	½	12	N	
8847.764	−02.5	12	1.7	1	"	N	
8906.605	+01.9	15	2.1	1	"	N	
8926.612	−00.1	14	1.5	1	"	N	
9151.924	+04.9	16	2.5	½	"	N	
H.D. 26015							
8404.905	+39.3	21	2.0	1	12	P	F2. ; Velocity probably variable; mean velocity +37.8 ± 1.7 km/sec.; range 14 km. Companion mag 8, sep. 4″. H.
8510.673	+42.9	27	1.6	1	"	P	
8816.764	+32.7	18	2.0	1	"	P	
8847.782	+40.8	24	2.1	1	"	P	
9143.913	+24.6	19	1.9	½	"	T	
	+32.6	17	2.6		"	N	
H.D. 27483							
8082.876	−16.8	10		1	25	P	F4. Double line binary; approximate velocity of the system, +33 km/sec.; it is not certain that the first recorded velocities refer always to the same component. Y.
	+80.6	9					
8412.904	−42.6	12		1	12	P	
	+122.5	6					
8430.878	−25.5	21		1	25	P	
	+97.9	19					
8484.700	−37.6	14		1	"	P	
	+106.7	15					

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 28271							
8083.847	−35.6	20	0.9	2	25	P	F5. Velocity probably variable; mean velocity −35.4 ± 1.6 km/sec.; range 18 km. H.
8184.622	−26.6	16	2.1	1	"	P	
8510.700	−33.3	18	2.0	1	12	P	
8587.503	−24.9	15	2.6	1	"	P	
	−30.4	12	2.8		"	N	
8789.901	−42.8	13	2.6	1	"	P	
8966.572	−45.5	14	2.9	1	"	P	
	−44.9	9	2.6		"	MR	
8973.517	−36.6	10	3.4	1	"	P	
H.D. 35076							
8083.926	−09.1	9	3.9	1	25	P	B9k. Velocity probably variable; mean velocity +07.7±4.3 km/sec. H.
	−07.3	9	4.0			MR	
8510.729	+14.1	4	4.2	1	12	P	
	+18.1	3	2.4			MR	
8515.743	+17.7	7	4.5	½	"	P	
	+36.9	3	6.2			MR	
8864.808	+21.0	5	4.5	1	"	P	
8868.762	−10.3	5	7.2	1	"	P	
8879.762	+10.1	5	2.6	1	"	P	
H.D. 35189							
8064.910	+29.9	6	6.9	½	12	P	A1s. Mean velocity +19.9 ±1.7 km/sec.; range of single-line plates 18 km. Many metallic lines visible; close double lines show clearly on one plate. M.
8161.670	−35.1	15	2.8	1	25	P	
	+70.6	9	1.7				
8484.819	+17.1	29	1.1	1	"	P	
8570.547	+25.2	13	3.1	1	12	M	
9189.870	+11.6	10	3.2	1	"	T	
9325.502	+22.7	5	2.9	1	"	T	
H.D. 35238							
8108.819	+52.6	18	2.2	1	12	N	K0. Velocity probably variable; mean velocity +41.5 km/sec. Hd.
	+56.1	27	1.7		"	MR	
8127.743	+40.3	26	1.7	2	25	N	
8563.585	+45.7	33	1.6	1	12	N	
8835.840	+34.7	16	2.2	1	"	N	
8967.606	+36.4	20	2.1	1	"	N	
9172.922	+37.4	12	2.3	1	"	N	

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 35522							
8450.842	+22.4	5	4.2	1	12	P	B8. Velocity probably
8909.688	+00.9	4	5.4	1	"	MR	variable; mean velocity
	+02.5	5	9.4			P	+17.1 ± 4.9 km/sec.;
9178.935	+35.1	5	2.0	1	"	T	range 35 km. Presence
9263.694	+26.0	8	4.4	1	"	T	of Si II suspected.
9317.508	+00.5	8	6.1	1	"	T	M.
H.D. 43044p							
8849.792	+27.1	4	5.9	1	12	P	B9. Velocity probably
8858.796	+10.9	2	3.2	½	"	M	variable; mean velocity
	+27.0	4	4.1		"	T	+10.8 ± 6.0 km/sec.;
8955.608	+27.0	5	9.1	1	"	P	range 63 km.
	+48.2	5	2.6		"	T	Suspect double lines on
9200.850	+01.1	3	4.4	1	"	T	one plate. M.
	+27.5	7	7.1		"	B	
9339.549	−00.1	4	10.8	1	"	T	
	−08.8	5	4.1		"	M	
9347.549	−25.2	2	6.0	½	"	T	
9357.540	−24.3	3	10.7	½	"	M	
H.D. 44250							
8101.872	+29.6	5	3.2	1	12	P	A0. Velocity probably
	+06.1	6	4.5		"	T	variable; mean velocity
8823.901	−06.9	5	4.5	1	"	P	+ 7.0 ± 4.7 km/sec.;
	−05.8	5	5.5		"	N	range 32 km.
8860.901	−14.9	5	8.2	1	"	M	Suspect Si II present; a
8996.582	+24.5	3	6.5	½	"	P	few faint metallic lines
9263.769	+15.2	6	2.5	1	"	T	on some plates. M.
H.D. 44867							
8108.859	+80.6	17	2.2	1	12	N	G7. Velocity probably
8449.914	+84.1	27	1.6	1	"	N	variable; mean velocity
8491.792	+72.5	39	0.8	2	25	N	+74.2 km/sec.
8919.677	+69.1	18	2.2	1	12	N	Hd.
9272.684	+66.2	16	2.5	1	"	B	

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 45194							
8472.904	+71.7	10	2.4	1	12	P	F8. Mean velocity −06.0
9208.890	−29.8	14	2.2	1	"	P	km/sec.
9209.867	−22.6	3	6.0	0	"	B	Hd.
9212.788	−23.5	10	1.9	1	"	B	
9272.726	−17.7	11	1.4	1	"	B	
9278.597	+08.8	13	2.4	1	"	T	
9283.664	+03.6	15	1.5	1	"	T	
9289.661	−54.5	8	4.0	1	"	T	
H.D. 45412							
8082.913	+03.0	25	1.1	1	25	P	F8. RT Aurigae. The
8544.681	+04.3	23	1.4	1	12	P	observations fit the curve
							of Kukarkin, Welno Bull.
							13, 1930, and are close
							to the curve of Duncan,
							L.O.B. They do not fit
							the curve of Kiess, Mich.
							3, 131, so well. Y.
H.D. 47270							
8128.831	−34.4	26	0.8	1	25	P	K0. Mean velocity −28.9
8167.728	−36.0	32	0.8	1	"	P	±1.6 km/sec.; range 17
8510.785	−17.2	22	2.7	½	12	P	km.
	−20.2	12	2.5		"	N	H.
8587.593	−21.4	25	1.7	1	"	P	
8837.904	−32.6	22	2.2	1	"	P	
8847.868	−28.3	25	1.5	1	"	P	
8966.657	−25.7	24	2.1	1	"	P	
H.D. 47395							
8091.938	+39.3	5	6.4	1	12	P	B7. Mean velocity +19.3
8815.941	+31.0	6	4.1	1	"	P	±1.2 km/sec.; range 36
8867.847	+10.4	5	5.9	1	"	M	km. Strength of helium
8907.724	+21.5	6	5.0	1	"	M	somewhat variable.
9290.687	+03.1	7	2.8	1	"	T	M.
9351.524	+07.4	7	3.4	1	"	M	

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D.55283N							
8870.877	+06.2	5	8.6	1	12	M	A0. Mean velocity −16.5
	+04.7	7	4.0		"	T	±5.6 km/sec.; range 40
8937.704	−31.3	6	7.3	1	"	MR	km. Poor lines.
8951.655	−01.4	4	2.4	1	"	N	M.
	−00.2	5	6.4		"	P	
8972.638	−33.7	4	4.1	1	"	MR	
9336.636	−34.9	4	7.4	½	"	T	
9341.632	−08.9	5	1.1	½	"	T	
H.D. 63630							
8160.793	+51.7	22	2.2	1	25	N	A5. From 17 plates, mean
	+51.4	14	3.2		"	MR	velocity +22.5 km/sec.;
8219.670	+35.0	22	2.8	1	"	N	range 96 km/sec.
	+43.6	14	4.3		"	MR	Definition of lines varies
8491.931	+24.9	16	2.5	1	"	N	from plate to plate.
	+38.8	14	4.1		"	MR	H.
8515.855	+29.0	9	3.0	1	12	N	
8590.640	−19.4	6	3.1	1	"	N	
	−18.1	7	6.5		"	P	
H.D. 68461							
8124.958	−26.2	50	0.7	2	25	P	G6. Mean velocity −19.0
8229.639	−26.5	51	0.8	2	"	P	km/sec.; range 36 km.
8544.751	−12.1	28	1.4	1	12	P	Y.
8593.578	+02.8	29	1.6	1	"	P	
	+05.6	28	2.8		"	MR	
8635.562	−14.5	34	2.0	1	"	P	
8880.888	−22.3	27	2.4	1	"	P	
8985.612	−30.5	25	1.8	1	"	MR	
9279.747	−09.7	22	1.2	1	"	T	
H.D. 68776							
8568.728	+28.9	25	1.5	1	12	P	K0. Mean velocity +26.1
8575.650	+24.0	26	2.2	1	"	P	km/sec.; range 29 km.
8925.742	+33.5	15	3.5	1	"	P	Hd.
8940.686	+11.2	17	4.3	½	25	MR	
	+02.1	14	2.3		"	P	
9023.532	+17.9	20	3.0	1	"	P	
	+14.9	18	3.3		"	T	
9278.780	+27.7	16	1.3	1	"	T	
9289.783	+35.9	23	1.6	1	"	T	

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 76216							
8128.946	−29.7	19	1.8	2	25	P	A2s. Velocity probably variable; mean velocity −27.6 ± 2.1 km/sec.; range 18 km. H.
8557.772	−17.7	16	3.0	1	12	P	
8657.562	−37.2	8	3.9	1	"	P	
	−32.7	13	2.8		"	MR	
8966.724	−17.5	14	2.7	1	"	P	
8973.682	−30.9	10	2.6	1	"	MR	
8984.638	−33.0	11	3.5	1	"	MR	
H.D. 93075							
9032.579	−55.1	19	3.2	1	12	P	A9. Mean velocity −29.8 km/sec.; range 52 km. H.
9035.576	−18.7	16	1.7	1	"	P	
9306.819	−58.4	16	2.6	1	"	T	
9358.653	−06.6	16	1.8	1	"	T	
9369.658	−20.0	19	1.1	1	"	T	
9379.604	−10.1	9	3.9	½	"	T	
H.D. 94118							
8165.875	−22.7	20	1.9	½	25	P	A1. Mean velocity +5.4 ±3.4 km/sec.; range 14 km. Most plates of this star poor. M.
8255.754	−04.7	7	1.9	½	"	P	
8280.635	+14.7	11	2.8	1	"	P	
8539.925	+21.8	13	4.2	1	12	P	
	+20.9	13	5.0		"	MR	
8999.627	−06.3	5	2.3	½	"	P	
9337.645	+04.2	14	3.2	1	"	T	
9340.685	+07.5	6	6.7	½	"	T	
H.D. 99267							
8950.799	+12.7	10	4.8	1	12	P	A8. Velocity probably variable; mean velocity −4.8±4.2 km/sec. Many lines which are rather difficult on 12-inch camera plates. Y.
8964.753	+07.5	19	5.4	1	"	P	
9027.570	−10.8	10	3.0	1	"	P	
9041.587	−16.3	10	4.1	1	"	P	
9048.588	−17.0	17	7.7	1	"	P	
H.D. 106677							
8622.734	−35.0	27	2.3	1	12	P	K0. Mean velocity −47.1 ±2.6 km/sec.; range 30 km. Fairly strong emission cores in 3933 and 3968. H.
	−37.1	29	1.7		"	MR	
8636.641	−51.1	14	2.3	1	"	P	
8643.648	−50.1	24	1.9	1	"	P	
8655.673	−51.8	27	1.8	1	"	P	
8984.701	−25.8	18	3.0	1	"	MR	
	−32.4	17	2.9		"	T	
9021.636	−58.8	21	3.2	1	"	P	
9026.647	−49.5	20	2.5	1	"	P	

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 106926							
8575.841	−31.5	26	1.8	1	12	P	K0. Mean velocity −40.9
8653.624	−43.0	23	2.1	1	"	P	km/sec.; range 23 km.
8876.953	−29.2	19	3.9	1	"	P	Hd.
	−32.8	19	1.8		"	T	
8968.753	−52.0	17	3.8	1	"	P	
	−54.8	15	2.1		"	T	
8987.708	−42.9	10	2.4	1	"	P	
9009.710	−34.1	8	6.0	½	"	P	
9023.643	−42.3	17	1.9	1	"	P	
H.D. 112570							
8272.749	+04.9	45	0.7	2	25	P	G8. Velocity probably
8282.698	+01.5	44	0.7	2	"	P	variable; mean velocity
8314.747	+17.7	31	1.7	1	12	P	+08.5 ± 1.8; km/sec.;
	+20.1	28	2.0		"	MR	range 17 km.
8599.838	+15.2	32	2.1	1	"	P	H.
8685.603	+11.6	24	1.6	1	"	P	
8984.800	+09.2	24	2.0	1	"	MR	
H.D. 112734							
8626.776	+13.5	4	10.0	½	12	P	A5. Mean velocity −6.1
8657.639	+06.7	12	2.9	1	"	P	±3.4 km/sec.; range 34
9059.590	−07.1	12	4.1	1	"	P	km. H.
9064.625	−13.6	6	6.0	1	"	P	
9337.706	−05.3	15	3.8	1	"	T	
9358.785	−21.0	13	4.1	1	"	T	
H.D. 116594							
8262.749	−02.3	43	0.7	2	25	N	G7. Mean velocity −04.9
8624.756	+05.4	24	1.2	1	12	N	km/sec., range 33 km.
8653.668	−02.3	12	3.4	1	"	N	Hd.
8682.611	+04.0	18	1.4	2	25	N	
8995.752	−20.0	14	3.8	1	12	N	
	−16.8	22	3.0		"	MR	
9016.686	−25.8	13	2.4	1	"	N	
	−29.3	27	2.0		"	MR	

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 141930							
8324.632	−12.1	8	3.3	1	12	N	A1. Velocity probably variable; mean velocity −20.2 km sec. The hydrogen lines and 3933 and 4481 are broad; all other lines very poor. This star is double; magnitudes 8.1, 9.3; separation 0″.57; the components were not resolved on the slit. Hd.
	−10.6	9	5.0		"	P	
8610.908	−33.4	12	6.3	1	"	N	
8624.865	−27.8	11	5.5	1	"	N	
8683.668	+20.9	8	5.4	1	"	N	
	−00.9	6	6.2		"	P	
9023.718	−37.2	7	8.4	1	"	N	
	−15.2	7	5.4		"	P	
9094.655	−50.8	4	13.0	½	"	P	
	−37.5	5	7.3		"	P	
H.D. 142926							
8206.977	−20.8	3	1.4	1	25	Hd	B9e. Announced as a spectroscopic binary by Plaskett (Pub. D.A.O., *1*, 287, 1921). From 26 D.D.O. plates, a preliminary orbit gives P = 0.9763 days; range 25 km sec.; velocity of system −16 km sec. Hydrogen lines have sharp cores with broad wings, suggesting the existence of indistinct double emission. Several panchromatic plates show strong Hα, confirming this view. 3933 is the only other line satisfactorily measurable. Hd.
8220.952	−15.4	3	1.4	1	"	Hd	
8221.940	−09.3	3	1.1	1	"	Hd	
8228.949	−21.9	3	2.3	1	"	Hd	
8262.854	+05.7	3	2.0	1	"	Hd	
H.D. 150203							
8657.807	−25.0	5	5.7	1	12	P	A2n. Velocity probably variable; mean velocity −17.2 ± 4.2 km sec.; range 64 km. Only hydrogen and 3933 measurable. H.
8685.642	−38.5	4	4.6	1	"	P	
	−20.2	4	4.4		"	P	
8720.594	−23.4	3	10.7	1	"	P	
8727.594	+05.0	2	13.0	½	"	P	
	+09.4	3	5.0		"	MR	
8735.594	−36.8	4	7.6	1	"	P	
8954.939	+30.1	3	10.8	½	"	P	
	+25.0	3	10.5		"	N	
9015.802	−10.3	5	7.1	1	"	P	
9143.563	−12.6	3	9.0	1	"	T	

TABLE IV—*Continued*

Star J.D.	Vel. Km. sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 151746							
8643.872	−17.5	21	1.8	1	12	P	A2. Mean velocity −10.8 ±2.6 km/sec.; range 30 km. H.
	−14.5	16	1.5		"	MR	
8664.821	−03.2	18	3.4	1	"	P	
8678.792	−03.2	15	3.9	1	"	P	
8709.633	−35.9	13	3.3	1	"	P	
	−27.8	14	2.8		"	N	
8728.636	−11.0	11	4.6	½	"	P	
9045.760	−06.0	23	2.7	½	"	MR	
9050.745	−02.1	26	3.1	1	"	MR	
H.D. 152951							
8265.894	+13.7	4	5.1	1	25	P	A2. Velocity probably variable; mean velocity −02.5 ± 2.7 km/sec.; range 41 km. Lines poor on most plates. H.
	+01.7	4	9.3		"	MR	
8371.617	+20.6	6	1.0	1	12	P	
	+19.5	4	1.9		"	MR	
8685.756	−08.1	7	3.4	1	"	P	
	+00.5	7	5.1		"	MR	
8707.695	−05.0	7	2.9	1	"	P	
8720.625	−14.0	8	4.5	1	"	P	
8727.630	−14.3	4	12.3	½	"	P	
	−01.5	6	9.1		"	N	
8735.636	+08.6	5	7.2	½	"	P	
	+30.6	5	9.5		"	MR	
8979.962	−01.3	5	10.0	1	25	MR	
9045.725	−21.0	6	4.3	1	12	MR	
9050.693	−11.3	5	11.3	1	"	MR	
H.D. 156653							
8019.562	+20.0	16	3.8	1	25	N	A2. Velocity probably variable; mean velocity −7.3 km/sec.; range 24 km. Hydrogen and 3933 strong and well defined; 25-inch camera plate shows many well defined metallic lines. Y.
8656.814	+20.1	4	4.2	1	12	N	
	+18.9	6	1.7		"	T	
8719.635	+00.4	6	3.0	1	"	N	
8719.657	−06.9	4	7.2	1	"	N	
	−01.7	6	5.1		"	MR	
8722.582	+11.0	4	4.1	1	"	N	
8999.785	−02.6	7	1.6	1	"	N	
H.D. 158251							
8718.685	−04.6	18	2.4	1	12	N	F0s. Velocity probably variable; mean velocity −11.5 km/sec. Hd.
9009.862	−04.1	8	2.0	1	"	N	
9019.853	−13.5	16	2.9	1	"	N	
9112.574	−22.7	20	2.6	1	"	P	
9114.579	−12.5	26	2.5	1	"	N	

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 159330							
8709.709	−09.4	15	2.8	1	12	N	K2. Velocity probably variable; mean velocity −12.7 ± 1.8 km/sec.; range 23 km. H.
8734.611	−18.2	15	1.9	1	"	N	
	−06.4	16	2.5		"	P	
8768.588	−15.1	16	1.1	1	"	N	
8984.912	−03.6	28	1.5	1	"	MR	
	−00.8	21	1.9		"	P	
9064.729	−25.7	22	1.7	1	"	P	
9141.542	−11.7	21	1.8	1	"	T	
H.D. 162880							
8379.614	+14.9	16	3.6	1	12	P	A6. Velocity probably variable; mean velocity −00.1 km/sec. This star is a double; magnitudes 7.8−7.8; separation 3″.4; guided on south star. Y
	+20.6	22	2.4		"	MR	
8684.740	−08.5	19	2.1	1	"	P	
9093.612	−06.3	10	5.1	1	"	P	
9104.597	−01.8	13	4.5	1	"	P	
9139.582	−01.9	21	2.6	1	"	P	
H.D. 164078							
8017.595	−07.9	4	5.0	1	25	N	F5n. Mean velocity +03.1 km/sec.; range 45 km. Hd.
8378.647	−09.1	7	2.2	1	12	N	
8773.554	+11.1	5	1.3	1	"	N	
8782.550	+29.9	4	3.0	1	"	N	
	+29.6	8	4.3	1	"	MR	
9112.649	−15.5	9	3.7	1	"	P	
9114.657	−03.3	11	5.8	1	"	N	
9116.589	+16.4	5	5.2	1	"	N	
H.D. 164898							
8362.694	+21.9	18	3.4	1	12	N	A0. Mean velocity −13.8 ±11.5 km/sec.; range 93 km. H.
8380.690	−37.0	7	5.6	1	"	N	
8685.805	+31.6	7	1.9	1	"	N	
	+27.3	6	3.3		"	B	
8707.742	−66.0	6	2.8	1	"	N	
	−61.9	4	3.5		"	B	
8720.662	+24.6	4	7.2	1	"	N	
8727.672	−11.8	5	5.9	½	"	N	
8731.653	−61.5	8	5.0	1	"	N	

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 165170							
8683.760	−20.0	10	2.7	1	12	N	F4. Velocity probably variable; mean velocity −19.4 km/sec. This star is double; magnitudes 7.8, 9.0; separation 0″.53; the components were not resolved on the slit. Hd.
9047.822	−09.2	11	3.1	1	"	MR	
9109.697	−28.4	15	2.0	1	"	P	
9110.716	−14.9	15	2.5	1	"	P	
9123.675	−24.7	14	2.3	1	"	T	
H.D. 166014							
7989.710	−40.9	4	9.2	1	12	M	B9. Helium weak, lines poor but suspected double in a few cases. Velocities given here show no evidence of the 21.90 day period listed by Schnellar. This confirms the constant luminosity found by Zverev in Sternberg Pub., v. 8, p. 99. There is the possibility that diffuse double lines are present but not separated enough for individual measurement. M.
	−25.4	3	2.5	1	"	S	
8221.965	−20.6	7	6.0	1	"	M	
8298.881	−21.3	3	4.4	1	"	M	
8304.858	−42.3	4	4.2	1	"	M	
8310.873	−27.5	7	8.3	1	"	M	
8316.767	−27.7	3	4.5	1	"	M	
8350.636	−34.1	4	2.3	1	"	M	
8350.640	−29.0	6	5.2	1	"	M	
8350.646	−27.9	4	7.2	1	"	M	
8356.649	−35.5	4	8.9	1	"	M	
8356.658	−33.0	4	4.0	1	"	M	
H.D. 169223							
8720.744	+24.5	19	2.9	1	12	P	K0. Velocity probably variable; mean velocity +15.7 ± 1.9 km/sec.; range 15 km. H.
8758.617	+16.6	20	3.2	1	"	P	
8762.615	+10.8	19	2.9	1	"	P	
9058.849	+22.8	15	4.0	1	"	P	
9063.747	+09.6	22	1.7	1	"	P	
9156.567	+09.8	23	2.1	1	"	T	
H.D. 172187							
8003.729	−56.6	7	9.3	1	25	S	A5. Velocity variable; mean velocity from 13 plates; +06.9 ± 6.4 km/sec.; range 111 km. Lines somewhat diffuse and variable in definition. H.
8678.862	+22.0	9	5.9	1	12	P	
	+29.1	12	5.2		"	MR	
8735.711	+44.7	11	3.8	1	"	P	
	+47.8	10	4.7		"	N	
8800.584	−53.1	8	8.1	1	"	P	
8837.465	−26.7	5	7.6	1	"	P	
	−09.3	4	6.0		"	MR	
9141.592	−01.7	7	6.3	1	"	T	

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 175865							
8014.632	−29.0	39	1.5	2	25	P	M5. R Lyrae. The
	−25.1	32	1.6		"	P	velocity is known to be
8799.522	−32.3	18	2.8	1	12	P	variable.
8806.526	−26.5	21	2.1	1	"	P	Hd.
H.D. 176053							
8055.551	−14.1	5	4.9	1	12	P	A3. Mean velocity −37.0
8363.708	−22.0	11	4.8	1	"	P	km/sec. Lines rather
8412.585	−17.1	6	5.3	1	"	P	wide for measurement.
8432.536	−70.1	9	2.8	1	"	P	This star is a visual
	−71.8	7	4.9		"	MR	double, magnitudes 6.2,
9069.832	−56.1	6	5.3	1	"	P	8.0; separation 1″.0
9083.681	−52.4	3	2.1	1	"	P	Y.
9188.483	−26.3	9	1.9	1	"	T	
H.D. 181144							
9082.758	+25.0	14	3.3	1	12	P	F7. Mean velocity −04.5
9170.583	−15.2	18	3.0	1	"	T	km/sec.
9172.540	−33.8	16	2.2	1	"	T	Hd.
9184.543	+18.0	16	3.4	1	"	B	
	+18.3	22	2.2		"	T	
9205.503	−28.2	6	3.8	½	"	T	
H.D. 182381							
8801.589	−19.4	3	2.6	1	12	MR	A0n. Velocity probably
9065.739	+31.6	4	9.0	1	"	P	variable; mean velocity
	+16.0	6	5.0			B	−11.1 ± 8.4 km/sec.;
9103.676	−39.8	4	8.7	1	"	T	range 64 km.
9131.660	−29.6	4	11.4	1	"	P	Very little but hydrogen
9133.626	+09.3	4	7.4	1	"	T	visible; presence of helium suspected. M.
H.D. 189013							
8377.717	+22.4	4	2.1	1	12	P	A1. Velocity probably
	+14.2	8	3.3		"	MR	variable; mean velocity
8736.717	+12.5	10	5.1	1	"	P	+7.5 km/sec.
8783.592	+06.5	8	3.3	1	"	P	Hydrogen, 3933 and
9104.724	+02.1	4	2.9	1	"	P	4481, and several metal-
9139.646	+12.0	6	3.9	1	"	T	lic lines well defined.
9157.624	−11.7	5	4.1	1	"	T	Y.
	+02.0	10	5.6		"	N	

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 193349							
8077.553	−09.9	10	8.3	1	12	M	A0sp. Velocity probably variable; mean velocity −17.8 ± 4.7 km/sec.; range 43 km. Spectrum appears peculiar, possibly due to blending with another star; Fe and Ca I unusually strong; suspect He on some plates; Ca II weak. M.
8823.499	−29.0	7	7.1	1	"	P	
9052.849	+00.9	12	6.7	1	"	P	
9120.681	−23.2	10	3.4	1	"	P	
9182.502	−42.3	11	5.7	1	"	M	
9194.547	−03.1	14	3.1	1	"	T	
H.D. 198726							
7994.751	−08.2	18	2.0	2	25	Hd	T Vulpeculae. Cepheid variable. Spectral types of these four plates are F4, F8, (F8), F9. Velocities fit Beal's orbit (P.A.O. *3*, 23) satisfactorily if the period be changed from 4.43578 to 4.43572 days. Hd.
8723.765	−11.3	16	2.0	2	"	Hd	
8773.687	+13.4	7	1.1	1	12	Hd	
8782.622	−01.2	14	4.9	1	"	Hd	
H.D. 199140							
8000.780	−47.2	21	2.8	2	25	S	B2sk. Known binary; Victoria mean velocity −07±5 km/sec. Mean velocity from D.D.O. plates −25.4 ± 8.5 km/sec.; range 124 km. H.
	−59.9	23	1.9		"	N	
8758.708	−51.0	8	6.6	1	12	P	
8778.606	−04.6	10	5.9	1	"	P	
	−11.1	14	4.1		"	MR	
9054.856	−33.7	9	3.7	1	"	P	
9064.851	−66.8	7	2.2	1	"	P	
	−70.8	9	4.0		"	B	
9169.565	−43.1	8	2.8	1	"	T	
9183.551	+18.2	12	1.7	1	"	T	
9206.501	+51.5	10	5.0	1	"	T	
	+60.4	10	4.4			B	

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 199479							
8737.743	−16.4	3	8.6	1	12	Hd	B8. Velocity probably
	−18.2	7	5.2		"	T	variable; mean velocity
8771.660	−58.2	5	3.6	1	"	Hd	−07.1 km/sec. Hydro-
	−18.0	3	6.4		"	MR	gen lines fair; helium
	−28.3	4	3.4		"	T	and 3933 and 4481 are
8777.628	−41.0	4	4.7	1	"	Hd	very weak.
	−03.8	5	10.8		"	T	Hd.
9110.808	+16.0	6	6.8	1	"	Hd	
	+03.6	8	6.1		"	T	
9114.769	+27.9	4	7.3	1	"	Hd	
	+10.7	7	4.6		"	T	
H.D. 201078							
8003.789	+16.3	21	1.3	1	25	N	F5. Cepheid variable;
8762.749	−05.4	16	3.2	1	12	N	orbit by Sanford.
8789.630	−14.5	15	2.1	1	"	N	H.
H.D. 201433							
8002.804	−08.2	8	2.6	1	25	N	A0. Known binary. Orbit
8803.599	−04.3	3	4.4	1	12	N	Pub. D.A.O. *1*, p. 303.
8803.621	−16.2	3	5.7	1	"	N	These observations fit
8838.512	−40.4	6	1.7	1	"	N	orbit very well if period
8838.531	−41.2	4	8.0	1	"	N	be altered from 3.3137
							to 3.3133 days. Previous
							orbit gives velocity of
							system = −25.8 km/sec.
							Hydrogen, calcium, and
							rather poor 4481. Y.
H.D. 208174							
8073.628	+00.9	11	1.4	1	12	M	A5v. Mean velocity −8.4
8417.685	−03.4	16	3.8	1	"	M	±2.8 km/sec.; range 28
9125.801	−24.0	16	6.6	1	"	P	km. Probably variable
	−28.0	29	2.9			T	velocity. Lines of Ca, Ca
9131.778	−13.3	13	3.1	1	"	T	II, Sr II and others
9147.656	−10.0	17	2.3	1	"	T	seem to vary in relative
9182.638	+01.7	17	2.2	1	"	B	intensity. M.

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 208835							
8042.657	+23.2	3	10.2	½	12	M	B8. Mean velocity +0.8 ±10.2 km/sec.; range 81 km. Si II lines visible. M.
8403.717	+30.8	7	7.1	1	"	M	
8844.551	+34.7	3	1.1	1	"	N	
9119.758	−37.2	5	10.	1	"	T	
	−55.0	5	5.5			P	
9144.692	+07.0	6	3.7	½	"	T	
9175.617	−30.3	7	2.9	1	"	T	
H.D. 209205							
8047.710	+33.1	3	7.3	1	12	M	B9n. Mean velocity +4.8 ±6.4 km/sec; range 63 km. Probably variable velocity. M.
9103.790	+21.3	3	4.9	1	"	P	
9105.778	+09.2	5	14.	½	"	P	
9117.802	−00.7	4	3.4	1	"	T	
9144.754	−12.2	2	12.5	1	"	T	
	−25.7	2	9.6			B	
9168.656	−10.9	2	2.4	½	"	T	
	−49.6	5	13.1			B	
H.D. 209469							
8036.687	−17.3	4	3.1	1	12	N	B9. Mean velocity −12.7 ±5.0 km/sec.; range 67 km. Probably variable. Y.
8763.728	−13.2	3	1.6	1	"	N	
8817.562	−44.5	4	8.1	1	"	N	
	−36.8	3	8.9			P	
9104.818	−09.8	2	1.6	1	"	P	
9139.689	−22.0	3	3.1	1	"	T	
9188.564	+26.5	3	5.5	1	"	N	
H.D. 209484							
8070.606	−17.9	11	3.5	1	12	M	B9. Mean velocity −7.0 ±3.4 km/sec.; range 34 km. Probably variable. 3933 and 4481 quite sharp on most plates, other lines poor. M.
8350.836	−32.1	4	4.8	1	"	M	
	−20.1	6	4.1			T	
9115.790	+08.2	5	2.2	1	"	P	
9119.790	−03.6	5	4.2	1	"	T	
9147.693	+03.2	5	1.9	1	"	T	
9182.611	−06.1	4	1.0	1	"	T	
H.D. 209813							
8131.491	−34.2	26	1.6	1	25	P	K0. Mean velocity −5.1 ±6.5 km/sec.; range 50 km. Y.
	−31.1	27	1.0			MR	
8432.731	+20.5	28	2.1	1	12	P	
	+11.5	18	1.7			MR	
8769.750	−08.0	23	1.4	1	"	P	
8798.644	+04.2	20	2.1	1	"	P	

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 209833							
8039.694	−66.9	6	12.8	1	12	N	B9n. Mean velocity
	−31.2	7	7.1			B	−15.4±6.9 km/sec.;
8483.478	−02.1	6	12.0	1	"	N	range 63 km. Only H
	+15.0	6	9.1			T	lines clearly visible.
9095.810	+13.7	3	5.4	1	"	P	Suspect He and Ca II
	+15.2	3	3.1			T	but neither identified
9120.805	−30.9	3	8.6	1	"	T	with certainty. M.
9133 742	−26.0	3	3.7	1	"	T	
9168.692	−07.3	3	2.3	1	"	T	
H.D. 210334							
8068.645	−154.	12		1	12	P	G0. Velocity of system
	+ 70.	9				P	from 12 plates −32 km.
8375.828	−114.	19		1	"	P	Double line Binary.
	+ 78.	15				P	Y.
8380.780	−109.	11		1	"	P	
	+ 65.	15				P	
8381.799	−103.	11		1	"	P	
	+ 62.	12					
H.D. 212442							
8052.686	+13.3	4	9.1	1	12	Hd	B8. Mean velocity from
8149.588	−33.2	5	6.5	1	"	Hd	10 plates +04.0 km/sec.;
	−30.8	7	2.5			T	range 73 km. H lines
8179.519	−26.8	5	9.8	1	"	Hd	are good, the other lines
8718.854	+09.3	4	3.0	1	"	Hd	4026, 4471, 4481 faint.
8737.808	+38.0	5	10.6	1	"	Hd	Hd.
	+46.2	3	4.7				
H.D. 213126							
8433.682	+10.2	7	4.9	1	12	MR	A2. Mean velocity −05.7
8664.576	−07.1	4	8.9	1	"	MR	±5.2 km/sec.; range 43
	+01.3	4	7.9			P	km. Few poor lines.
8882.467	−27.1	3	1.5	1	"	MR	H.
	−20.6	5	7.5			P	
8896.965	+13.7	4	10.0	1	"	MR	
	+05.1	5	9.5			P	
8926.814	+06.0	5	4.6	1	"	MR	
9141.725	−29.1	5	3.8	1	"	T	
	−36.8	7	7.1			B	

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 215242							
8429.685	+03.3	5	5.4	1	12	MR	A0s. Mean velocity −18.2 ±5.1 km/sec.; range 45 km. Many faint metallic lines seen; 4025, 4046 and some others seem anomalously strong. M.
8760.726	−27.4	4	4.2	1	"	MR	
8858.499	−25.8	4	2.5	1	"	M	
9125.839	−06.9	5	4.5	1	"	P	
9144.782	−02.9	4	7.0	½	"	T	
9178.672	−41.9	10	2.9	1	"	M	
H.D. 215566							
8417.731	−39.5	3	9.6	1	12	MR	B8. Mean velocity −23.1 ±5.0 km/sec.; range 41 km. Probably variable. 3933 very faint. M.
	−38.4	5	12.			P	
8420.671	−12.2	3	7.5	1	"	MR	
8811.613	−11.6	4	5.2	1	"	MR	
9117.846	−59.0	3	5.8	1	"	T	
	−42.7	3	7.7			N	
9137.809	−15.6	3	6.0	1	"	T	
9161.674	−09.5	3	3.9	1	"	T	
H.D. 216608							
8089.652	+05.4	26	1.8	1	25	P	A4. Mean velocity +16.2 ±4.2 km/sec.; range 29 km. Many fine lines. Star is double magnitude 6.0, 8.0; sep. 0″.2 Y.
8845.551	+35.4	15	4.2	1	12	P	
	+33.6	23	2.2			MR	
8776.744	+17.3	19	3.0	1	"	P	
9188.585	+07.6	25	1.7	1	"	T	
H.D. 217491							
8090.669	−07.1	16	2.3	1	25	MR	A3. Mean velocity −05.0 ±3.5 km/sec.; range 26 km. Probably variable. H.
8380.812	+05.1	16	3.8	1	12	MR	
8440.692	−16.1	11	5.0	½	"	MR	
	−19.1	14	3.6			N	
8750.791	+08.7	11	5.6	1	"	MR	
8789.742	+06.6	13	3.9	1	"	MR	
9171.728	−18.4	13	2.4	1	"	T	
9183.685	−18.3	19	1.8	1	"	T	

TABLE IV—*Continued*

Star J.D.	Vel. Km./sec.	Lines	P.E.	Wt.	Cam.	M.	Remarks
H.D. 219634							
8368.863	−31.5	6	4.5	1	12	Hd	B4nk. Mean velocity
	−25.2	4	2.8			MR	−08.9 from 21 plates;
8370.824	−01.1	4	4.2	1	"	Hd	range 176 km. 3933 is
	+12.9	3	1.8			MR	interstellar and gives a
8374.868	+14.5	8	5.4	1	"	Hd	mean velocity of −06.3
	+40.1	6	9.7			MR	from 15 plates.
	+40.1	6	9.7			MR	Hd.
8378.879	−89.4	6	9.1	1	"	Hd	
	−106.0	5	8.8			MR	
H.D. 219675							
8029.789	+21.4	14	3.0	1	25	T	A8. Mean velocity +12.0;
8113.554	+02.3	19	2.0	1	12	N	velocity is probably var-
	−05.6	17	2.4			MR	iable; range 23 km. The
8521.458	+09.2	21	3.1	1	"	N	star is double 7.4 and
8742.864	+19.2	17	1.6	1	"	N	8.8, sep. 0″.41.
8771.736	+14.3	12	1.9	1	"	N	Hd.
H.D. 221114							
8019.849	+24.9	3	8.8	0	25	P	A2. Mean velocity +02.2
	+24.9	2	1.3			MR	±3.7 km/sec; Probably
8082.656	−21.2	8	1.8	1	12	P	variable. First plate
	−05.9	4	1.8			MR	very weak.
8784.762	+00.5	12	3.4	1	"	P	Y.
9146.755	+06.9	5	5.2	1	"	T	
9223.549	+14.9	6	3.6	1	"	N	
H.D. 224801							
8084.717	−14.3	5	0.9	1	25	N	A0p. Mean velocity −2.0
	−15.4	11	1.1			P	±2.8 km/sec.; range 27
8511.483	+05.3	5	2.0	1	12	N	km. Probably variable.
	+11.9	7	3.8			P	Many ionized lines—
8804.704	+14.6	5	1.8	1	"	N	Si II, Mg. II, Sr. II.
	+09.0	6	4.3			P	
9105.856	−18.5	2	6	0	"	T	M.
9119.869	−01.6	5	2.9	1	"	T	
9144.799	−12.1	6	5.0	1	"	N	
9182.691	−03.9	5	1.5	1	"	T	

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A CATALOGUE OF 1116 VARIABLE STARS IN GLOBULAR STAR CLUSTERS

BY

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A. Introduction.

It is now fifty years since the discovery of the first variable star was announced in a globular cluster. The Nova which appeared in the cluster Messier 80 in 1860 can hardly be said to be the beginning of variable star astronomy in clusters, as it is still in a class by itself. In 1902 Bailey gave a summary of the variables in all the clusters which he himself had investigated, and published co-ordinates for the variables. Except for this compilation however, no catalogue of the variable stars in globular clusters has ever been published.

In 1930 Shapley published in *Star Clusters* a summary of the variables known in globular clusters. This summary was brought up to date in 1933 in the *Handbuch der Astrophysik.* Considerable knowledge has been added in the interim, with many new variables discovered, and periods determined. In June, 1938, the writer sent a paper to the Ottawa meeting of the American Association for the Advancement of Science summarizing the present state of our knowledge. As a basis for this paper, a catalogue was made giving the magnitudes, positions, and periods of all the individual variables. There was originally no intention of publishing the actual catalogue of variables, but only a summary of the data contained therein. As the work progressed however, the writer became more and more impressed with the lack of unity in the subject, the wide scattering of the references through the literature, and the various ways observers have published their data. The writer came to the conclusion that one unifying publication of actual lists of variables arranged according to individual cluster would be worth the time spent in preparation and the cost of publication.

The purpose of the catalogue is to enable a worker interested in the subject to get a clear picture of exactly what has been done on variables in clusters, either for clusters as a whole or for any individual cluster in which he may be interested. For a person intending to work on the variables in any given cluster, the catalogue is not intended to supplant the original papers. The original papers naturally contain much more information than could possibly be carried over into the catalogue. Often it has been difficult to decide what values to excerpt, in the case of slight changes of epoch, period, or other elements.

While the catalogue is almost entirely a reprinting of material which can be located from published sources, its publication may help to prevent overlapping researches. For several clusters, variables have been announced by several observers, when the later worker did not know of the work of the earlier one. Confusion has arisen in the numbering of the variables. It would seem that this will happen more frequently in the future as the list of variable star references lengthens. Furthermore there has been a decided lack of homogeneity in the published results. The co-ordinates for the variables are given in several different units, and sometimes are not given at all. Maximum and minimum magnitudes are often lacking. Epochs are given in almost every possible way, for minimum phase, maximum phase, or an arbitrary point on either the ascending or descending branch of the light curve. It is hoped that, if the available data are gathered together now in a uniform manner for all clusters, observers will be encouraged in the future to publish their results in a more standard form. This should make the material more suitable for statistical investigation.

No attempt has been made to republish marked prints for the clusters. In general cluster variables are most readily identified from prints, although these have not been published for all clusters. For each cluster, however, a publication in which a marked print can be found is indicated. But it is felt that a compilation of the positions, even without the prints, is certainly statistically valuable. As a matter of fact, for some of the crowded clusters where the prints are blurred in the centre, one needs to use the positions anyway, rather than the prints, for identification.

The positions of the variables are most logically given in x and y co-ordinates from the centre of the cluster. As the position of the exact cluster centre is practically never published, it may seem a trifle illogical to publish x and y co-ordinates without identifying the origin. But even though the position of the origin is indefinite, when there are as many as two variables published in a cluster, the identification from the positions only should not be ambiguous.

B. Summary of Data on Variable Stars in Globular Clusters.

1. Numbers of Variables.

At the present time, 1215 variable stars have been found in 60 globular clusters. There is no printed record of a search in the other 34 clusters. Of these 1215 variables, 99 are listed as unpublished, and so cannot be catalogued with positions and magnitudes.

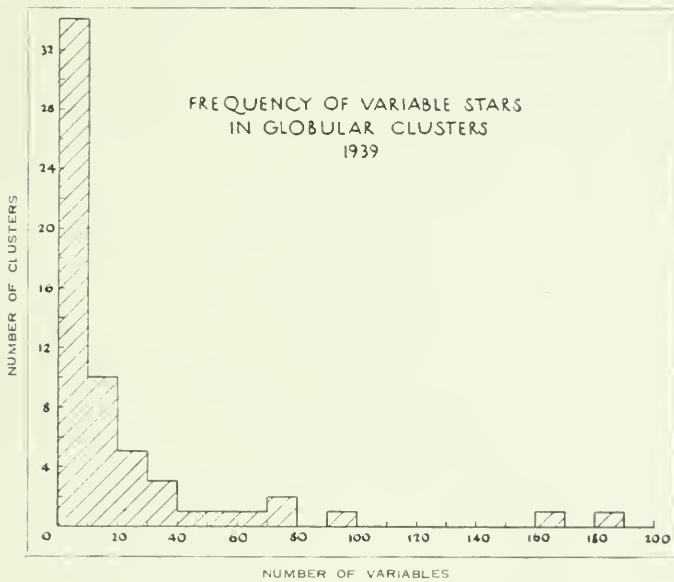

Figure 1

It is a somewhat startling fact that only recently have the efforts of all other astronomers equalled those of Professor Bailey alone, in the finding of new variables. Bailey found 541 new variables, other observers 774.

Of the 60 globular clusters searched so far, only 4 have been found to be entirely devoid of variables. These four have been searched by only one observer, and it is quite possible that in the future some variables may be found in them. The cluster Messier 3 (NGC 5272) has the largest number of variables, with a total of 185, while ω Centauri (NGC 5139) is a close second with 161. No other globular cluster has more than 100. Of all the clusters searched, 80 per cent have less than 30 variables. Figure 1 shows the frequency distribution of number of variables per globular cluster.

Table I gives a summary of variable stars in globular clusters, arranged according to NGC number of the cluster. The second column gives the total number of variables known; an italicized number indicates that some unpublished variables have been included in the total. The name of the discoverer is given in the third column, followed by the date on which definite publication of the new variables was made. The numbers in parenthesis indicate the number of variables found by that person. As in some clusters variables have been found independently by several observers, it should not be expected that the numbers in parenthesis will total the exact number now known in the cluster. Stars which were once announced as variable, and since shown to be unvarying, have been omitted from the total. The fifth column gives the total number of periods actually determined. No attempt has been made to include in this table the numbers of stars which have been shown to have periods less than a day, but for which the actual period has not been established. In the sixth column are given the names of the authors who determined periods, and in the seventh the date when the periods were published. The last three columns of the table give the number of cluster type variables, of variables with periods between 1 and 125 days, and with periods greater than 125 days. The grouping of periods from one to 125 days was purposely taken to include a number of stars with periods just over one hundred days. This group seems in rather higher proportion in globular clusters than in the galactic system. There are few variables with periods greater than 125 days; they apparently belong to the class of long period variables.

2. Number of known periods.

Of the known variables, periods have been determined for 656, or about one-half. Periods are known in only 20 globular clusters, or about one-fifth of the total number. Of the 656 periods determined, the four bright clusters investigated by Bailey, Messier 3, Messier 5, Messier 15, and ω Centauri account for 449 periods, or 70 per cent of the total. The other 207 periods known are scattered through 16 clusters. Bailey has determined more periods in globular clusters than all other workers combined; he determined 353 periods, while others have so far determined only 303.

TABLE I

SUMMARY OF VARIABLE STARS IN GLOBULAR CLUSTERS

NGC	No. Vars.	Found by	Date	Total Periods Determined	Det. by	Date	P <1 day	P 1-125 days	P >125 days
104	8	Bailey	1902	3	Woods	1922	0	0	3
288	*2*	Mt. Wilson							
362	14	Bailey	1902	10	Sawyer	1931	7	3	0
1851	*3*	Bailey (2	1902						
		Swope (*1*							
1904	5	Bailey	1902						
2298	*6*	Shapley							
2419	36	Baade	1935						
2808	*4*	Shapley							
3201	61	Woods (56	1919						
		Bailey (5	1922						
4147	4	Davis (1	1917	3	Baade	1930	3	0	0
		Baade (3	1930						
4372	*8*	Shapley							
4590	28	Shapley and	1919						
		Ritchie	-20						
4833	*6*	Swope and							
		Shapley							
5024	40	Shapley and	1920	32	Grosse	1932	32	0	0
		Ritchie (22							
		Baade (16	1926						
		Grosse (2)	1932						
5053	9	Baade	1927						
5139	161	Bailey (128	1902	150	Bailey	1902	135	13	2
		van Gent,	1937		Martin	1937			
		Hertzsprung,							
		and Martin							
		(33)			Barnard	1906			
5272	185	Pickering (1	1889	166	Bailey	1913	164	2	0
		Belopolsky (1)	1895		Larink	1922			
		Bailey (132)	1902		Slavenas	1929			
		(5)	1913						
		Barnard (1	1905		Müller	1933			
		Shapley (23	1914		Greenstein	1935			
		Larink (3	1922						
		Müller,	1933						
		Guthnick and							
		Prager (42							
		Greenstein (16	1935						
5286	0	Bailey	1924						

Italicized numbers indicate unpublished data. Sources of data for this summary may be found under individual clusters in the catalogue.

TABLE I—*Continued*

NGC	No. Vars.	Found by	Date	Total Periods Determined	Det. by	Date	P <1 day	P 1-125 days	P >125 days
5466	14	Baade	1926						
5634	*4*	Baade							
5694	0	Baade	1934		Barnard	1898			
5904	92	Common (5)	1890	73	Bailey	1917	70	3	0
		Packer (1)	1890		Shapley				
		Bailey (85)	1902		and Roper	1927			
		(7)	1917						
5986	1	Bailey	1902						
6093	3	Auwers (1)	1860						
		Bailey (2)	1902						
6121	32	Leavitt	1904	20	Sawyer	1931	19	1	0
6171	24	Oosterhoff	1938						
6205	*10*	Barnard (2)	1900, 1914	2	Barnard	1909	0	2	0
		Bailey (2)	1902						
		Shapley (4)	1915						
		Guthnick and Prager (*3*)							
6218	1	Sawyer	1938	1	Sawyer	1938	0	1	0
6229	*21*	Davis (1)	1917						
		Baade (*20*)							
6254	2	Sawyer	1938	1	Sawyer	1938	0	1	0
6266	26	Bailey	1902						
6293	3	Shapley and Ritchie	1920						
6333	*1*	Mt. Wilson							
6341	16	Woods (1)	1922	13	Hachen-berg	1939	13	0	0
		Nassau (14)	1938						
		Guthnick and Prager (14)							
		Hachenberg	1939						
6362	17	Woods (16)	1919						
		Bailey (1)	1919						
6366	*6*	Sawyer							
6397	2	Bailey	1902	2	Sawyer	1931	0	1	1
6402	72	Sawyer	1938	*15*	Sawyer	1937	*12*	3	0
6426	*10*	Baade							
6535	*1*	Baade							
6539	*1*	Baade							
6541	1	Woods	1922						
6553	0	Shapley	1920						
6584	0	Bailey	1924						

Italicized numbers indicate unpublished data. Sources of data for this summary may be found under individual clusters in the catalogue.

TABLE I—*Continued*

NGC	No. Vars.	Found by	Date	Total Periods Determined	Det. by	Date	P <1 day	P 1-125 days	P >125 days
6626	9	Bailey	1902						
6656	17	Bailey (16)	1902	8	Shapley	1927	6	1	1
		Swope (1)	1927		and Swope				
6712	*4*	Davis (1)	1917						
		Baade (*3*)							
6723	19	Bailey (16)	1902	19	Bailey	1924	19	0	0
		van Gent (3)	1932-3		van Gent	1932-3			
6752	1	Bailey	1902						
6760	*2*	Baade							
6779	*6*	Davis (1)	1917						
		Shapley and							
		Ritchie (2)	1920						
		Sawyer (*4*)							
6809	2	Bailey	1902						
6864	11	Shapley and	1920						
		Ritchie							
6934	51	Sawyer	1938	*35*	Sawyer		*35*		
6981	31	Davis (2)	1917	26	Shapley	1920	26	0	0
		Shapley and			and Ritchie				
		Ritchie (31)	1920						
7006	*20*	Shapley and	1920						
		Ritchie (2)							
		Shapley, and	1921						
		Mayberry (9)							
		Hubble (9)							
7078	74	Bailey (51)	1902	60	Bailey,	1919	59	1	0
		Bailey (15)	1919		Leland and				
		Guthnick and			Woods				
		Prager (8)			Wemple				
					Levy				
7089	17	Chèvre-mont (1)	1897	17	Chèvre-mont	1898	13	4	0
		Bailey (10)	1902		Sawyer	1935			
		Sawyer (6)	1935						
7099	3	Bailey	1902						
7492	*9*	Shapley and	1920						
		Ritchie (1)							
		Shapley (8)							

Italicized numbers indicate unpublished data. Sources of data for this summary may be found under individual clusters in the catalogue.

3. Distribution of periods.

It is general knowledge that among the stars with known periods the variables of cluster type with periods less than one day greatly predominate. There are 614 cluster type periods in 15 clusters. In many clusters where no definite periods are known, inspection of the changes in magnitudes from a number of plates indicates that most of the variables have periods less than one day. There are 43 variables with periods greater than one day. Of these, 7 have periods greater than 125 days; 27 are long period Cepheids, and the rest are semi-regular variables or belong in the group with periods about one hundred days.

It is a rather amazing fact that while in globular clusters cluster type periods outnumber periods greater than one day in a 15 to 1 proportion, yet the variables with periods greater than one day are distributed as widely among the clusters investigated as are the large numbers of cluster type variables! The 613 cluster type variables are to be found in 15 clusters, while the 43 variables with periods greater than one day are also scattered through 14 clusters.

This fact lends considerable zest to the hunt for periods in globular clusters; for while one may guess that a cluster with 30 variables may probably have a long period Cepheid, yet one must realize that a cluster with only one or two variables is quite as likely to have one. The relative scarcity of Cepheids with periods greater than one day naturally makes them the more interesting objects. From the point of view of distance determination, the distance as computed from the apparent magnitude of the cluster type Cepheids is probably just as good as the distance computed from the period-luminosity relation of the long period Cepheids. But because periods greater than one day are comparatively rare in globular clusters, these variables are summarized in Table II. A similar table which had 27 entries was published by the writer in 1931 (*H.C.* no. 366). Since then 17 stars have been added, and one dropped. Of these, 11 are Cepheids, 3 found by Martin in ω Centauri, and 8 by the writer in 4 other clusters. A period of 103 days has been determined for Variable 95 in Messier 3, and several variables in ω Centauri have been shown to have semi-regular periods.

TABLE II

Periods Greater than One Day in Globular Clusters

NGC	Var. No.	Period	Magnitudes Max.	Min.	Med. Mag. Cl. Type	Remarks
104	1	211.3	11.0	14.4	.....	
	2	203.	11.0	14.2		
	3	192.	11.0	14.3		
362	2	105.22	13.0	14.5	15.49	
	8	3.901447	15.0	16.5		Member of Small Mag. Cloud.
	10	4.20519	14.9	16.4		Member of Small Mag. Cloud.
5139	1	58.7027	10.7	12.6	14.65	RV Tauri, formerly thought Cepheid with $P=29^d.34$
	2	484.	13.06	16.12		
	17	60: irr.	14.18	14.61		
	29	14.72429	12.44	13.50		
	42	149.4	12.5	14.9		
	43	1.1568183	13.41	14.55		
	48	4.474293	13.09	13.95		
	53	87: irr.	13.30	13.87		
	60	1.349464	13.32	14.48		
	61	2.273582	13.72	14.48		
	78	1.1681179	14.17	14.84		Eclipsing variable
	92	1.3450659	14.10	14.58		
	138	74.6: irr.	12.5	13.6		
	148	90: irr.	12.9	13.8		
	152	124: irr.	12.8	13.7		
5272	95	103.19	13.73	14.42	15.57	
	154	15.2828	12.9	14.0		
5904	41	25.74	11.20	12.24	15.11	
	50	106.0	13.00	14.2		
	84	26.5	11.54	12.61		
6121	29	1.097452 ?	13.4	14.1	13.88	
6205	1	6.0	13.7	14.9	15.20	
		5.10	12.85	13.8		
6218	1	15.508	11.9	13.2	.....	

TABLE II—*Continued*

NGC	Var. No.	Period	Magnitudes Max.	Min.	Med.Mag. Cl. Type	Remarks
6254	2	18.754	11.9	13.7	.....	
6397	1	314.6	11.2	16.0	.....	
	2	45 or 60	13.8	14.8		RV Tauri ?
6402	1	18.75	14.3	16.0	16.85	
	2	2.7952	15.4	16.3		
	7	13.59	14.9	16.2		
6656	5	7.097 ?	12.0	12.8	14.06	
	14	200.0	13.8	[15.5		
7078	1	1.437478	14.36	15.54	15.63	
7089	1	15.5647	13.2	14.8	16.1	
	5	17.5548	13.2	14.9		
	6	19.3010	13.2	14.9		
	11	33.600	12.5	13.7		

C. Description of the Catalogue.

The catalogue contains all clusters for which there is a published record of a search for variables, and a few others for which the unpublished data have been kindly supplied to the writer. The clusters are arranged in order of NGC number. If the cluster has a Messier number, it is given. The right ascension and declination are for the equinox of 1950.

The variables are numbered according to the number given by the discoverer except in a few cases where an adjustment has had to be made. The x and y co-ordinates are given in seconds of arc and correspond in direction to right ascension and declination. Whenever they have been published, magnitudes, epochs and periods are given. A blank in these columns indicates lack of published data. Some magnitudes have been followed by colons in the original papers; the colons have been omitted in the catalogue because the writer felt that there was far more uncertainty in many magnitudes in other clusters which had been published without colons. When an observer has given a table of maximum and minimum magnitudes, these have been taken. In many cases the writer has had to read these values from published measures of many plates; in these cases the brightest and faintest estimates of magnitude for the variable have been taken. Epoch of maximum gives the number of days past J.D. 2,400,000.000.

Suspected variables have not been included in the catalogue except for one or two which had been assigned definite numbers in the midst of list of variables. It was felt that in these cases it would disturb the numbering less to include these suspected variables until they were definitely disproved. Announced variables which are now considered not to vary have been left in the catalogue so that a reader would not think the numbers had been omitted by accident; their non-variable nature has been indicated and they have not been included in the totals of known variables.

When necessary, notes pertaining to the cluster are given at the end of the data on that particular cluster.

D. References to Literature on Variable Stars in Globular Clusters.

To the catalogue is appended a complete bibliography of literature on variable stars in globular clusters. The 39 fundamental references given in Shapley's *Star Clusters*, Table IV, I, have been increased to 118, partly by inclusion of some of the very early references, partly by references since 1930, and partly by somewhat obscure references which had been overlooked earlier. These references have been arranged by years in the hope that the numbering would have some significance and might be reasonably permanent. In any one year the references have been arranged alphabetically by author. References to field variables around a cluster (when published under the name of that cluster) have been included, since there is often ambiguity as to which variables are actually cluster members. Variable star literature has been assumed to start with the first typical variable found in 1889, and not with the early nova of 1860. The list of nova references therefore is not given directly in the bibliography, but can be found in the most recent paper under NGC 6093. At the end of each cluster the list of numbers indicates the references to that cluster, and special note is made of the references in which plates or charts of the clusters giving identification of the variables can be found.

E. Suggestions for Publication of Future Results.

The writer would like to make the following suggestions that workers in this field might follow in the future. These suggestions arise out of the practice that has been most usual in the past; if the same practice could always be followed in the future it would put the knowledge of variable stars in globular clusters on a uniform basis, as Prager's catalogue has the knowledge of variables in the galactic system.

It is suggested:

1. That for the announcement of new variables, the x and y co-ordinates be published, with an assumed centre of the cluster, with the signs such that an increase in x or in y means an increase in right ascension or north declination. That since most co-ordinates have been published in seconds of arc, this unit should be adopted. That if an observer finds additional variables in a cluster already examined and wishes to change the origin of the co-ordinate system for some good reason, he republish on his system the x and y co-ordinates for all variables.

2. That variables be numbered consecutively from the last known variable in the cluster. (This appears to be a very obvious procedure, but in a number of cases it has not been followed).

3. That observers refrain from numbering suspected variables along with stars considered definitely variable. (The suspects can be lettered or designated in any way that the author wishes; but it is bound to lead to much unnecessary confusion in the future if they are numbered along with well-established variables).

4. That since the maximum and minimum magnitudes of the variables in a cluster may be considered one of the convenient and fundamental quantities in which many astronomers are interested, a table giving these for all variables (including those for which no period has been determined) be published whenever possible.

5. That, for variables whose periods have been determined, a table of well-established epochs of maximum be published. (Although the period may doubtless be computed more accurately from some other point, yet it would seem that a table of epoch of maximum is of general interest and use, and should always be published even when the periods have been computed from points selected on some other part of the light curve.)

Naturally a serious attempt has been made to make the catalogue as complete and as accurate as possible. In a work of this sort, however, it is almost inevitable that errors will be found, sins both of omission and of commission, and the writer will be very grateful for all that are brought to her attention. She will also be glad to receive additional data as it is accumulated in the future.

The writer wishes to acknowledge with thanks the assistance of Miss Edna Fuller in the preparation of this catalogue, and constructive suggestions regarding the manuscript made by Professor Shapley and Dr. Prager.

March 3, 1939.

CATALOGUE
OF VARIABLE STARS IN GLOBULAR CLUSTERS

NGC 104 (47 Tucanae) α 00^h 21^m.9, δ −72° 21′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
1	+36.8	−112.6	11.0	14.4	12717.	211.3
2	+64.7	−193.9	11.0	14.2	12685.	203.
3	+328.4	+52.8	11.0	14.3	12755.	192.
4	−18.8	−160.4	.....	.....	....	....
5	+271.9	−284.6	.....	.....	....	....
6	+97.3	−103.8	.....	.....	....	....
7	+349.2	−113.0	.....	.....	....	....
8	+16.	+57.	.....	.....	....	....

Refs. 9, 14, 20, 68. Plate in 20.

NGC 288 α 00^h 50^m.2, δ −26° 52′

2 unpublished variables, Ref. 87. No map.

NGC 362 α 01^h 00^m.6, δ −71° 07′

1	−246.2	−67.6	14.9	16.1	23751.558	0.5850512
2	+41.4	−204.4	13.0	14.5	24391.8	105.22
3	+93.6	−143.2	14.6	16.1	23604.806	0.4744151
4	−50.2	−27.3	14.0	15.8	....	....
5	−79.2	−31.9	15.1	16.4	24025.729	0.4900846
6	+82.4	+15.5	14.9	16.3	24461.642	0.5146080
7	+131.1	−21.2	14.8	16.0	24468.687	0.5285492
8	+33.4	−308.5	15.0	16.5	24433.677	3.901447
9	−400.4	+224.4	14.7	16.0	24404.670	0.5476126
10	+282.8	−381.8	14.9	16.4	23315.643	4.20519
11	−136.1	−26.0	15.1	16.0	....	....
12	−30.4	−115.4	15.2	16.1	24391.839	0.65254518
13	+14.5	+38.8	14.6	16.3	....	....
14	−23.8	−66.8	14.8	16 2	....	....

Refs. 11, 14, 20, 90, 94. Plate in 20. Corrected period for No. 12 from ref. F.

NGC 1851 α 05^h 12^m.4, δ −40° 05′

1	+261	−9	14	15½	....	....
2	−45	+30	14	15½	....	....

1 unpublished variable.
Refs. 72, 87. No map.

CATALOGUE—*Continued*

NGC 1904 (Messier 79) α 05^h 22^m.2, δ −24° 34′

No.	x″	y″	Magnitudes Max.	Magnitudes Min.	Epoch of Maximum	Period
1	+29.6	−199.6	.....	.....	....	....
2	+78.3	−68.3	.....	.....	....	....
3	+34.8	−64.6	.....	.....	....	....
4	+93.4	−50.3	.....	.....	....	....
5	−11.6	+20.2	.....	.....	....	....

Refs. 14, 20. Plate in 20.

NGC 2298 α 06^h 47^m.2, δ −35° 57′

6 unpublished variables, 5 suspected.
Ref. F.

NGC 2419 α 07^h 34^m.8, δ +39° 00′

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period
1	+40	−52	17.59	18.32	....	....
2	−4	−19	.....	.....	....	....
3	+52	−24	18.66	19.96	....	....
4	+80	−15	18.84	19.65	....	....
5	+33	+47	18.75	19.72	....	....
6	+56	−127	18.86	19.64	....	....
7	+91	+87	18.69	19.77	....	....
8	−17	+41	17.50	18.10	....	....
9	−32	+88	18.59	19.76	....	....
10	+20	−51	17.31	17.93	....	....
11	+95	−8	18.55	19.81	....	....
12	+133	+111	18.69	19.71	....	....
13	+101	−10	18.55	19.75	....	....
14	−115	−13	18.81	19.62	....	....
15	+62	+40	18.62	19.76	....	....
16	+47	+72	18.77	19.85	....	....
17	+109	+111	18.65	19.75	....	....
18	−15	+114	17.84	18.53	....	....
19	−107	−40	18.77	19.86	....	....
20	−28	+45	17.65	18.16	....	....
21	−55	+30	18.76	19.74	....	....
22	+109	−5	18.60	19.81	....	....
23	+27	+79	.....	.....	....	....
24	−117	−10	18.91	19.58	....	....
25	−59	+38	18.74	19.81		....

CATALOGUE—*Continued*

NGC 2419

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
26	−70	−50	.....	.....	....	....
27	+19	−103	19.10	19.55	....	....
28	−192	+59	18.72	19.78	....	....
29	−58	−7	19.01	19.92	....	....
30	−26	+23	.....	.....	....	....
31	+154	−146	19.08	19.53	....	....
32	−19	+48	18.60	19.71	....	....
33	+47	−17	19.11	20.13	....	....
34	+21	+157	19.00	19.66	....	....
35	+43	+8	18.78	19.70	....	....
36	+23	+44	19.10	19.83	....	....

Ref. 108, with plate.

NGC 2808 α 09ʰ 10ᵐ.9, δ −64° 39′

4 unpublished variables, 7 suspected.

Ref. F.

NGC 3201 α 10ʰ 15ᵐ.5, δ −46° 09′

1	+59	−118	.....	.....	....	....
2	+29	−117	.....	.....	....	....
3	+182	−43	.....	.....	....	....
4	+155	+3	.....	.....	....	....
5	+42	−24	.....	.....	....	....
6	−116	−143	.....	.....	....	....
7	−91	−189	.....	.....	....	....
8	−69	−99	.....	.....	....	....
9	−51	−91	.....	.....	....	....
10	−181	+235	.....	.....	....	....
11	−104	+112	.....	.....	....	....
12	−86	+108	.....	.....	....	....
13	−160	+92	.....	.....	....	....
14	−156	+133	.....	.....	....	....
15	−279	−173	.....	.....	....	....
16	−197	−238	.....	.....	....	....
17	+11	−25	.....	.....	....	....
18	+23	−24	.....	.....	....	....
19	+23	+317	.....	.....	....	....
20	+39	+284	.....	.....	....	....
21	+94	+135	.....	.....	....	....

CATALOGUE—*Continued*

NGC 3201

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
22	−100	−56	.....	.....	....	....
23	−49	−50	.....	.....	....	....
24	−339	+17	.....	.....	....	....
25	+93	+173	.....	.....	....	....
26	+219	−140	.....	.....	....	....
27	+58	−323	.....	.....	....	....
28	+66	−48	.....	.....	....	....
29	−256	+113	.....	.....	....	....
30	−289	+272	.....	.....	....	....
31	+182	+131	.....	.....	....	....
32	+195	+199	.....	.....	....	....
33	+48	−40	.....	.....	....	....
34	+296	+285	.....	.....	....	....
35	−11	+121	.....	.....	....	....
36	−108	−11	.....	.....	....	....
37	−68	−74	.....	.....	....	....
38	−61	−60	.....	.....	....	....
39	+41	+54	.....	.....	....	....
40	−96	+68	.....	.....	....	....
41	+291	+28	.....	.....	....	....
42	−301	+197	.....	.....	....	....
43	−377	+15	.....	.....	....	....
44	+31	+67	.....	.....	....	....
45	+127	−32	.....	.....	....	....
46	−396	−510	.....	.....	....	....
47	+108	+245	.....	.....	....	....
48	−252	+12	.....	.....	....	....
49	−38	+151	.....	.....	....	....
50	−13	+27	.....	.....	....	....
51	−205	−26	.....	.....	....	....
52	+14	−812	.....	.....	....	....
53	−873	−758	.....	.....	....	....
54	+671	−804	.....	.....	....	....
55	−338	+767	.....	.....	....	....
56	+246	+94	.....	.....	....	....
57	+288	−72	.....	.....	....	....
58	+346	−80	.....	.....	....	....
59	−490	−70	.....	.....	....	....
60	−850	+95	.....	.....	....	....
61	−1125	+175	.....	.....	....	....

Refs. 46, 59. No map.

CATALOGUE—*Continued*

NGC 4147 α 12^h 07^m.6, δ +18° 49′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
1	−100.1	−45.7	15.90	16.95	25324.68	0.4993
2	−20.2	−28.8	15.95	17.25	25305.541	0.4920
3	−28.5	−35.3	16.32	16.78	25321.528	0.3834
4	+1	+18	16.5	17.1	....	....

Refs. 36, 85, 89. Photograph in 85.

NGC 4372 α 12^h 23^m.0, δ −72° 24′

8 unpublished variables, 6 suspected.

Ref. F.

NGC 4590 (Messier 68) α 12^h 36^m.8, δ −26° 29′

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period
1	−280	+109	15.28	16.03	....	....
2	−168	−45	15.69	16.39	....	....
3	−140	+91	15.54	16.34	....	....
4	−117	−131	15.56	16.02	....	....
5	−56	+170	15.51	16.14	....	....
6	−54	+17	15.64	16.03	....	....
7	−50	−79	15.48	16.16	....	....
8	−38	−134	15.69	16.14	....	....
9	−31	+40	15.43	16.28	....	....
10	−25	−16	15.28	16.62	....	....
11	−18	−112	15.31	16.11	....	....
12	−10	−1	15.07	16.23	....	....
13	−6	−56	15.62	16.28	....	....
14	−4	+218	15.16	16.29	....	....
15	+9	+58	15.65	16.36	....	....
16	+11	+80	15.71	16.43	....	....
17	+16	−75	15.65	16.60	....	....
18	+19	−96	15.59	16.28	....	....
19	+33	+70	15.65	16.21	....	....
20	+34	−114	15.45	16.02	....	....
21	+48	+8	15.82	16.60	....	....
22	+61	−22	15.30	16.52	....	....
23	+64	+380	15.08	16.34	....	....
24	+74	−8	15.74	16.34	....	....
25	+141	+123	15.77	16.21	....	....
26	+158	−44	15.67	16.35	....	....
27	+380	+263	10.88	15.04	....	....
28	+440	+160	15.62	16.14	....	....

Refs. 44, 49. Photograph in 49.

CATALOGUE—*Continued*

NGC 4833 α 12^h 56^m.0, δ −70° 36′
6 unpublished variables, 2 suspected.
Refs. 65, 87, F. No map.

NGC 5024 (Messier 53) α 13^h 10^m.5, δ +18° 26′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
1	+9.6	−171.0	16.05	16.95	23083.422	0.6098204
2	−78.0	−183.6	16.38	16.88	23113.368	0.3861006
3	−60.6	−138.0	16.14	16.93	23113.383	0.6306142
4	−169.5	−156.6	16.41	16.84	23113.482	0.3851668
5	−237.0	−258.0	15.89	16.98	23143.308	0.6394291
6	+123.6	+13.5	16.08	17.11	23083.448	0.6640180
7	+79.5	+83.5	16.02	16.95	23145.435	0.5448344
8	+72.0	+60.0	16.28	16.95	23143.552	0.6144954
9	+67.5	−40.5	16.03	17.10	23145.500	0.6003745
10	−138.6	+54.0	15.90	16.98	23143.445	0.6082565
11	−143.4	−58.5	16.04	16.82	23113.536	0.6299540
12	+409.5	+187.5	16.05	16.91	23113.548	0.6125865
13	+462.0	−299.7	15.87	17.03	23143.409	0.6274463
14	+354.6	−207.0	15.88	17.00	23143.366	0.5454021
15	+248.4	+228.0	16.39	16.67	23113.458	0.2358820
16	−136.5	−202.5	16.43	16.90	23113.399	0.3031713
17	−214.5	+114.0	16.29	16.80	23113.588	0.3815014
18	−96.0	+12.6	.....	.....	....	....
19	+165.6	−42.0	16.34	16.85	23113.534	0.3913751
20	+188.4	−351.6	16.32	16.81	23113.615	0.3844312
21	+437.4	−27.0	16.32	16.81	23113.315	0.3381193
22	−53.4	−288.0	variable ?		....	....
23	+96.0	−89.7	16.34	16.88	23113.460	0.3658077
24	−118.5	−29.2	15.71	16.43	....	....
25	+130.3	+31.7	16.16	16.90	23113.340	0.7051765
26	−288.0	−279.9	16.29	16.74	23113.337	0.3911181
27	−203.8	−157.9	16.16	16.93	23083.628	0.6710581
28	−181.4	+459.0	15.78	16.94	23113.223	0.6327872
29	+125.4	−79.5	16.61	16.88	22811.132	0.391870
30	+57.7	−482.8	16.18	17.01	23113.398	0.5354915
31	+60.6	−0.1	.....	.....	....	....
32	−111.9	−86.6	16.26	16.65	23113.545	0.3900810
33	−165.0	+12.2	.....	.....	....	....
34	−144.0	−216.7	.....	.....	....	....
35	+104.1	+153.2	16.38	16.88	23113.345	0.3726730

CATALOGUE—*Continued*

NGC 5024

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
36	+120.3	+306.5	16.33	16.71	23113.698	0.3732511
37	−44.0	+62.2	.....	.....	....	....
38	+21.3	−143.2	16.08	16.81	23083.777	0.7057845
39	−234.0	+212.5	.....	.....	....	....
40	+8.9	+111.5	16.55	16.89	26418.664	0.239250
41	In	centre				
42	In	centre				

Refs. 51, 58, 79, 92, 97. Photograph in 51, chart in 92.

NGC 5053 α 13ʰ 13ᵐ.9, δ +17° 57′

1	−380	+158	15.85	16.55	....	....
2	−193	−3	15.83	16.46	....	....
3	+140	+138	15.84	16.50	....	....
4	+31	−114	15.83	16.50	....	....
5	+220	−220	15.85	16.50	....	....
6	+126	+77	15.99	16.44	....	....
7	−87	+169	15.93	16.43	....	....
8	+117	+50	15.94	16.50	....	....
9	−199	+382	.....	16.46	....	....

Ref. 83, with plates.

NGC 5139 (ω Centauri) α 13ʰ 23ᵐ.8, δ −47° 03′

1	−416.16	+298.89	10.7	12.6	....	58.7027
2	−340.00	+238.51	]13.06	16.12	....	484.
3	−507.93	+167.43	14.19	15.11	26524.245	0.8412205
4	−337.61	+262.10	13.89	15.18	26473.374	0.6273172
5	−282.75	+328.29	14.06	15.34	26460.409	0.5152828
6	−162.43	+252.95	13.84	15.24	....	irr.
7	+153.19	+879.15	13.98	15.11	26470.425	0.7130181
8	+629.43	+16.20	13.90	15.29	26472.238	0.5212846
9	−473.17	+137.14	14.35	15.32	26453.421	0.5233358†
10	−397.76	+244.48	14.38	14.90	26524.241	0.374950
11	−158.63	+338.73	14.3	15.0	irr.	0.56481
12	−193.16	+274.34	14.43	14.95	26469.446	0.3867486
13	−487.26	+199.54	13.98	15.12	26438.457	0.6690480
14	−473.51	−627.56	14.40	15.01	26472.456	0.3771799
15	−194.09	+242.62	14.13	14.98	26469.427	0.8106198

CATALOGUE—*Continued*

NGC 5139

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
16	+517.05	−536.81	14.38	14.95	26435.488	0.3301694
17	+522.24	+200.00	14.18	14.61	....	60:
18	+596.64	+220.15	13.89	15.18	26454.408	0.6216682
19	+444.14	+32.44	14.68	15.22	26434.540	0.2995533
20	+280.88	+32.06	14.01	15.20	26469.388	0.6155547†
21	−355.75	+162.07	14.20	14.81	26469.257	0.3808180
22	+552.18	−330.22	14.43	14.97	irr.	0.39609
23	+2.54	+240.71	14.26	15.39	26470.392	0.5108651
24	+524.71	−336.96	14.41	14.88	26468.520	0.4622108
25	−210.77	+17.48	13.98	15.07	26469.433	0.5885005
26	−229.58	+101.21	14.36	15.06	26459.469	0.7847199†
27	−205.47	+24.11	14.50	15.19	26471.386	0.6156761
28	......	......	not variable		....	....
29	−193.25	−6.45	12.44	13.50	26465.88	14.72429
30	−307.92	−75.01	14.40	14.86	irr.	0.40448†
31	......	......	not variable		....	....
32	+174.39	+420.01	13.87	15.20	26469.421	0.6204317
33	−554.54	−24.00	13.88	15.24	26461.436	0.6023262
34	−396.87	−269.04	14.18	15.13	26471.369	0.7339450
35	+71.70	+365.07	14.37	14.94	26468.484	0.3868382
36	+246.11	+789.42	14.38	14.93	irr.	0.37984†
37	......	......	not variable		....	....
38	+169.10	−170.37	14.36	15.11	26469.456	0.7790480
39	+741.86	−365.80	14.43	14.99	26469.474	0.3933567
40	−220.99	−125.30	13.95	15.15	26471.364	0.6340969†
41	+151.80	−142.18	14.03	15.06	26523.185	0.6629590
42	+0.21	−50.21	12.5	14.9	....	149.4
43	−119.23	+103.16	13.41	14.55	26470.385	1.1568183
44	−243.40	−351.05	14.24	15.36	26466.380	0.5675440
45	−764.48	+80.97	13.94	15.19	26473.404	0.5891259
46	−770.61	+170.11	14.03	15.17	26454.471	0.6869382
47	−504.32	+269.26	14.27	14.73	irr.	0.48517†
48	−86.54	−104.54	13.09	13.95	26523.70	4.474293
49	−391.98	−553.77	14.16	15.28	26470.407	0.6016505
50	−530.75	+65.40	14.57	15.10	26472.336	0.3861815
51	−36.85	+258.73	13.86	15.16	26441.448	0.5741359
52	−112.85	+36.47	13.60	14.22	26461.348	0.6603737
53	−482.79	−447.74	13.30	13.87	....	87:
54	−229.39	+592.76	14.22	15.05	26472.412	0.7728973
55	−617.73	−816.68	14.38	15.39	26471.323	0.5816930
56	−515.93	−541.96	14.37	15.38	26428.437	0.5680030
57	+635.72	−493.26	14.31	15.06	26471.342	0.7944118

CATALOGUE—*Continued*

NGC 5139

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
58	−335.44	+277.68	14.49	14.74	26524.233	0.3699057
59	−282.90	−65.84	14.20	15.18	26523.231	0.5185176†
60	−108.42	−247.33	13.32	14.48	26473.513	1.349464
61	+280.44	+68.07	13.72	14.48	26468.345	2.273582
62	−199.80	+45.28	13.88	15.10	26424.515	0.6197937
63	−996.82	−491.46	14.47	15.04	26438.567	0.8259507
64	−448.01	−457.49	14.45	15.02	26466.410	0.3444512
65	−454.49	−474.32	14.77	15.22	26523.238	0.06272282
66	−133.37	+375.15	14.46	14.95	irr.	0.40745†
67	−178.11	+593.57	14.18	15.28	26470.377	0.5644551
68	−338.18	+545.12	14.15	14.67	26469.366	0.5344773
69	−965.76	−530.94	14.10	15.25	26438.468	0.6532165
70	+417.83	−304.65	14.45	14.94	26524.219	0.3906091
71	+220.39	+47.13	14.38	14.92	26523.271	0.3574826
72	+477.85	+734.87	14.42	14.94	26471.459	0.3845163
73	−532.49	+750.76	13.87	15.18	26472.358	0.5752184
74	+215.47	+664.83	13.75	15.24	26454.399	0.5032505
75	+341.44	+591.55	14.42	14.87	26456.501	0.4222508
76	+113.31	+511.81	14.40	14.82	26523.135	0.3378438
77	+352.29	+392.42	14.45	14.93	irr.	0.42593†
78	+586.10	+146.68	14.17	14.84	27943.307¶	1.1681179
79	+1000.12	−51.02	13.97	15.27	26456.423	0.6082747
80	.....	.....	not variable		....	....
81	+511.36	+228.72	14.46	14.98	26523.110	0.3894022
82	+499.94	+126.98	14.43	14.96	26463.452	0.3358520
83	+226.09	+424.66	14.43	15.00	26471.427	0.3566071
84	−1202.81	−74.70	14.09	14.90	26472.382	0.5798722
85	−1010.51	+307.98	14.23	15.09	26523.243	0.7427555
86	+293.14	+147.26	13.96	15.18	26470.383	0.6478442
87	+113.68	+184.13	14.40	14.90	26454.448	0.3965019
88	+98.13	+203.28	14.01	14.81	26523.273	0.6901992
89	−2.95	+159.29	14.47	14.97	26523.329	0.3748505
90	−5.30	+137.09	13.81	14.73	26460.432	0.6034020
91	+43.72	+144.35	14.25	14.91	26459.480	0.8951422
92	−317.86	+446.38	14.10	14.58	26473.345	1.3450659
93	.....	.....	not variable		....	....
94	−504.09	+355.09	14.64	14.95	26463.416	0.2539318
95	−824.80	−11.05	14.49	14.98	26473.448	0.4049213
96	−71.20	+97.06	13.93	14.82	26455.467	0.6245312
97	+225.50	+187.93	14.11	15.16	26523.234	0.6918869
98	+198.25	+102.38	14.57	15.09	26524.265	0.2805657
99	+160.35	+50.36	13.77	14.90	26472.390	0.7660839

CATALOGUE—*Continued*

NGC 5139

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
100	+179.49	+65.68	14.05	15.05	26434.489	0.5527119
101	+444.11	−73.28	14.50	14.94	26523.291	0.3408843
102	+361.83	−94.10	14.16	15.22	26468.445	0.6913841
103	+283.14	+2.35	14.46	14.80	26456.354	0.3288461
104	+822.98	−309.01	14.54	14.95	26471.370	0.8678506
105	+603.23	−246.92	14.57	15.12	26524.300	0.3353375
106	+130.35	+26.92	13.88	15.02	26523.189	0.5699074
107	+279.83	−139.13	14.07	15.39	26466.424	0.5141010
108	+185.66	−46.36	13.84	14.81	26472.360	0.5944533
109	+153.91	−57.13	13.99	15.03	26469.395	0.7440653
110	+158.94	−87.08	14.41	14.96	26524.256	0.3221021
111	+27.26	−0.30	14.18	14.80	26438.498	0.7628923
112	+79.83	−103.36	13.92	14.92	26470.380	0.4743558
113	+99.99	−187.65	13.94	15.22	26523.244	0.5733636
114	+38.08	−101.15	14.00	14.75	26470.416	0.6753065
115	−345.49	−336.14	14.03	15.21	26467.406	0.6304590
116	−109.66	+33.71	14.12	14.77	26472.437	0.7201327
117	−267.73	−40.22	14.40	14.92	26456.506	0.4216653
118	−58.87	−98.67	13.88	15.02	26473.380	0.6116200
119	−82.04	−157.45	14.51	14.83	26472.319	0.3058774
120	−211.29	−247.61	14.26	15.23	26523.264	0.5485722
121	−184.36	−189.58	14.48	14.81	26524.259	0.3041814
122	−162.92	−261.41	13.99	15.17	26437.512	0.6349307†
123	+46.11	−512.55	14.41	14.90	26473.331	0.4739051
124	+78.88	−626.81	14.37	14.97	26524.107	0.3318614
125	+23.74	−742.59	13.87	15.29	26471.408	0.5928902
126	+822.95	−730.44	14.45	14.97	26453.493	0.3418933
127	−880.16	+4.31	14.54	14.92	26524.177	0.3052752
128	−289.77	−92.09	14.25	14.86	26469.401	0.8349748
129	+192.02	−25.83	.....	.....	....	....
130	−366.17	+900.99	14.30	15.40	irr.	0.4932377
131	−165.05	−59.95	14.40	14.86	26523.329	0.3921392
132	−72.44	−29.31	13.97	14.96	26469.386	0.6556410
133	−1914.22	+1053.78	.....	.....	....	....
134	−942.87	+972.72	13.93	15.20	26466.386	0.6529039
135	−181.88	−37.25	13.87	14.85	26470.314	0.6325795
136	−154.26	+60.08	14.22	14.64	26472.409	0.3919136
137	−149.54	+96.23	14.38	14.90	26473.286	0.3342134
138	−111.12	−187.55	12.5	13.6	....	74.6
139	−86.94	+65.18	14.00	14.90	26462.404	0.6768666
140	−42.65	−86.60	.....	.....	....	....
141	−55.47	−47.46	14.05	14.75	irr.	0.6975651

CATALOGUE—*Continued*

NGC 5139

No.	x''	y''	Magnitudes Max.	Min.	Epoch of Maximum	Period
142	−37.35	−2.56	.....	.....	....	....
143	−37.45	+71.40	14.24	14.77	26470.394	0.8207020
144	−33.28	+22.44	14.33	14.81	26454.329	0.8353054
145	+49.07	−148.51	14.40	14.87	irr.	0.37315†
146	+65.96	−48.03	13.87	14.77	26469.386	0.6331021
147	+298.70	−151.04	14.35	14.80	26473.333	0.4226945
148	+299.20	+44.21	12.9	13.8	....	90:
149	+477.33	+894.18	13.92	15.13	26523.256	0.6827332
150	+543.18	−442.23	14.07	14.94	26462.387	0.8991585
151	+1010.06	+753.35	14.42	14.84	26523.333	0.4077805
152	+13.84	−48.83	12.8	13.7	....	124:
153	+34.46	+136.32	14.48	14.88	26524.176	0.3864509
154	+169.59	−113.20	14.55	14.72	26524.165	0.3223311
155	+75.25	+237.31	14.43	14.88	26473.344	0.4139117
156	+15.06	−191.94	14.41	14.83	26468.432	0.3591887
157	+1.77	+82.58	14.42	14.79	26523.370	0.4064970
158	−10.58	−119.80	14.32	14.74	26472.442	0.3673350
159	−2039.94	−891.45	.....	.....	....	....
160	−711.13	+969.21	14.46	14.98	26473.439	0.3972932
161	−96.81	−129.27	13.3	13.8	....	irr.
162	−392.40	−252.39	12.9	13.6	....	irr.
163	−575.24	+499.91	14.51	14.78	26472.451	0.3132294
164	+152.75	+478.38	.....	.....	....	....
165	−69.92	+104.59	.....	.....	....	....
166	−2.89	+144.71	.....	.....	....	....
167	−352.63	−321.43	.....	.....	....	....

†Two periods given by Martin. ¶Epoch of minimum.
Variables Nos. 28, 31, 37, 93 are said by Bailey to be not variable.
Epochs of maximum from ref. D.
Refs. 14, 17, 20, 31, 40, 62, 67, 90, 99, 113, 116, 118, 119. Plates in 20 and 118.

NGC 5272 (Messier 3) α 13ʰ 39ᵐ.9, δ +28° 38′

1	−5.2	−128.5	14.80	16.14	15021.378	0.5206324
2	+15.8	+52.6	.....	.....	....	....
3	+57.9	−66.0	14.91	16.16	15021.225	0.5590333
4	−43.5	−8.8	14.9	16.0	....	....
5	+261.0	−22.3	14.76	16.09	15021.239	0.50618
6	−123.9	+60.1	14.75	16.19	15021.452	0.5143207
7	−4.8	+87.2	14.69	16.25	15021.064	0.4974290

Catalogue—*Continued*

NGC 5272

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
8	−81.7	−23.4	not variable		....	....
9	−291.4	−207.8	14.84	16.22	15021.111	0.5415672
10	+153.6	+138.0	15.03	16.17	15021.270	0.5695127
11	−152.6	−209.7	14.89	16.22	15021.131	0.5078921
12	−3.8	−145.4	15.35	15.98	15021.015	0.3178890
13	−26.0	−137.5	15.08	16.14	15021.323	0.4830535
14	−49.0	−161.0	15.01	16.10	15021.179	0.6358993
15	−90.8	−273.2	14.83	16.24	15021.299	0.5300771
16	−301.4	−93.1	14.73	16.24	15021.418	0.5115124
17	+142.4	−440.4	15.24	16.37	15021.265	0.5761344
18	+97.6	−295.3	15.08	16.34	15021.142	0.5163462
19	+350.5	−245.6	15.64	16.20	....	0.630971
20	+333.5	−271.6	14.74	16.13	15021.289	0.4912607
21	+346.9	+17.9	14.88	16.29	15021.171	0.5157165
22	+190.2	−10.7	14.83	16.25	15021.200	0.481364
23	−113.0	+279.2	14.79	15.70	15021.082	0.5953756
24	−147.6	+10.4	15.07	16.09	15021.563	0.6633499
25	−124.4	−31.4	14.77	16.23	15021.089	0.480048
26	−177.4	−43.0	14.89	16.15	15021.239	0.5977479
27	−110.2	−102.8	15.17	16.21	15021.566	0.5790981
28	−25.0	−105.8	15.03	16.28	24290.335	0.47123
29	−65.2	−73.6	.....	.....	....	....
30	−36.5	+58.0	14.88	16.19	22760.635	0.5120891
31	+33.1	+65.1	14.73	16.25	15021.542	0.5807218
32	+11.8	+60.1	14.86	16.38	15021.108	0.4953526
33	+70.5	−89.0	15.01	16.22	15021.217	0.5252255
34	+135.4	+170.2	14.89	16.16	15021.136	0.5591078
35	−107.3	−278.2	15.04	16.24	15021.032	0.530608
36	+172.0	−35.4	14.86	16.26	15021.272	0.5455861
37	−236.7	+164.7	15.14	16.02	15021.248	0.3266402
38	−203.0	+127.7	15.06	16.26	24290.304	0.5580326
39	−243.6	+121.4	15.07	16.17	15021.073	0.5870732
40	−271.2	+112.4	14.93	16.18	15021.609	0.5515422
41	−93.3	+54.0	15.04	16.21	15021.441	0.4850291
42	−78.6	+41.0	14.85	16.27	15021.515	0.5902069
43	+99.9	+24.7	14.86	16.23	15021.191	0.5405023
44	+170.0	+99.4	14.75	16.21	15021.368	0.506443
45	−241.2	−129.9	14.93	16.30	15021.349	0.5368966
46	−128.1	−51.5	15.46	16.24	15021.264	0.6123751
47	−117.5	−73.2	14.98	16.20	15021.459	0.5110201
48	+126.9	−102.7	15.16	15.99	15021.088	0.6278087
49	+140.0	−100.7	15.19	16.23	15021.266	0.5182222

Catalogue—*Continued*

NGC 5272

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
50	+8.8	−234.0	15.15	16.09	15021.327	0.5131155
51	+30.8	−226.4	15.08	16.21	15021.486	0.5839856
52	−76.8	+152.0	14.99	16.16	15021.485	0.5174045
53	−7.4	+122.8	14.70	16.13	15021.006	0.5048891
54	−32.6	+106.4	14.94	16.22	15021.193	0.506493
55	−204.2	+324.4	14.85	16.21	15021.699	0.5298114
56	−141.1	+358.6	15.20	15.94	22760.623	0.247931
57	+155.2	−0.2	14.97	16.22	15021.618	0.5122311
58	−86.2	+46.2	14.78	16.16	22760.621	0.517101
59	−109.8	−228.4	15.22	16.24	15021.332	0.5888026
60	−297.4	−315.4	15.20	16.14	15021.389	0.7077216
61	+190.2	+363.0	14.88	16.20	15021.076	0.5209267
62	+90.2	+417.0	15.21	16.10	15021.331	0.6524059
63	+37.2	+341.9	14.93	16.14	15021.094	0.5704204
64	+114.8	+330.4	15.05	16.10	15021.324	0.6054592
65	+125.4	+327.5	14.74	16.09	15021.503	0.6683397
66	−101.4	+121.4	15.20	16.01	15021.323	0.6201973
67	−131.4	+123.0	15.21	16.12	15021.411	0.5683681
68	+21.9	+174.8	14.8	16.3	....	....
69	+80.6	+141.0	15.09	16.18	15021.553	0.5665806
70	+37.6	+152.2	15.12	15.70	15021.315	0.3268207
71	+160.6	−2.0	15.12	16.20	15021.168	0.5490517
72	+445.5	−2.2	14.61	16.37	15021.327	0.4560721
73	+438.5	+62.2	15.0	16.0	....	....
74	+88.2	+151.0	14.87	16.26	15021.452	0.4921415
75	+49.0	+159.5	15.23	15.99	15021.411	0.3140813
76	−14.4	−88.2	14.72	16.41	15021.293	0.5017529
77	−94.4	+27.8	14.85	16.36	15021.451	0.4593422
78	+47.5	+66.4	15.10	16.13	15021.249	0.6119228
79	+43.4	+349.4	14.81	16.24	15021.229	0.4832979
80	+416.8	+284.6	15.05	16.27	15021.433	0.5385169
81	+342.8	+351.1	14.67	16.28	15021.325	0.5291108
82	−102.6	−601.8	14.92	16.27	15021.527	0.5245027
83	−441.6	+113.4	14.66	16.25	15021.046	0.5012348
84	+64.0	+165.2	15.20	16.14	15021.248	0.5957289
85	+306.2	+225.8	15.00	15.83	22760.517	0.2623439
86	+513.0	−114.2	15.31	16.13	15021.016	0.2928977
87	+110.6	+60.2	15.31	15.91	22760.535	0.3571320
88	−35.0	−70.2	14.9	16.0	24290.324	0.3012792
89	+28.0	−110.8	14.86	16.15	15021.507	0.5484778
90	+97.2	−188.2	14.80	16.24	15021.461	0.5170344
91	−14.3	−550.0	15.05	16.27	15021.259	0.5301710

CATALOGUE—*Continued*

NGC 5272

No.	x″	y″	Magnitudes Max.	Magnitudes Min.	Epoch of Maximum	Period
92	−29.0	−408.4	14.88	16.23	15021.083	0.5035579
93	−319.4	−396.6	15.30	16.22	15021.177	0.6023041
94	−488.4	−224.6	14.84	16.21	15021.118	0.5236921
95	−154.7	+15.4	13.73	14.42	....	103.19
96	−164.2	−234.0	14.78	16.13	15021.019	0.4994538
97	−130.0	−196.7	15.53	16.01	15021.524	0.2509695
98	+132.4	−3.2	not variable		....	....
99	+201.8	−55.0	14.8	15.8	....	....
100	+69.9	+97.3	15.3	16.2	....	....
101	+46.4	+83.7	15.50	16.14	15021.101	0.6438557
102	+58.4	+114.9	15.2	15.9	....	....
103	+58.1	+120.4	not variable		....	....
104	−25.8	+145.5	14.74	16.09	15021.288	0.5699246
105	−20.9	+191.6	15.17	15.66	15021.315	0.2877445
106	−48.0	+168.0	15.17	16.20	15021.310	0.5471636
107	−75.8	+335.0	15.02	15.99	15021.443	0.3090344
108	−219.0	+310.9	14.77	16.21	15021.083	0.5196047
109	−89.3	+2.7	14.86	16.31	15021.033	0.5339259
110	−99.4	−15.8	15.02	16.24	15021.397	0.5353700
111	−92.7	+21.9	14.96	16.18	15021.402	0.5101921
112	−144.6	−719.4	not variable		....	....
113	+199.8	−689.8	14.90	16.43	15021.241	0.5130031
114	+11.8	+622.0	15.08	16.24	15021.515	0.5977254
115	+445.0	+664.7	14.69	16.25	15021.297	0.5133533
116	−491.8	+465.2	14.80	16.22	15021.441	0.5148090
117	+89.6	−467.6	15.26	16.23	15021.579	0.6005122
118	+144.4	−292.2	14.73	16.28	15021.272	0.4993795
119	+253.4	+106.2	14.73	16.16	15021.460	0.5177376
120	−295.8	+231.4	15.36	16.05	15021.284	0.6401377
121	−43.6	+56.1	15.41	16.25	22760.550	0.5351935
122	−33.5	−46.4	14.6	16.1	....	0.5017
123	−259.	−985.	15.16	16.75	15021.395	0.5454116
124	−66.4	−201.4	15.3	16.2	....	....
125	+186.3	−132.8	15.41	16.08	15021.029	0.3498185
126	−15.4	−146.4	15.50	16.03	15021.208	0.3484044
127	+95.6	−63.6	not variable		....	....
128	+114.6	+131.4	15.07	15.97	....	0.2922661
129	−43.6	+77.2	15.2	16.1	....	0.3059594
130	+4.2	+84.6	15.10	16.13	22760.347	0.5688389
131	−73.2	+27.4	15.18	15.94	15021.318	0.2976902
132	−53.6	−22.0	15.3	16.1	24290.387	0.3398479
133	−58.6	+43.5	14.89	15.96	15021.482	0.5507230

CATALOGUE—*Continued*

NGC 5272

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
134	−22.4	+52.4	14.9	16.3	24290.282	0.6190
135	−27.0	+38.0	15.0	16.5	....	0.56843
136	−25.4	+33.4	15.6	16.2	....	....
137	+53.0	−18.8	14.9	16.2	15021.155	0.5742061
138	−263.6	+41.9	not variable		....	....
139	+34.5	+28.0	15.25	16.12	22760.465	0.5608270
140	−15.7	+108.9	15.10	15.88	22760.216	0.3331259
141	−1497.5	−249.9	14.9	16.4	....	....
142	−30	−59	15.6	16.6	24290.397	0.56783
143	−34	+16	15.4	16.4	24290.337	0.51111
144	+54	−100	14.8	16.7	24290.565	0.59674
145	+29	+8	14.9	16.5	24290.528	0.5004
146	+96	−59	14.6	16.5	24290.563	0.37308
147	−21	+46	15.1	16.3	24290.005	0.34641
148	−7	+37	15.3	16.4	24290.170	0.46777
149	+34	+52	14.7	16.5	24290.228	0.54985
150	+69	+37	14.8	16.7	24290.359	0.52397
151	+4	−40	14.9	16.3	24290.191	0.51705
152	+77	+50	15.0	16.3	24290.355	0.32641
153	−38	+60	not variable		....	....
154	+2	−29	12.9	14.0	24647:	15.2828
155	−64	−74	.....	.....	....	....
156	−21	−42	not variable		....	....
157	−17	+35	14.2	15.7	24647.650:	0.59713
158	−16	−41	15.2	16.5	24647.564:	0.50809
159	−15	+16	14.9	16.6	24647.602:	0.56594
160	−9	−44	14.9	16.1	24647.446	0.64792
161	+17	−58	15.4	16.4	24647.567:	0.49874
162	+28	−32	not variable		....	....
163	−16	−32	not variable		....	....
164	+21	−36	15.3	15.9	....	....
165	+73	+20	14.7	16.5	24647.544	0.49
166	−97	−8	15.1	16.2	....	....
167	−78	−37	15.4	16.5	24647.448	0.69245
168	−45	+7	14.9	16.0	24647.617	0.37740
169	−29	−35	not variable		....	....
170	−28	+32	15.1	16.1	24647.716:	0.57187
171	−27	+16	15.0	16.1	24647.864	0.30095
172	−21	+25	14.9	16.5	24647.700	0.59400
173	−13	+39	15.2	16.6	24647.670:	0.4988
174	−9	−34	15.1	16.1	24647.710	0.4082
175	+42	+26	14.9	16.2	24647.914	0.60780

CATALOGUE—*Continued*

NGC 5272

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
176	+46	+32	14.8	16.4	24647.621	0.58118
177	+63	−29	15.0	16.3	24647.953	0.34835
178	+79	+46	15.2	16.5	24647.755	0.26480
179	+39	−774	not variable		....	....
180	−19	−27	not variable		....	....
181	−30	−14	not variable		....	....
182	−19	+60	not variable		....	....
183	+29	+7	not variable		....	....
184	−25	−14	14.9	16.4	24647.841	0.517
185	−15	+32	15.2	16.1	....	....
186	+12	−64	15.1	16.1	24647.670	0.675
187	−23	+9	14.9	16.2	24647.961	0.3927
188	−27	+24	15.0	16.0	24647.615:	0.3677
189	−25	−21	15.2	16.0	24647.964	0.668
190	−8	+28	14.8	16.5	24647.936	0.501
191	0	+24	15.1	16.1	24647.981	0.512
192	−2	+3	15.0	16.1	24647.933:	0.525
193	+15	−7	14.8	16.3	24647.777	0.630
194	+17	−13	15.1	16.4	24647.758	0.549
195	−13	−29	15.0	16.2	24647.470:	0.600
196	+47	+ 1	.....	.....	....	....
197	+58	+10	15.1	16.5	24647.689	0.499
198	−23	+15	15.2	16.0	24647.923:	0.3617
199	−19	+13	14.8	16.3	24647.699:	0.488
200	−4	+21	.....	.....	....	....
201	+4	−9	.....	.....	....	....

Refs. 1, 8, 10, 11, 14, 17, 19, 20, 22, 25, 28, 31, 32, 38, 40, 43, 45, 50, 55, 56, 61, 76, 84, 86, 98, 101, 105, 109, 110, 111, 115. Plates in 20 and 25.

The data for this cluster have had to be collected from several sources, as follows: Positions: Nos. 1-137 Bailey, 138-141 Larink, 142-183 Müller, 184-199 Greenstein. Magnitudes and periods from Greenstein. Epochs: 1-153 from Müller, 154-199 Greenstein.

Shapley's publication in 1914 of 23 new stars in this cluster as definitely variable (Ref. 28) appears to have been confused with his several lists of suspected variables. Accordingly several observers have announced as new, variables which Shapley had definitely found earlier. The writer's careful checking of all Shapley's variables against variables 142-199 results in the conclusion that all but two of Shapley's variables have later been announced by some one else. These two are therefore numbered 200 and 201. Shapley's co-ordinates were published in right ascension and declination. Using von Zeipel's value of the cluster centre, the writer has transformed these to x and y in seconds of arc, for purposes of comparison. As the identification of Shapley's variables with those announced later is not always a positive one, a table giving the comparison of Shapley's computed x and y with the variables is given. A correction to Shapley's origin of $+2''$ in x, and $-4''$ in y appears to bring the two sets of co-ordinate systems into correspondence. Eight of the stars suspected variable by Shapley in 1914 are to be found on the lists of variables announced later.

CATALOGUE—*Continued*

NGC 5272

IDENTIFICATIONS OF SHAPLEY'S ANNOUNCED VARIABLES

Shapley's Variables	Shapley's Positions x''	Shapley's Positions y''	Permanent No.	x''	y''
1	−66	−70	155	−64	−74
2	−32	−55	142	−30	−59
3	−29	+21	171	−27	+16
4	−27	−17	189	−25	−21
5	−23	−25	? 180	−29	−27
6	−22	−38	156	−21	−42
7	−18	+40	157	−17	+35
8	−17	−36	158	−16	−41
9	−16	+20	159	−15	+16
10	−11	−40	160	−9	−44
11	−10	+33	190	−8	+28
12	−6	+25	200	−4	+21
13	−4	+7	192	−2	+3
14	+2	−5	201	+4	−9
15	+12	−3	193	+15	−7
16	+15	−9	194	+17	−13
17	+16	−53	161	+17	−58
18	+25	+13	183	+29	+7
			145 prob.	+29	+8
19	+26	−27	162	+28	−32
20	+32	+31	139	+34 5	+28 0
21	+45	+5	196	+47	+1
22	+57	+14	197	+58	+10
23	+92	−57	? 146	+96	−59

NGC 5286 α 13^h 43^m.0, δ −51° 07′

No variables found in this cluster. Ref. 71. No map.

NGC 5466 α 14^h 03^m.2, δ +28° 46′

No.	x''	y''	Magnitudes Max.	Magnitudes Min.	Epoch of Maximum	Period
1	+858	−95	15.66	16.68	....	....
2	−62	−110	15.68	16.59	....	....
3	−31	−8	15.48	16.55	....	....
4	−80	+9	15.76	16.63	....	....
5	−64	+112	15.58	16.57	....	....
6	+122	−24	.....	.....	....	....
7	−210	−225	15.91	16.59	....	....
8	+23	−6	15.76	16.59	....	....
9	+31	+15	15.72	16.67	....	....
10	+85	+46	15.96	16.62	....	....
11	+117	+68	.....	.....	....	....
12	+17	−88	16.14	16.39	....	....
13	−49	−73	16.01	16.51	....	....
14	−47	+52	15.80	16.47	....	....

Refs. 78, 79. Chart in 78.

CATALOGUE—*Continued*

NGC 5634 α 14^h 27^m.0, δ −05° 45′
4 unpublished variables. Ref. A.

NGC 5694 α 14^h 36^m.7, δ −26° 19′
No variables found. Ref. 104. No map.

NGC 5904 (Messier 5) α 15^h 16^m.0, δ +02° 16′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
1	+28.3	+161.3	14.21	15.57	15021.106	0.5217858
2	−345.0	−29.9	14.58	15.51	15021.508	0.526344
3	+160.9	+113.1	14.68	15.54	15021.575	0.6001873
4	−11.9	+74.2	14.20	15.53	15021.130	0.4496387
5	−7.6	+52.0	14.29	15.60	15021.191	0.545903
6	+27.1	−46.3	14.20	15.20	15021.039	0.5488300
7	−5.0	−191.4	14.26	15.80	15021.478	0.4943870
8	+134.3	−133.8	14.26	15.61	15021.205	0.5462242
9	+196.2	+87.3	14.40	15.50	15021.473	0.6988919
10	+107.9	+381.8	14.17	15.47	15021.353	0.5306634
11	−155.2	+85.3	14.13	15.42	15021.484	0.5958924
12	−175.9	−16.2	14.20	15.76	15021.060	0.4677208
13	+11.8	−65.4	14.20	15.26	15021.418	0.513121
14	−146.4	+104.7	14.50	15.41	15021.466	0.4872364
15	+193.2	+2.9	14.79	15.30	15021.372	0.507743
16	+91.6	+83.7	14.20	15.50	15021.366	0.6476222
17	−27.7	+43.7	14.17	16.4	....	0.60186?
18	+151.9	−108.8	14.60	15.48	15021.436	0.4640011
19	+237.0	−130.8	14.30	15.75	15021.034	0.4699535
20	−256.9	−23.7	14.30	15.31	15021.537	0.6094762
21	+324.1	+72.8	14.54	15.48	15021.469	0.6048955
22	−206.2	+384.2	14.63	16.15	....	....
23	−254.6	−9.6	14.71	15.3	....	....
24	−46.8	−71.5	14.40	15.50	15021.398	0.4783750
25	−29.6	−127.9	13.83	14.73	....	....
26	+22.2	+101.8	14.34	15.40	15021.591	0.622562
27	−6.6	−58.9	14.48	15.58	15021.381	0.4703355
28	+132.9	−121.8	14.45	15.72	15021.460	0.5439475
29	−376.0	−75.1	14.50	15.49	15021.339	0.4514423
30	+23.3	−213.0	14.60	15.50	15021.307	0.5921773
31	+152.0	−142.5	14.66	15.38	15021.193	0.2309690?
32	+202.7	−151.7	14.16	15.60	15021.220	0.4577848
33	−21.1	+127.8	14.34	15.75	15021.296	0.5014729
34	+84.8	+59.2	14.41	15.48	15021.425	0.5681454

CATALOGUE—*Continued*

NGC 5904

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
35	−12.1	−114.7	14.62	15.23	15021.096	0.3083788
36	−7.5	−51.7	14.17	15.78	....	....
37	+44.7	+67.2	14.10	15.76	15021.256	0.4887962
38	−44.0	+117.2	14.34	15.51	15021.414	0.4704310
39	−126.1	−249.5	14.13	15.57	15021.512	0.5890323
40	+125.5	+113.2	14.51	15.78	....	....
41	+19.5	+231.4	14.10	15.68	15021.279	0.4885745
42	−123.8	−120.1	11.20	12.24	15032.48	25.74
43	−202.7	+155.1	14.68	15.43	15021.122	0.660235
44	−102.8	+31.0	14.66	15.23	15021.240	0.2478988
45	−117.5	+65.9	14.37	15.40	15021.080	0.6166379
46	−80.2	+69.6	15.11	16.0	....	variable?
47	−75.4	+58.2	14.28	15.78	15021.050	0.5397330
48	−62.8	+106.4	14.56	15.47	....	variable?
49	+53.1	+177.4	15.16	15.78	....	variable?
50	+38.5	+109.5	13.00	14.20	15101.0	106.0
51	−0.1	+136.2	not variable		....	....
52	+108.7	+35.0	14.25	15.40	15021.216	0.5017575
53	+68.8	+19.2	not variable		....	....
54	+27.1	+56.8	13.83	16.10	....	....
55	+80.3	−163.1	14.75	15.25	15021.106	0.4907365
56	−68.8	+96.9	14.34	15.60	15021.015	0.5346931
57	−30.3	+99.7	14.39	15.47	....	....
58	−608.	+163	14.10	15.56	15021.467	0.4915684
59	−150.9	−34.8	14.26	15.44	15021.229	0.5420250
60	−110.1	+8.6	14.40	15.47	....	0.45?
61	−255.7	−30.2	14.46	15.52	15021.298	0.5686140
62	+167.6	−217.9	14.70	15.34	15021.012	0.2814092
63	+214.0	+50.6	14.23	15.57	15021.412	0.4976776
64	−51.6	−249.2	14.40	15.70	15021.000	0.5445091
65	−160.7	−93.6	14.36	15.52	15021.057	0.4806628
66	+219.7	+405.9	14.69	15.18	15021.194	0.3510465
67	−102.3	−60.	14.17	16.0	....	....
68	+896.	+50.	14.75	15.23	15021.217	0.502136
69	+654.	+751.	14.17	15.44	15021.205	0.4948754
70	+393.	+626.	14.40	15.50	15021.153	0.5585215
71	+661.	+292.	14.26	15.60	15021.027	0.5024678
72	+689.	+38.	14.59	15.49	15021.505	0.5621279
73	+18.3	+605.0	14.22	15.32	21425.710	0.340116
74	+205.6	+162.2	13.45	14.17	....	....
75	+78.6	−413.8	14.70	15.40	15021.501	0.6868916
76	+80.9	−309.8	14.40	15.42	....	....

CATALOGUE—*Continued*

NGC 5904

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
77	−172.7	−184.5	14.50	15.27	15021.108	0.8451077
78	+65.7	+159.4	14.61	15.37	....	....
79	−134.3	−31.7	14.60	15.15	15021.089	0.2498925
80	−48.7	+111.8	14.73	15.25	15021.059	0.2516290
81	−72.5	−121.5	14.57	15.65	15021.510	0.5573287
82	−68.3	+13.1	14.69	15.31	15021.349	0.556012
83	−84.9	−87.6	14.50	15.70	15021.538	0.5533048
84	+43.0	−32.8	11.54	12.61	15027.5	26.5
85	+37.9	−35.1	14.50	15.60	15021.409	0.527046
86	+34.7	−31.6	14.40	15.40	15021.050	0.567901
87	+122.3	−2.3	14.80	15.29	15021.511	0.7383832
88	+65.4	+61.4	14.87	15.38	15021.189	0.2468705
89	+60.4	+64.3	14.53	15.70	15021.518	0.558430
90	−44.8	+15.3	14.31	15.47	15021.070	0.557151
91	−35.9	+35.5	14.60	15.49	15021.172	0.585855
92	−57.0	−122.5	13.83	15.26	....	....

Co-ordinates, magnitudes and epochs from Bailey; periods as determined by Bailey and revised by Shapley and Roper.

Refs. 2, 3, 4, 5, 6, 7, 11, 12, 14, 15, 17, 20, 24, 26, 31, 33, 40, 42, 53, 54, 60, 82. Plates in 20 and 33.

NGC 5986 α 15^h 42^m.8, δ −37° 37′

1 variable at a radial distance of 1′.7 from center.

Refs. 14, 20. No map.

NGC 6093 (Messier 80) α 16^h 14^m.1, δ −22° 52′

1	−137.6	+79.7	.....	.....	....	....
2	+22.5	−19.0	.....	.....	....	.....
Nova	+4.0	+2.7	6.8	.....	....	.....

Refs. 20, 69, 122. Plate in 20. Ref. 122 contains a complete bibliography of references on the nova.

NGC 6121 (Messier 4) α 16^h 20^m.6, δ −26° 24′

1	−281	+42	13.73	14.19	.....	.....
2	−248	−195	13.87	14.36	....	.....
3	−208	−507	13.04	14.37	20684.736	0.5066293
4	−185	−340	11.43	12.25	.....	.

CATALOGUE—*Continued*

NGC 6121

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
5	−185	−93	14.08	14.24	....	....
6	−115	+318	13.65	14.18	....	....
7	−113	+231	13.88	14.72	23307.556	0.5347988
8	−110	+111	13.01	14.38	23221.536	0.5081713
9	−104	+105	13.76	14.64	....	....
10	−68	+159	13.03	14.64	23914.687	0.4823935
11	−64	−297	13.42	14.59	22105.782	0.4930734
12	−53	−207	14.03	14.79	26178.679	0.4461313
13	−47	+270	12.37	13.08	....	....
14	−47	−244	13.82	15.16	23593.585	0.4635316
15	−32	+436	13.98	14.71	23877.741	0.4438676
16	−29	+69	13.58	14.47	23249.656	0.5425413
17	−8	+20	not variable		....	....
18	+4	+27	13.54	14.78	20685.714	0.470
19	+11	+358	13.37	14.37	23610.551	0.4678131
20	+13	−63	13.7	14.3	....	....
21	+19	−4	12.90	14.18	22163.683	0.4719722
22	+34	+80	13.72	14.20	....	....
23	+38	−26	13.37	14.17	....	....
24	+49	+48	13.37	14.77	20626.811	0.5174238
25	+70	+70	13.45	14.18	....	....
26	+94	−72	13.64	14.77	20685.714	0.5412222
27	+118	+255	13.38	14.24	23280.513	0.6120161
28	+259	+84	13.37	14.18	20685.714	0.5223606
29	+326	+598	13.19	14.61	23249.555	1.097452
30	+340	−69	13.28	14.06	23249.656	0.3697670
31	+353	+45	12.98	14.18	23914.686	0.5053175
32	+746	−40	13.51	14.31	....	....
33	+805	+630	13.3	14.1	21078.568	0.6148267

Refs. 21, 90, 93. Plate in 90. Magnitudes from B.

NGC 6171 α 16^h 29^m.7, δ −12° 57′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
1	−112.8	−522.0	]14.16	[16.75	....	......
2	+148.8	−388.8	15.62	16.29	....	......
3	−224.4	−183.6	15.55	16.14	....	....
4	−99.6	−156.6	15.64	16.14	....	......
5	+231.0	−161.4	15.74	16.21	....	......
6	−10.8	−67.2	15.68	16.15	....	......
7	+42.0	−61.2	15.57	16.64	....	....
8	+12.0	−42.0	15.57	16.52	....	....

CATALOGUE—*Continued*

NGC 6171

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
9	−26.4	−19.8	15.91	16.33	....	....
10	−57.0	+8.4	15.48	16.65	....	....
11	+9.6	+33.0	15.69	16.46	....	....
12	+58.8	+61.2	15.27	16.48	....	....
13	−27.0	+72.0	15.45	16.59	....	....
14	+17.4	+82.2	15.35	16.45	....	....
15	+19.2	+120.0	15.57	16.12	....	....
16	−67.2	+113.4	15.69	16.51	....	....
17	−99.0	+71.4	15.35	16.45	....	....
18	+77.4	+215.4	15.75	16.46	....	....
19	+232.8	+162.6	15.77	16.25	....	....
20	+31.2	+51.0	15.66	16.40	....	....
21	+81.0	−144.6	16.33	16.78	....	....
22	−1354.2	−183.0	.....	.....	....	....
23	−263.4	+19.2	15.61	16.13	....	....
24	0.0	+8.4	15.66	16.46	....	....

Ref. 121, with chart.

NGC 6205 (Messier 13) α 16^h 39^m.9, δ +36° 33′

1	+91.1	−24.9	13.7	14.9	....	6.0
2	−67.4	−3.0	12.85	13.8	....	5.10
3	−159.2	+16.5	15.2	16.11	....	....
4	−59.0	+58.2	15.33	15.86	....	....
5	+89.3	−14.1	14.6	15.8	....	....
6	+115.5	+76.6	14.0	14.74	....	....
7	−49.6	−82.7	14.7	15.16	....	....

3 unpublished variables.

Co-ordinates of variables taken from Ludendorff's Catalogue (*Potsdam Pub.*, v. 15, no. 50, 1905).

Refs. 11, 18, 20, 23, 27, 29, 30, 37, 40, 76. Plate in 20.

NGC 6218 (Messier 12) α 16^h 44^m.6, δ −01° 52′

1	+34	−62	11.9	13.2	27306.708	15.508

Refs. 11, 102, 113, 123, 124. Plate in 123.

NGC 6229 α 16^h 45^m.6, δ +47° 37′

1	−5	−38	15.4	15.8	.....	.....

20 unpublished variables.

Refs. 36, 113, A. No map.

CATALOGUE—*Continued*

NGC 6254 (Messier 10) α 16h 54m.5, δ −04° 02′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
1	+5	+22	13.2	13.8	....	....
2	+30	+120	11.9	13.7	26607.712	18.754

Refs. 14, 102, 113, 123, 124. Plate in 123.

NGC 6266 (Messier 62) α 16h 58m.1, δ −30° 03′

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period
1	+41.0	+6.1	.....	.....	....	....
2	−26.6	−68.9	.....	.....	....	....
3	−89.2	−5.8	.....	.....	....	....
4	−94.6	−39.6	.....	.....	....	....
5	−163.4	+123.4	.....	.....	....	....
6	−81.2	+33.1	.....	.....	....	....
7	+22.6	+169.1	.....	.....	....	....
8	−94.6	+163.4	.....	.....	....	....
9	−92.7	+214.0	.....	.....	....	....
10	−452.7	+160.0	.....	.....	....	....
11	−456.2	+128.3	.....	.....	....	....
12	−203.4	+268.9	.....	.....	....	....
13	+1.6	+30.2	.....	.....	....	....
14	−92.2	+264.7	.....	.....	....	....
15	+122.8	+303.0	.....	.....	....	....
16	−74.8	+94.1	.....	.....	....	....
17	−21.4	+102.7	.....	.....	....	....
18	−33.4	+91.4	.....	.....	....	....
19	−15.3	+65.2	.....	.....	....	....
20	+131.4	+159.8	.....	.....	....	....
21	+105.4	+80.6	.....	.....	....	....
22	+62.6	+12.6	.....	.....	....	....
23	−74.3	−37.4	.....	.....	....	....
24	+62.6	−39.0	.....	.....	....	....
25	+150.4	−73.4	.....	.....	....	....
26	−186.8	−302.1	.....	.....	....	....

Refs. 14, 20. Plate in 20.

NGC 6293 α 17h 07m.1, δ −26° 30′

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period
1	+81.0	+49.5	.....	.....	....	....
2	−135.6	+64.5	.....	.....	....	....
3	+48.6	+18.6	.....	.....	....	....

Ref. 51. No map.

CATALOGUE—*Continued*

NGC 6333 (Messier 9) α 17^h 16^m.2, δ −18° 28′
1 unpublished variable. Ref. 87.

NGC 6341 (Messier 92) α 17^h 15^m.6, δ +43° 12′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
1	+127.5	+41.3	14.44	15.48	27340.211	0.702807
2	+91.2	+69.2	14.56	15.51	27340.329	0.643886
3	+53.7	+252.7	14.57	15.59	27340.344	0.637494
4	−76.0	+58.0	14.52	15.43	27340.111	0.628911
5	+81.6	−53.7	14.55	15.43	27340.302	0.619707
6	+38.7	+43.3	14.53	15.40	27340.360	0.600001
7	+1.6	−50.5	14.14	14.58	27340.373	0.515075
8	+208.9	+208.0	14.73	15.43	27340.366†	0.401895
9	+18.0	−48.1	14.73	15.43	27340.218	0.377949
10	+83.0	+36.3	14.75	15.29	27340.283	0.377315
11	+71.2	−67.1	14.74	15.29	27340.301	0.235734
12	−29.9	−97.8	14.80	15.16	27340.009	0.225130
13	+153.4	−60.1	14.93	15.08	....	....
14	−316.0	+245.7	14.80	15.10	27340.089	0.346178*
15	+30	−102	14.6	15.2	....	....
16	−2	+77	14.0	14.5	....	....

†Two epochs given.

*Variable No. 14 is of the W UMa type.

Refs. 64, 76, 114, 120, 125, C. Plate in 120, but the numbers of the variables marked on the plate are those assigned by Nassau and do not correspond with the numbers as listed here, which were assigned by Hachenberg. Most of the variables were discovered independently by Guthnick and Prager, and by Nassau. The numbering of the German astronomers has been adopted, since they first published references to the variables and the periods, although the identification was first published by Nassau.

The correspondence in numbering is as follows:

Hachenberg	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Nassau....	7	3	1	8	6	2	5	4	9	13	11	..	14	..

Variable No. 11 was first found by Miss Woods in 1922.

Nassau's variables 10 and 12 were not found by the German observers and I have assigned them numbers 15 and 16 respectively.

NGC 6362 α 17^h 26^m.6, δ −67° 01′

1	00	00	.....	.....	....	....
2	−29	−100	.....	.....	....	....
3	−83	−89	.....	.....	....	....

CATALOGUE—*Continued*

NGC 6362

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
4	−79	−88	.....	.....	....	....
5	+81	−14	.....	.....	....	....
6	+54	+175	.....	.....	....	....
7	+22	+104	.....	.....	....	....
8	−263	+108	.....	.....	....	....
9	−207	+138	.....	.....	....	....
10	+186	+352	.....	.....	....	....
11	−28	+48	.....	.....	....	....
12	−245	−104	.....	.....	....	....
13	−234	−120	.....	.....	....	....
14	+370	+28	.....	.....	....	....
15	+51	+2	.....	.....	....	....

2 unpublished variables.
Refs. 47, 87. No map.

NGC 6366 α 17ʰ 25ᵐ.1, δ −05° 02′
6 unpublished variables. Ref. E.

NGC 6397 α 17ʰ 36ᵐ.8, δ −53° 39′

1	+210.7	+448.4	11.2	16.0	13727.6	314.6
2	−279.0	−424.6	13.8	14.8	....	45. or 60. ?

Refs. 11, 20, 66, 90. Plate in 20.

NGC 6402 (Messier 14) α 17ʰ 35ᵐ.0, δ −03° 13′

1	+17	+47	14.3	16.0	....	18.75
2	−116	−119	15.4	16.3	....	2.7952
3	−3	−90	16.2	17.0	....	....
4	+169	+73	16.3	17.5	....	....
5	−136	+90	16.1	17.5	....	....
6	+34	−77	15.8	16.4	....	....
7	+62	−97	14.9	16.2	....	13.59
8	+96	+35	16.6	17.7	....	....
9	+151	−39	16.3	17.5	....	....
10	−51	−205	16.3	17.4	....	....
11	+196	−223	16.0	17.3	....	....
12	+224	−177	16.2	17.6	....	....
13	−29	−118	16.3	17.6	....	....

CATALOGUE—*Continued*

NGC 6402

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
14	+54	+1	16.2	17.5	....	....
15	−135	+147	16.1	17.5	....	....
16	−79	−36	16.2	17.4	....	....
17	−228	+122	14.8	15.7	....	....
18	+61	−22	16.1	17.7	....	....
19	−128	+2	16.3	17.6	....	....
20	−145	+98	16.3	17.4	....	....
21	+72	+125	16.3	17.4	....	....
22	+70	+95	16.4	17.6	....	....
23	+74	+281	15.9	17.4	....	....
24	−2	+75	16.1	17.6	....	....
25	−28	−312	16.4	17.5	....	....
26	−85	+27	16.5	17.5	....	....
27	−421	+151	15.4	16.2	....	....
28	−465	+372	15.0	16.0	....	....
29	−68	−152	15.7	16.2	....	....
30	+76	−12	16.2	17.5	....	....
31	−41	+32	16.0	17.0	....	....
32	+36	+147	16.2	17.1	....	....
33	−138	+12	16.2	17.3	....	....
34	−70	+26	16.4	17.6	....	....
35	−112	−49	16.2	17.4	....	....
36	+204	−346	16.4	17.5	....	....
37	+5	+18	16.4	17.7	....	....
38	+11	−17	16.0	17.0	....	....
39	+46	−2	16.1	17.6	....	....
40	+253	+310	16.4	17.1	....	....
41	−13	−3	16.0	17.1	....	....
42	+36	+12	15.9	17.1	....	....
43	+68	+23	16.2	17.3	....	....
44	+20	+116	16.3	17.5	....	....
45	−90	+94	15.7	16.4	....	....
46	+91	−66	16.4	17.4	....	....
47	−89	+26	16.5	17.6	....	....
48	−4	+40	16.3	17.7	....	....
49	−98	−19	16.0	16.9	....	....
50	−15	−38	16.1	17.0	....	....
51	+104	−305	16.5	17.5	....	....
52	+82	+39	16.5	17.0	....	....
53	+134	+129	16.4	17.3	....	....
54	+121	+113	16.6	17.6	....	....
55	+33	+106	16.5	17.5	....	....

CATALOGUE—*Continued*

NGC 6402

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
56	−68	−184	16.4	17.4	....	....
57	+134	−116	16.3	17.6	....	....
58	−123	−34	16.4	17.3	....	....
59	−32	+30	16.4	17.7	....	....
60	+41	+54	16.2	17.7	....	....
61	+12	−43	16.1	17.7	....	....
62	−232	−154	16.5	17.6	....	....
63	+122	−63	16.5	17.4	....	....
64	−51	−169	16.5	17.5	....	....
65	−125	+13	16.4	17.2	....	....
66	−133	+37	16.6	17.4	....	....
67	+34	+14	16.1	17.5	....	....
68	+10	−19	16.6	17.5	....	....
69	+140	+26	16.6	17.3	....	....
70	+43	−23	16.0	17.2	....	....
71	−116	−50	16.5	17.7	....	....
72	+122	−119	16.5	17.5	....	....

Refs. 102, 113, 117, 123. Plate in 123.

NGC 6426 α 17ʰ 42ᵐ.4, δ +03° 12′

10 unpublished variables. Ref. A.

NGC 6535 α 18ʰ 01ᵐ.3, δ −00° 18′

1 unpublished variable. Ref. A.

NGC 6539 α 18ʰ 02ᵐ.1, δ −07° 35′

1 unpublished variable. Ref. A.

NGC 6541 α 18ʰ 04ᵐ.4, δ −43° 44′

1	−54	−100:	12.5	[16.	....	....

Ref. 63, 70. No map.

NGC 6553 α 18ʰ 06ᵐ.3, δ −25° 56′

2 suspected variables. Ref. 51. No map.

NGC 6584 α 18ʰ 14ᵐ.6, δ −52° 14′

No variables in cluster. Ref. 71. No map.

CATALOGUE—*Continued*

NGC 6626 (Messier 28) α 18ʰ 21ᵐ.5, δ −24° 54′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
1	+174.0	+188.5	.....	.....	....	....
2	−47.3	+63.1	.....	.....	....	....
3	−32.9	+111.0	.....	.....	....	....
4	−34.5	+33.6	.....	.. ..	....	....
5	−44.8	+16.4	.....	.....	....	....
6	+34.1	+50.4	.....	.....	....	....
7	+172.2	+102.7	.....	.....	....	....
8	+227.3	−222.3	.....	.....	....	....
9	−158.6	−252.4	.....	.....	....	....

Refs. 11, 14, 20. Plate in 20.

NGC 6656 (Messier 22) α 18ʰ 33ᵐ.3, δ −23° 58′

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period
1	−54.0	−10.0	13.8	14.75	....	0.615542
2	+158.6	+69.2	13.8	14.35	....	0.6428+
3	+214.7	+420.2	14.55	[15.0	....	0.340+
4	−4.0	−68.0	13.6	14.5	....	0.6±
5	−178.2	−33.8	12.0	12.8	... .	7.097?
6	−74.4	−100.0	13.3	14.5	....	0.6±
7	−342.4	+411.2	13.3	14.5	....	0.6495191
8	−39.5	−64.8	12.0	12.7	....	....
9	−211.2	−35.0	12.7	13.3	....	....
10	−39.0	−125.0	13.3	14.6	....	0.6±
11	−14.4	+14.0	12.65	13.9	....	....
12	+0.8	−77.8	14.2	14.5	....	variable ?
13	+76.4	+158.9	13.4	14.55	....	0.6725203
14	+250.8	+486.4	13.8	[15.5	....	200.0
15	+115.3	−83.2	14.0	14.55	....	0.3+
16	+185.0	−17.8	14.0	14.45	.. ..	0.324+
17	−138.0	+126.0	14.6	15	....	....

Refs. 11, 14, 20, 48, 81. Plate in 20.

NGC 6712 α 18ʰ 50ᵐ.3, δ −08° 47′

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period
1	−67	−8	15.9	16.7	.....	....

Several unpublished variables.

Ref. 35, A. No map.

CATALOGUE—*Continued*

NGC 6723 α 18ʰ 56ᵐ.2, δ −36° 42′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
1	+75.6	−197.4	15.10	15.80	23618.56	0.5384149
2	+135.2	−76.9	14.45	16.05	23618.68	0.5048
3	−244.9	+6.0	14.70	15.80	23618.90	0.4949
4	+17.1	+77.4	14.55	15.90	23618.79	0.4524
5	−4.8	+50.8	15.20	16.00	....	0.49
6	+7.1	+46.2	14.90	16.05	23618.80	0.4812
7	+197.9	−70.1	15.20	15.75	23618.91	0.4675
8	+15.9	+10.8	14.75	15.60	....	0.53
9	+73.6	+17.2	14.70	15.80	23618.71	0.5779
10	+149.6	+84.2	15.10	15.60	23618.60	0.33855
11	+133.3	+228.8	14.85	15.65	23618.70	0.5342935
12	+45.1	−45.0	14.95	15.85	23618.53	0.5333
13	−46.8	−70.8	14.80	16.00	23618.48	0.5078
14	−37.9	−43.0	14.95	15.80	23618.91	0.6190
15	−93.4	+165.7	14.40	15.80	23618.74	0.4355162
16	−46.4	+91.6	14.75	15.65	23618.67	0.4114
17	+43.9	−102.0	14.4	15.7	....	0.5301595
18	−139.2	−24:	14.6	15.3	....	0.5263801
19	−174.0	−120:	14.6	15.5	....	0.5347108

The three variables found by van Gent have been given numbers 17, 18, 19.
Refs. 14, 20, 73, 74, 91, 96. Plate in 20, charts in 96.

NGC 6752 α 19ʰ 06ᵐ.4, δ −60° 04′
1 variable, 4′ from cluster centre.
Refs. 11, 14, 20. No map.

NGC 6760 α 19ʰ 08ᵐ.6, δ +00° 57′
2 unpublished variables. Ref. A.

NGC 6779 (Messier 56) α 19ʰ 14ᵐ.6, δ +30° 05′

1	+51.0	+75.6	.....	.....	....	....
*2	+21.0	+54.4	.....	.....	....	....
3	+33.0	+124.5	14.43	15.20	....	....

*Suspected. Several unpublished variables.
Refs. 35, 51, E. Plate in 51.

CATALOGUE—*Continued*

NGC 6809 (Messier 55) α 19^h 36^m.9, δ −31° 03′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
1	+304.2	−55.6	.....	.....	....	....
2	−214.9	−26.0	.....	.....	....	....

Refs. 20, 75, 77. Plate in 20.

NGC 6864 (Messier 75) α 20^h 03^m.2, δ −22° 04′

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period
1	+15.6	−83.4	.....	.....	....	....
2	−9.0	+54.0	.....	.....	....	....
3	+18.0	+85.5	.....	.....	....	....
4	−18.0	−84.6	.....	.....	....	....
5	+108.0	−36.0	.....	.....	....	....
6	+8.4	−81.0	.....	.....	....	....
7	−24.6	+78.0	.....	.....	....	....
8	−13.5	−41.4	.....	.....	....	....
9	+45.6	−24.0	.....	.....	....	....
*10	−43.5	+50.4	.....	.....	....	....
11	+121.2	+84.0	.....	.....	....	....
12	+39.6	+75.0	.....	.....	....	....

*Suspected. Four additional suspected variables, numbered 13-16, are omitted.

Ref. 51, with plate.

NGC 6934 α 20^h 31^m.7, δ +07° 14′

No.	x″	y″	Max.	Min.	Epoch of Maximum	Period
1	−45	−39	15.9	17.3	....	....
2	−40	−14	16.0	17.4	....	....
3	0	+58	15.9	17.3	....	....
4	+39	+58	15.6	17.2	....	....
5	+59	+221	15.9	17.2	....	....
6	−27	−33	16.1	17.5	....	....
7	+92	+59	16.2	17.3	....	....
8	+100	+50	16.3	17.1	....	....
9	+63	+18	15.9	17.4	....	....
10	−135	+72	15.8	17.2	....	....
11	+17	+28	16.6	17.5	....	....
12	+29	−44	15.6	17.1	....	....
13	−47	+25	16.0	17.2	....	....
14	−7	−90	15.8	17.4	....	....
15	+10	−53	15.2	15.8	....	....

CATALOGUE—*Continued*

NGC 6934

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
16	+36	+18	16.1	17.4	....	....
17	−73	−107	16.2	17.4	....	......
18	+49	−8	16.1	17.1	....	....
19	+30	+1	15.9	17.4	....	......
20	−26	+17	16.0	17.3	....	......
21	−35	−3	16.1	17.5	....	....
22	−240	−173	16.0	17.2	....	....
23	−31	−16	16.4	17.4	....	......
24	+37	−53	16.3	17.3	....	....
25	+50	+37	15.9	17.4	....	....
26	+31	−196	16.4	17.2	....	....
27	−148	+180	16.2	17.2	....	....
28	−234	+100	15.7	17.3	....	....
29	−85	−183	15.7	17.3	....	....
30	+161	+127	16.2	17.2	....	....
31	+146	−101	16.0	17.3	....	....
32	−10	+51	15.8	17.1	....	....
33	+37	+12	16.0	17.2	....	....
34	−21	+16	16.1	17.4	....	....
35	+157	−142	16.0	17.5	....	....
36	+10	−35	15.6	17.0	....	....
37	+23	+10	16.0	17.3	....	....
38	+12	−18	16.2	17.3	....	....
39	+8	−16	16.1	17.3	....	....
40	−8	+26	15.7	16.3	....	....
41	+30	−39	16.2	17.5	....	....
42	+55	+20	15.9	17.3	....	....
43	+21	+27	15.9	17.4	....	....
44	−43	−30	15.8	17.3	....	....
45	−32	−9	15.8	17.2	....	....
46	+14	−24	16.4	17.4	....	....
47	+10	−26	16.3	17.3	....	....
48	+33	+52	16.0	17.4	....	....
49	+13	−55	16.2	17.3	....	....
50	+15	−37	16.4	17.3	....	....
51	+7	−25	15.4	16.1	....	....

Ref. 102, 107, 113, 123. Plate in 123.

CATALOGUE—*Continued*

NGC 6981 (Messier 72) α 20^h 50^m.7, δ −12° 44′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
1	+43.5	−54.0	16.40	17.27	22162.97	0.61974
2	+99.0	+194.4	16.00	17.32	22162.817	0.46561
3	−52.5	−58.5	16.25	17.35	22162.968	0.48965
4	−106.5	+37.5	16.16	17.34	22162.90	0.3619
5	−38.4	−21.6	16.40	17.43	22163.738	0.4991
*6	+78.0	+78.6	.....	.....	....	....
7	−3.6	+55.5	16.20	17.29	22163.896	0.52463
8	−6.6	+89.4	16.40	17.32	22163.835	0.5743
9	+11.4	+50.4	16.30	17.34	22162.61	0.5902
10	−48.6	−73.5	16.23	17.32	22163.63	0.5483
11	+57.0	−36.6	16.35	17.32	22162.736	0.3345
12	+9.0	−21.6	16.31	17.17	22163.90	0.4111
13	+13.5	+17.4	16.10	17.15	22161.907	0.54182
14	−13.5	+36.0	16.40	17.06	22163.90	0.5904
15	−64.5	−21.0	16.15	17.30	22163.83	0.5499
16	−4.5	−19.5	16.30	17.37	22163.83	0.5641
17	+3.6	−43.5	16.35	17.32	22162.845	0.56308
18	−26.4	−37.5	15.70	16.28	22162.88	0.52016
*19	+3.0	+112.5	.....	.....	....	....
20	−54.6	+15.0	16.42	17.42	22162.92	0.59555
21	−82.5	+12.6	16.32	17.37	22162.583	0.5310
22	−113.4	+1.5	.....	.....	....	....
23	−99.0	+116.4	16.20	17.25	22163.90	0.5969
24	−15.6	−24.0	16.20	16.55	22161.92	0.4973:
25	−133.5	+67.5	16.45	17.06	....	....
26	−91.5	−45.0	.....	.....	....	....
27	+209.4	−234.0	15.72	17.15	22162.981	0.65885
28	−65.4	+81.0	16.48	17.21	22162.94	0.36381
29	+36.0	−52.5	16.40	17.37	22161.83	0.36865
30	+71.4	−97.5	16.38	16.91	....	....
31	+5.4	+36.6	16.50	17.22	22162.02	0.55465
32	−138.0	−42.0	16.50	17.22	22163.73	0.50544
*33	+2.4	−60.6	.....	.....	....	....
34	−6.0	+7.5	16.06	16.73	....	....

*Suspected.

The two variables first discovered by Miss Davis in 1917 are probably the same as Nos. 3 and 18.

Refs. 36, 51, 52. Plate in 51.

CATALOGUE—*Continued*

NGC 7006 α 20^h 59^m.1, δ +16° 00′

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
1	−177.6	+113.8	.....	.....	....	....
2	−38.0	−38.0	.....	.....	....	....
3	−27.6	+32.8	.....	.....	....	....
4	−24.2	−42.2	.....	.....	....	....
5	−24.2	+36.2	.....	.....	....	....
6	−15.5	−44.8	.....	.....	....	....
7	0.0	−38.0	.....	.....	....	....
8	+31.0	+13.8	.....	.....	....	....
9	+36.2	+15.5	.....	.....	....	....
10	+38.0	−13.8	.....	.....	....	....
11	+141.4	+48.3	.....	.....	....	....

Variables Nos. 2 and 5 were first announced by Shapley and Miss Ritchie in 1920.

Numerous unpublished variables.

Refs. 51, 57, A. No map.

Note added in proof: Hubble reports that one of the stars in this cluster is a long period variable. Ref. G.

NGC 7078 (Messier 15) α 21^h 27^m.6, δ +11° 57′

1	−118.6	+24.4	14.36	15.54	15021.990	1.437478
2	−171.7	+6.0	15.14	15.95	15021.078	0.684270
3	−248.0	−46.8	15.34	16.03	15021.097	0.3891545
4	−112.6	−163.6	15.31	16.08	15021.277	0.3135750
5	−100.3	−212.5	15.33	16.00	15021.291	0.384619
6	+24.4	+76.5	15.20	16.29	15021.603	0.665971
7	+10.1	+73.2	15.56	16.16	15021.134	0.367586
8	−0.6	+126.8	15.22	16.14	15021.330	0.646251
9	+15.6	+138.7	15.12	15.98	15021.425	0.715284
10	+125.6	+1.7	15.50	16.04	15021.370	0.386395
11	+172.3	−21.8	15.28	16.07	15021.243	0.3435678
12	+163.0	−50.7	15.22	16.13	15021.090	0.592934
13	+126.6	−68.8	15.12	16.20	15021.365	0.574961
14	+84.1	−256.2	15.44	16.00	15021.128	0.381999
15	+81.7	−304.1	15.22	16.16	15021.064	0.584386
16	+101.9	+129.8	15.50	15.97	15021.556	0.69464
17	+83.7	+110.6	15.40	15.90	15021.216	0.666979
18	+77.3	+100.4	15.50	16.00	15021.331	0.37816
19	+111.3	+160.4	14.85	16.10	15021.552	0.572293
20	+81.2	−9.8	15.27	16.17	15021.261	0.700570
21	+34.4	−57.5	15.25	16.20	15021.322	0.624690

CATALOGUE—*Continued*

NGC 7078

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
22	−330.8	−45.8	15.18	16.04	15021.566	0.721728
23	+192.0	+256.1	15.07	15.95	15021.198	0.632690
24	−106.7	−6.1	15.42	16.17	15021.055	0.369697
25	+302.9	−10.7	15.10	16.00	15021.499	0.665329
26	+23.5	+331.9	15.33	15.97	15021.272	0.402326
27	+222.5	+248.2	variable ?		....	....
28	+309.9	+534.2	15.19	16.15	15021.632	0.670640
29	+163.3	+212.2	15.13	16.06	15021.281	0.574062
30	−165.0	−3.4	15.42	16.00	15021.293	0.405976
31	−112.6	+245.6	15.30	16.07	15021.375	0.435693
32	−50.4	+107.8	15.14	15.98	15021.066	0.605400
33	−41.2	−29.4	.....	.....	....	....
34	−55.4	−54.5	variable ?		....	....
35	−34.0	−163.6	15.40	16.11	15021.278	0.383997
36	−27.7	−81.6	15.18	16.26	15021.371	0.624142
37	−25.2	−77.4	.....	.....	....	....
38	+7.6	−146.2	15.29	16.16	15021.328	0.375274
39	+20.5	−124.8	15.34	16.14	15021.259	0.389984
40	+131.8	−116.7	15.34	16.00	15021.320	0.377390
41	+62.9	−55.4	.....	.....	....	....
42	+227.5	−36.8	15.34	16.07	15021.110	0.360167
43	+416.7	+103.2	15.25	15.88	15021.041	0.406744
44	+91.3	+3.0	15.20	16.11	15021.373	0.595568
45	+66.9	−31.0	15.19	16.14	15021.521	0.66210
46	+56.0	+33.2	15.40	16.32	15021.210	0.692730
47	+45.7	−4.3	15.32	16.04	15021.604	0.662900
48	+59.7	+150.6	15.35	16.17	15021.266	0.378881
49	+40.3	+166.6	14.75	15.35	15021.037	0.417972
50	+165.0	+100.0	15.35	16.00	15021.262	0.29850
51	+6.2	+91.4	15.51	16.03	15021.158	0.397757
52	+192.4	−22.6	15.12	16.21	15021.106	0.575608
53	−92.6	−111.0	15.28	15.91	15021.301	0.414135
54	+10.8	+88.4	15.58	16.13	15021.210	0.398325
55	+65.3	−18.8	15.49	16.30	15021.675	0.719615
56	+57.4	0.0	15.19	16.11	15021.219	0.570307
57	+75.2	−56.4	15.26	15.97	15021.213	0.348935
58	−55.6	+8.8	15.64	16.32	15021.388	0.420463
59	+41.3	+41.5	15.50	16.10	15021.117	0.565260
60	+53.4	−59.3	15.29	16.00	15021.118	0.691852
61	−67.3	−40.2	15.43	16.16	15021.526	0.61030
62	−71.6	+39.6	15.65	16.26	15021.161	0.38818
63	+49.8	+31.0	15.54	16.11	15021.076	0.67370

CATALOGUE—*Continued*

NGC 7078

No.	x″	y″	Magnitudes Max.	Min.	Epoch of Maximum	Period
64	−46.2	+19.1	15.61	16.24	15021.207	0.351695
65	−102.4	−38.7	15.43	16.18	15021.377	0.756048
66	−68.4	−112.4	15.41	16.10	15021.191	0.379330

8 additional variables without published data (Ref. 74).
Refs. 14, 17, 20, 34, 39, 41, 45, 76, 95, 100. Plates in 20 and 41.

NGC 7089 (Messier 2) α 21h 30m.9, δ −01° 03′

1	+25.6	+79.4	13.2	14.8	26607.800	15.5647
2	−45.8	+71.1	14.6	16.1	21454.971	0.527858
3	+222.9	−39.6	15.1	16.4	26921.936	0.619705
4	−26.8	+31.5	15.2	16.6	26628.644	0.564247
5	−44.4	+2.1	13.2	14.9	26628.644	17.5548
6	+11.8	−45.4	13.2	14.9	22162.928	19.3010
7	+153.0	−189.2	15.1	16.4	27274.901	0.594857
8	−66.9	−56.8	15.1	16.4	27273.896	0.643677
9	−173.2	−128.2	15.2	16.4	27274.901	0.609291
10	+90.6	+38.8	15.2	16.4	27275.909	0.466910
11	+85	+8	12.5	13.7	26607.800	33.600
12	−62	+43	15.1	16.5	26628.776	0.665616
13	−77	+73	15.1	16.4	26921.972	0.706616
14	+83	−68	15.4	16.4	20749.843	0.693785
15	+80	−76	15.7	16.4	26944.880	0.430152
16	−31	−27	15.3	16.5	27275.950	0.655917
17	+2	−63	15.2	16.3	27274.901	0.636434

Refs. 11, 13, 14, 16, 20, 88, 102, 106, 112, 123. Plates in 20 and 112.

NGC 7099 (Messier 30) α 21h 37m.5, δ −23° 25′

1	+30.0	−60.6	.....	.....	....	....
2	+58.6	−126.2	.....	.....	....	....
3	−96.7	−39.6	.....	.....	....	....

Refs. 11, 14, 20. Plate in 20.

NGC 7492 α 23h 05m.7, δ −15° 54′

1	+1.2	+96.6	.....	.....	....	....

Variables numbered 2-5 are only suspected of varying.
8 unpublished variables.
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TWELVE NEW VARIABLE STARS IN THE GLOBULAR CLUSTERS NGC 6205, NGC 6366, AND NGC 6779

BY

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TWELVE NEW VARIABLE STARS IN THE GLOBULAR CLUSTERS NGC 6205, NGC 6366, AND NGC 6779

BY HELEN B. SAWYER

(with Plates XXV and XXVI)

An intensive search of three globular clusters on plates taken with the large reflectors at both the Dominion Astrophysical and the David Dunlap Observatories has resulted in the discovery of a few new variable stars. Material is being accumulated which will enable a determination of the periods in all three clusters. Although each of these clusters is rather poor in variables, at least two of them contain long period Cepheids. The study of even a few variables should yield interesting results.

1. NGC 6205 = MESSIER 13 HERCULIS

Although the great star cluster in Hercules, situated in R.A. $16^h\ 39^m.9$, Dec. $+36°33'$ (1950), is one of the best known objects in the sky, the variable stars in this cluster have received very little attention. It is frequently cited as an example of a globular cluster in which variable stars are practically absent, but the writer's study of this cluster brings the total of known variables to eleven, which are certainly sufficient to make an interesting study. However, in comparison with the clusters Messier 3, Omega Centauri, and Messier 5, the Hercules cluster is poor in variables.

Two variable stars, both of them relatively bright with large ranges, were discovered many years ago in this cluster. Bailey[1] found them in 1898 but did not publish their positions until 1902. Barnard,[2] hearing of Bailey's discovery, independently found Variable No. 2. In 1914 Barnard[3] also announced the discovery of a third variable. Shortly afterward, in his comprehensive study of the Hercules cluster, Shapley[4] announced the discovery of additional variables, refinding those previously announced, so that the total stood at seven. The ranges for several of these were small and no further work has been done in confirming them in the intervening years.

The writer has intensively compared, by the method of positive and negative, about fifty plates of the Hercules cluster, and has found four additional variable stars, besides rediscovering most of those previously announced. About ten other stars were suspected of variability by the writer, and measured on a hundred plates, but finally rejected. The variation was no larger than might be expected from stars in rather crowded regions under different conditions of seeing. One suspected variable is the star Ludendorff 928 which though usually of magnitude 14.8 was found to be definitely fainter on one plate only with a magnitude of 15.2.

Table I lists the variables in the cluster and Plate XXV gives the identification. For variables 3 and 4, found by Shapley, the ranges are small, and the variables near the limiting magnitude of many of the plates. But the writer's plates give no evidence for rejecting them as variables. The other variables on the list have ranges sufficiently large to establish their variability.

The magnitudes of the comparison stars were taken from Shapley's catalogue[5] of the Hercules cluster; the positions are computed from Ludendorff's catalogue.[6] A correction should here be noted to the positions of the first seven variables as catalogued by the writer[7] in 1939. The co-ordinates referred to there as x'' are really $\Delta\alpha''$, and should therefore be multiplied by a factor of .8023 to transform them to x''. Bailey's sequence was used to start the investigation (except for his stars *a* and *b* which are too distant from the centre) but as this was not sufficient to cover the large area of the cluster, supplementary sequence stars were selected close to the variables. This was not so satisfactory a procedure as hoped, since Shapley did not publish magnitudes within 2′ of the centre of the cluster. When accurate magnitudes are determined closer to the centre of the cluster the magnitudes of the variables can then be reduced to them.

When the writer came to measure Shapley's variable Ludendorff 806β on her plates, after much struggling with the measures of this close double star, she became convinced that both its components vary. Shapley's variable is the northern component; accordingly the preceding and southern component of this double is called α. There is a range of a full magnitude in each component, even on plates taken under good seeing conditions.

The eleven variables have been measured on over one hundred plates and a number of the periods determined. The writer expects to publish periods and light curves for these very soon.

In 1900 Barnard[2] published a series of 36 visual observations of Variable No. 2, made mostly during the summer of 1900, and announced a period of 5.10 days. The writer's observations con-

TABLE I

Variable Stars in NGC 6205 = Messier 13 Herculis

No.	Lud.	x''	y''	Magnitudes Max.	Min.	Mean	Discoverer
1	816	+73.06	−24.86	13.1	15.2	14.2	Bailey
2	306	−54.10	− 3.04	12.6	14.0	13.3	Bailey, Barnard
3	135	−127.70	+16.52	15.4	15.8	15.6	Shapley
4	322	−47.34	+58.18	14.9	15.6	15.2	Shapley
5	806β	+71.62	−14.06	14.0	15.1	14.6	Shapley
6	872	+92.68	+76.60	13.5	14.8	14.2	Shapley
7	344	−39.78	−82.72	14.5	15.5	15.0	Barnard, Shapley
8	206	−93.02	+11.29	14.2	15.5	14.8	Sawyer
9	806α	+71.62	−14.06	14.0	15.1	14.6	Sawyer
10	487	− 5.40	−70.73	13.1	14.0	13.6	Sawyer
11	324	−45.78	−75.88	12.9	13.8	13.4	Sawyer

Comparison Stars

Bailey	Lud.	x''	y''	Shapley Mag.
	222	− 82.01	−103.40	12.54
	835	+ 79.03	−115.34	13.23
c	954	+117.50	−217.87	13.45
d	1073	+244.16	−209.44	13.75
e	919	+105.24	−185.88	13.88
f	948	+114.83	−162.85	13.94
g	921	+106.34	−146.85	14.16
h	833	+ 78.40	−234.26	14.52
k	946	+113.83	−139.06	14.71
l	943	+113.11	−150.46	14.80
m	1011	+155.44	−196.23	15.23
n	1035	+177.21	−205.27	15.85
	123	−139.39	− 14.35	15.54
	170	−113.33	− 4.92	14.98
	194	−100.47	+ 38.95	13.58
	195	− 99.55	+ 32.91	15.90
	313	− 51.66	+ 95.81	15.42
	953	+116.93	+ 65.45	15.20
	985	+136.60	− 20.92	14.74
	1001	+145.42	+ 45.61	14.65

firm this period. In a later paper on the Hercules cluster in 1909,[8] he commented that he had determined a period of 6.0 days for Variable No. 1. The writer's observations show that this is an erroneous period.

2. NGC 6366

This little known cluster lies in the constellation of Ophiuchus, at R.A. $17^h 25^m.1$, Dec. $-05°02'$ (1950). It is an outstanding example of the type of globular cluster which is exceedingly faint, but possesses a large angular diameter, like the cluster NGC 5053 investigated by Baade.[9] The modulus adopted in 1929[10] from integrated apparent magnitude and diameter alone, uncorrected for absorption, was 17.34.

A search for variables on 30 existing plates, mostly taken at the David Dunlap Observatory with half-hour exposures has resulted in the discovery of two variable stars. These are fairly conspicuous because of their large ranges and brightness compared with other cluster stars. Variable No. 1 is one of the brightest stars in the cluster. Variable No. 2 is equally bright but is situated at a considerable distance from the centre of the cluster. The other four variables mentioned in D.D.O. Pub. 1, no. 4, could not be confirmed. The observational material is as yet insufficient to determine whether the periods of these variables are greater than one day.

Table II gives the positions of the variables and comparison stars, and the maximum and minimum magnitudes of the variables. The magnitudes are considered as preliminary as they are based on only one sequence plate, exposed for twenty minutes on the cluster and for twenty minutes on Selected Area 109.* The positions were measured by means of a reseau which was oriented by a trail

TABLE II

VARIABLE STARS IN NGC 6366

No.	x''	y''	Magnitudes Max.	Min.	Mean
1	− 26	− 42	15.5	17.0	16.2
2	+305	−390	15.7	16.8	16.2
		COMPARISON STARS			
a	+ 69	−104	14.2		
b	−206	+106	15.1		
c	− 12	− 35	15.5		
d	− 47	− 48	16.0		
e	− 48	− 67	16.7		
f	− 75	− 6	17.1		

*Note added to proof. Two additional sequence plates taken in July, 1940, confirm that these magnitudes are of the right order.

in right ascension. An arbitrary origin was selected as being near the centre of the cluster. This origin is indicated on the print by a cross. Plate XXV shows the cluster with the variables and comparison stars indicated.

Baade[9] and Hubble pointed out in 1927 the similarity between the clusters NGC 5053, 6366 and 6539. As more data are now available on NGC 6366, it is interesting to make a table of comparison of these first two clusters. The writer has estimated the magnitudes of the brightest stars on the one available sequence plate and determined a preliminary modulus from these by the usual method. Unless otherwise noted, the data in Table III are taken from Baade's paper for NGC 5053 or determined by the writer for NGC 6366.

TABLE III

	NGC 5053	NGC 6366
Concentration class[11]	XI	XI
Integrated apparent magnitude[12] (on int. photographic scale[13])	10.9	12.1
Angular diameter (large scale plates)	13′.4	12′
Number of variables	9	2
Median magnitude of variables	16.19	16.2
Magnitude 25 brightest stars	15.65:	15.78
Magnitude 6th brightest star	15.1	14.2
Magnitude 30th brightest star	16.0	16.5
Colour excess[14]	0.0*	.55
Modulus uncorrected for absorption	16.20	16.2
Modulus corrected for absorption (if pg. abs. = 9 times colour excess[15])	16.2	11.2
Distances allowing for absorption	17,400 parsecs	1,740 parsecs
Galactic longitude	309°	346°
Galactic latitude	+78°	+15°

*Assumed

The extreme faintness of these clusters combined with their large angular diameters has made it difficult to obtain measures of integrated brightness or diameter from small scale plates. Shapley and Sayer[16] did not measure the angular diameter of either. The diameter of NGC 6366 was determined as 4′: by Shapley and Sawyer,[17] while Baade has estimated that a diameter of 6′.25 contains 90% of the stars in NGC 5053.

A comparison of the absolute magnitudes of these two clusters should be of great interest. Christie[13] has not yet determined the integrated magnitude of either with the schraffierkassette, and the magnitudes in NGC 6366 must be regarded as preliminary. But if we use the data available at present, and Christie's formula, we derive a value of −5.3 for NGC 5053 and −4.0 for NGC 6366. These clusters are at the lower end of the luminosity scale for globular clusters.

But although these clusters are very similar in appearance they differ radically in their position in the sky. NGC 5053 is near the north galactic pole, whereas NGC 6366 is toward the general direction of the galactic centre. Stebbins and Whitford gave a colour excess of 0.55 magnitudes for NGC 6366. They were unable to determine that for NGC 5053, stating it "too faint and diffuse for measurement of color," but they determined the colour excess of NGC 5024, only a degree away, as 0.0 magnitudes. If the ratio of total photographic absorption to colour excess is large, as much as 9, the latest value given by Stebbins, Huffer and Whitford, then, corrected for absorption, the brightest stars in NGC 6366 are of the eleventh magnitude. Since there is no absorption correction to be applied to NGC 5053 the bright stars remain in the fifteenth magnitude. Therefore the similarity in appearance of magnitude in these clusters is caused by the absorbing cloud. NGC 6366 may be one of the nearest globular clusters.

3. NGC 6779 = Messier 56.

This cluster is one of the most northern of the globular clusters, situated at R.A. $19^h 14^m.6$, Dec. +30°05′ (1950). It is in a rich region of the sky, at galactic latitude +8°, and has the appearance of a knot of stars in a rich star field, though it is, of course, definitely a globular cluster. The cluster is classed as X on the basis of its central concentration[11]; the angular diameter as determined by Shapley and Sayer[16] is 7′.2, but the writer's plates indicate at least 10′. This diameter is similar to that of NGC 6366 but the appearance of the cluster is vastly different. The magnitude of the 25 brightest stars is 15.31.[10]

Several investigators have previously worked on this cluster. Miss Helen Davis[18] first published the discovery of a variable star in this object, commenting that the variable was one of the brightest stars in the cluster at maximum. Later, Shapley[19] published the discovery of one variable, one suspected variable, and Miss Davis' star. At about the same time Küstner[20] published an extensive catalogue of the positions and magnitudes of 532 stars in this cluster but did not work especially with the variables. Since 1920 the cluster has been apparently untouched.

The writer has examined carefully about 35 David Dunlap Observatory photographs and has found six new variable stars. The two variables found by Miss Davis and by Shapley are very definitely confirmed, but the one suspected by Shapley is neither confirmed nor rejected. The star which the writer identified as Shapley's suspected variable has only a small variation, if any, on these plates. One of the new variables found by the writer is quite definitely the brightest star in the cluster at maximum. It is estimated that about 500 stars were searched for variability, of which, however, probably only half are actually members of this cluster.

Table IV gives the positions and magnitudes of the variables and comparison stars. The sequence was established by means of

TABLE IV

Variable Stars in NGC 6779

No.	Küstner No.	x''	y''	Magnitudes Max.	Min.
1	363	+ 44.69	+ 74.10	15.0	16.2
2	326	+ 18.16	+ 33.09	15.1	15.6
3	337	+ 25.10	+ 91.69	14.2	15.1
4	141	−112.13	−159.46	15.9	16.4
5	305	+ 6.79	−134.78	14.5	15.0
6	284	− 2.02	+ 37.05	12.9	14.8
7	504	+293.48	−213.24	15.5	16.2
8	150	− 97.63	−335.90	15.9	16.6
9	...	+177	+525	15.5	16.1

Variable No. 6 has a close companion, Küstner No. 285

Comparison Stars

				Magnitudes Küstner	Sawyer
a	412	+ 87.34	+159.20	12.10	11.5
b	195	− 62.15	+115.95	13.46	13.0
c	161	− 88.77	+108.70	13.82	13.5
d	117	−144.19	−105.88	14.43	14.8
e	85	−205.82	− 22.66	15.22	15.2
f	125	−133.19	− 81.48	15.33	15.8
g	118	−141.12	− 82.35	16.01	16.3
h	...	−168	− 82	.....	16.7
k	...	−176	− 76	.....	17.0

two plates with exposures on Kapteyn Area 64 of 15 and 20 minutes' duration. The magnitude of the sequence stars as determined by the writer agrees with Küstner's magnitude at 15.2, but diverges at the ends, particularly for the brighter stars. The positions of the variables are taken from Küstner's Catalogue except for Variable No. 9, which is outside the limits of this catalogue and was measured on a D.D.O. plate with a reseau. The positions of the comparison stars also are taken from Küstner except for stars *h* and *k* which were too faint to be included in his catalogue and were measured on plates here and reduced to Küstner's origin. The variables and comparison stars are marked on Plate XXVI.

From an inspection of the measures on the existing plates it would appear that several of these variables probably have periods greater than one day. The fainter variables are probably cluster type Cepheids. At present 56 plates are available for this cluster. It is hoped that at the end of another season the plates will be sufficiently numerous for a determination of the periods in this cluster. It should prove an exceedingly interesting one.

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[18]Davis, *P.A.S.P.*, v. 29, p. 210, 1917.
[19]Shapley, *Mt. W. Cont.*, no. 190, 1920.
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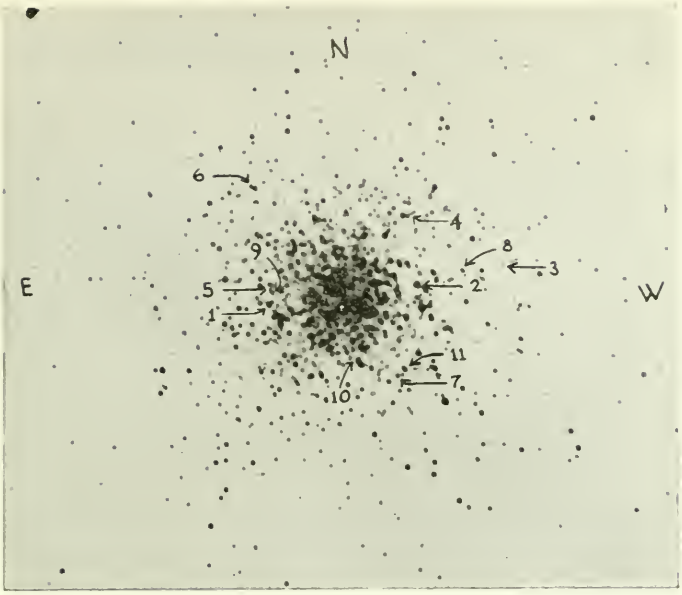
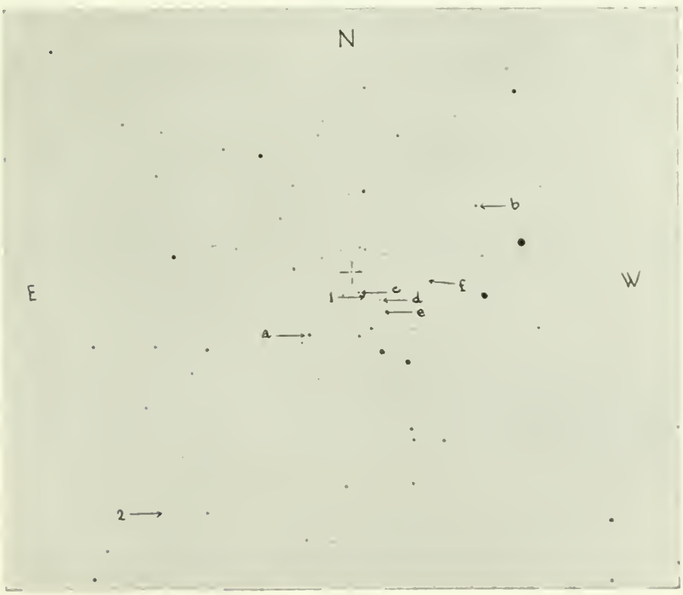
Richmond Hill, Ontario,
July 2, 1940





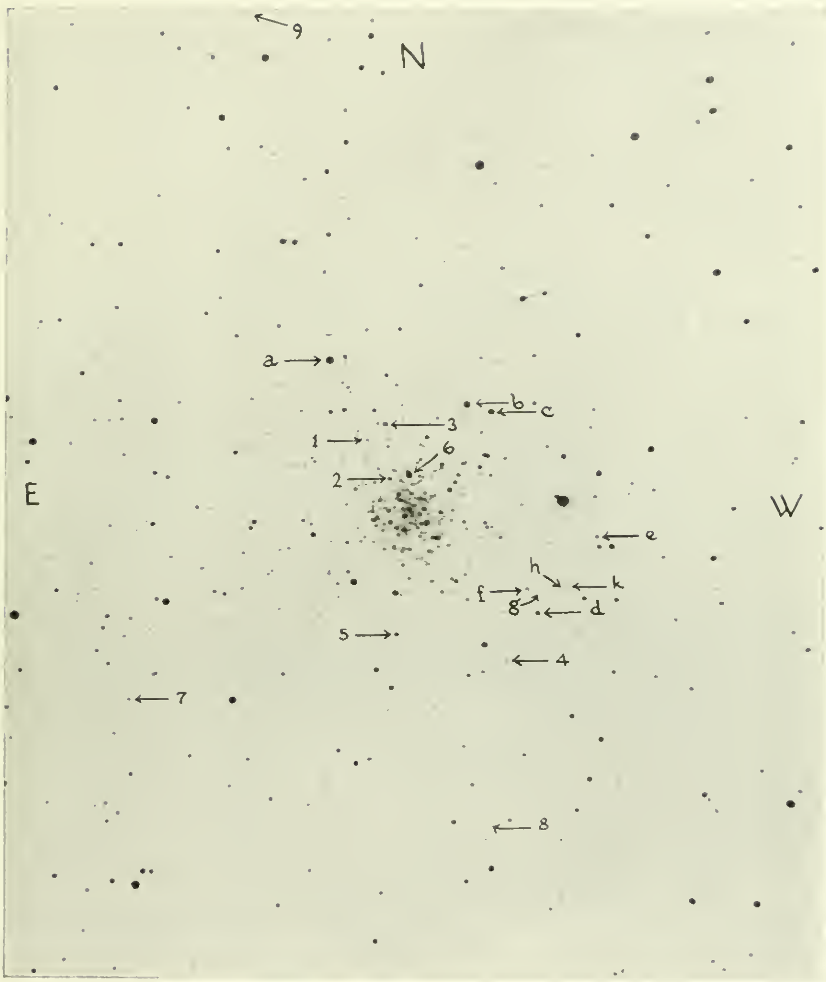
Upper. The globular cluster NGC 6205 = Messier 13 Herculis, with the eleven variables indicated. Comparison stars have been omitted to avoid congestion.

Scale, 1mm = 6″.4. Enlarged from D.D.O. plate 4816, 1939 Aug. 14.

Lower. The globular cluster NGC 6366, a heavily obscured object, showing two variables and comparison stars.

Scale, 1mm = 12″.2. Enlarged from D.D.O. plate 1996, 1937 June 5.

PLATE XXVI.



The globular cluster NGC 6799 = Messier 56, showing nine variables and comparison stars.
Scale, 1 mm = 8″.2. Enlarged from D.D.O. plate 4967, 1939 Sept. 11.

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VOLUME I NUMBERS 6, 7, 8

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 1826

By G. H. Tidy

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 9312

By John F. Heard

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 22124

By Ruth J. Northcott

1940
THE UNIVERSITY OF TORONTO PRESS
TORONTO, CANADA

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 1826

By G. H. Tidy

THE star H.D. 1826, $\alpha(1900)\ 00^h17^m.6$, $\delta(1900) +28°56'$, vis. mag. 6.89, type A5, was announced as a binary in D.D.O. Publications, Vol. I, No. 3. Forty-four plates given in Table I have been made the basis of a least-squares solution for the orbital elements. The spectrum is characterized by many fine well-defined metallic lines ; 39 lines were used in all. The wave-lengths based on the system given in the reference above were corrected to give a zero residual for each line.

TABLE I

J.D. 242	Vo Km./sec.	Phase from final T	Vc Km./sec.	Vo − Vc Km./sec.
8036.806	+28.1	1.290	+27.8	+ 0.3
379.865	−07.4	2.892	− 7.7	+ 0.3
412.768	−28.6	2.963	−18.0	−10.6
776.806	+38.0	2.560	+25.4	+12.6
9188.654	−26.6	0.719	−26.6	0.0
89.696	+51.4	1.761	+55.4	− 4.0
91.644	−49.2	0.426	−47.0	− 2.2
97.630	−34.8	3.129	−33.7	− 1.1
99.626	+53.9	1.841	+57.0	− 3.1
9200.614	−04.0	2.830	− 3.3	− 0.7
02.619	+49.1	1.551	+46.6	+ 2.5
03.615	+20.2	2.547	+27.0	− 6.8
06.619	+48.2	2.268	+47.7	+ 0.5
07.582	−46.3	3.231	−41.5	− 4.8
09.603	+53.7	1.969	+57.6	− 3.9
12.584	+52.8	1.667	+52.2	+ 0.6
13.585	+14.7	2.668	+14.3	+ 0.4
14.555	−48.4	0.354	−48.4	0.0
17.576	−48.8	0.092	−48.9	+ 0.1
18.563	+05.9	1.079	+08.3	− 2.4
23.595	+01.8	2.828	− 2.8	+ 4.6

TABLE I—continued

J.D. 242	Vo Km./sec.	Phase from final T	Vc Km./sec.	Vo−Vc Km./sec.
26.557	+30.3	2.507	+30.5	− 0.2
28.547	+17.5	1.213	+21.0	− 3.5
30.533	−40.5	3.200	−39.5	− 1.0
34.527	−37.3	0.627	−34.4	− 2.9
47.571	−41.4	0.538	−40.7	− 0.7
52.524	+50.9	2.208	+51.0	− 0.1
9496.818	−46.8	0.258	−50.8	+ 4.0
500.751	+07.3	0.908	−08.6	+15.9
02.804	−13.4	2.958	−17.2	+ 3.8
03.848	−37.3	0.721	−26.4	−10.9
09.781	−42.0	0.088	−48.8	+ 6.8
10.769	+07.4	1.076	+ 7.9	− 0.5
12.803	−31.9	3.110	−39.5	+ 7.6
24.752	+61.6	1.926	+57.7	+ 3.9
30.785	+24.0	1.393	+36.0	−12.0
38.694	−05.4	2.735	+07.0	−12.4
40.700	+37.8	1.458	+40.8	− 3.0
56.628	+01.6	0.970	− 2.8	+ 4.4
68.624	−30.0	3.116	−32.8	+ 2.8
87.639	+45.4	2.431	+36.9	+ 8.5
92.568	−31.7	0.794	−19.7	−12.0
96.461	+51.1	1.403	+36.8	+14.3
9602.473	−04.5	0.849	−13.5	+ 9.0

The observations given in Table I were first plotted on a single cycle and reduced to 29 normal places. A preliminary orbit was then obtained by a graphical method and the residuals left treated by the method of least squares to give the final elements given below. All six elements are included in the solution.

FINAL ELEMENTS

Period	$P=$ 3.28325 days	$\pm$ .000029
Eccentricity	$e=$ .056	$\pm$ .016
Angle of periastron	$\omega=151°.63$	± 21.5
Date of periastron	$T=$ J.D. 2429191.218	$\pm$ .194
Velocity of system	$\gamma=$ +5.90 km.	$\pm$ 0.66
Semi-amplitude	$K=$ 54.49 km.	$\pm$ 0.96
$a \sin i$	= 2,460,000 km.	
$\frac{m_1^3 \sin^3 i}{(m_1+m)^2}$	= .055$\odot$	

Figure 1 shows a plot of the individual observations. The residuals in Table I yield a probable error of a single plate 3.9 km.

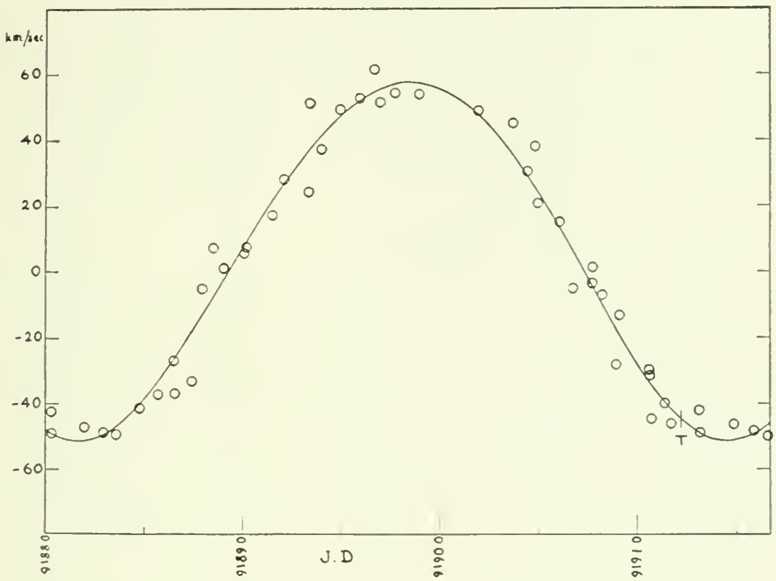


Fig. 1. Radial Velocity Curve of H.D. 1826

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 9312

By John F. Heard

The star H.D. 9312, α(1900) $01^h\,26^m.6$, δ(1900) $+16°28'$, vis. mag. 6.81, type G5, was announced as a spectroscopic binary from 19 plates taken at this observatory in the course of a recent radial velocity program.[1] Since then 16 additional plates have been obtained. The orbit here presented has been determined from these 35 plates which are dated from September 18, 1935, to February 15, 1940. All the spectrograms have been taken with the 12-inch camera of the one-prism spectrograph, an arrangement giving a dispersion of about 66 A/mm. at Hγ.

The spectrum of H.D. 9312 is of average quality for G5 type. On our spectrograms upwards to 28 lines may be measured in the region 4005 to 4415. Some of these lines, however, notably 4045, 4101, 4143, 4254, 4260, have consistently large velocity residuals when the standard wave-lengths[1] are employed—an effect, no doubt, of blending. Accordingly, corrections were applied to the velocities of 11 lines for which the residuals were well marked. These corrections do not affect the velocities from well-exposed plates on which all the lines involved are measurable; they do appreciably affect the velocities from under-exposed plates.

Table I shows the preliminary elements derived by R. K. Young's graphical method and the final elements derived from a least-squares solution using 23 normal places. Reduction of Σpv^2 was from 787 to 702.

Table II shows the data for the individual plates. Considering the observations numbered serially, the following were grouped: 6, 7, 8; 9, 10; 11, 12; 23, 14; 15, 16; 18, 20; 26, 27, 28; 29, 30, 31; 33, 34. Weights were assigned according to numbers of plates.

TABLE I

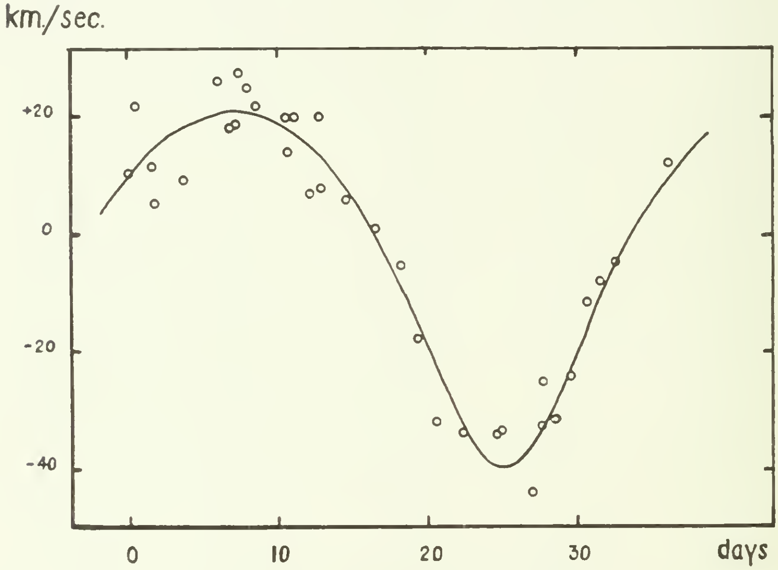
	Preliminary	Final	
Period	$P=$ 36.64 days	36.588 days	$\pm$ .024
Eccentricity	$e=$ 0.20	.203	$\pm$ .031
Angle of periastron	$\omega=165°$	178°.8	+8.3
Date of periastron	$T=$J.D. 2428085.75	2428088.87	$\pm$1.24
Velocity of system	$\gamma=-2.9$ km.	-3.49	$\pm$0.57
Semi-amplitude	$K=$ 29.5 km.	29.97	$\pm$0.88
$a \sin i$	=	14,780,000 km.	
$\dfrac{m_1^3 \sin^3 i}{(m_1+m)^2}$	=	.0964$\odot$	

[1]Pub. D.D.O. vol. I, no. 3, 1939.

TABLE II

J.D. 242	Vo Km./sec.	Phase from final T	Vc Km./sec.	Vo−Vc Km./sec.
8063.788	+10.2	0	+10.1	+ .1
8771.828	+19.6	12.862	+13.0	+ 6.6
8786.804	−25.4	27.838	−32.7	+ 7.3
8806.782	+19.5	11.228	+16.6	+ 2.9
9130.902	+25.8	6.053	+20.2	+ 5.6
9197.668	+11.3	36.231	+ 8.7	+ 2.6
9199.673	+11.4	1.648	+14.4	− 3.0
9201.720	+ 9.0	3.695	+17.9	− 8.9
9205.684	+27.1	7.659	+20.4	+ 6.7
9206.701	+21.5	8.676	+20.0	+ 1.5
9208.603	+19.4	10.578	+17.7	+ 1.7
9208.782	+13.9	10.757	+17.6	− 3.7
9212.613	+ 5.6	14.588	+ 7.2	− 1.6
9214.592	+ 0.7	16.567	− 0.3	+ 1.0
9218.604	−32.1	20.579	−22.1	−10.0
9222.683	−34.2	24.658	−39.7	+ 5.5
9226.616	−31.9	28.591	−29.0	− 2.9
9247.519	+ 7.4	12.905	+13.0	− 5.6
9278.526	+18.4	7.324	+20.4	− 2.0
9283.476	+ 6.7	12.274	+14.3	− 7.6
9289.510	− 5.6	18.308	− 9.1	+ 3.5
9498.851	+24.7	8.119	+20.1	+ 4.6
9517.828	−44.2	27.096	−35.8	− 8.4
9527.817	+21.7	0.497	+11.6	+10.1
9570.694	+17.9	6.786	+20.4	− 2.5
9591.665	−32.9	27.757	−33.1	+ 0.2
9592.616	−31.8	28.708	−28.7	− 3.1
9593.601	−24.4	29.693	−23.2	− 1.2
9594.617	−12.0	30.709	−16.3	+ 4.3
9595.592	− 8.4	31.684	−10.4	+ 2.0
9596.558	− 5.3	32.650	− 5.6	+ 0.3
9625.517	−33.5	25.020	−39.5	+ 6.0
9656.510	−18.0	19.425	−15.2	− 2.8
9659.484	−33.9	22.399	−32.7	− 1.2
9675.497	+ 5.2	1.824	+14.9	− 9.7

Since, with our telescope and seeing conditions, it is hardly practicable to study spectroscopic binaries of this magnitude and fainter with higher dispersion than that used here, it is of some interest to notice the degree of accuracy which may, apparently, be expected. From the solution the probable error of a single observation comes out to be 3.2 km./sec. The larger part of this is to be regarded as arising from the difficulty of measuring the plates, since the average probable error of an observation as computed from inter-agreement of the lines is 1.7 km./sec. The remaining part must represent instrumental errors arising from such effects as focus, temperature, flexure. These, like the errors of measurement, will be expected to be greater with lower dispersion.



Radial Velocity Curve of H.D. 9312

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 22124

By Ruth J. Northcott

THE star H.D. 22124, $\alpha(1900)\ 3^h28^m.8$, $\delta(1900)+31°41'$, vis. mag. 6.76, type F2, was announced as a spectroscopic binary from six plates taken at this observatory in 1935-38.[1] Forty-four spectrograms between the dates 1935 and 1939 have been made the basis of a least-squares solution for the orbital elements. All the spectrograms save the first have been taken with the 12-inch camera and one-prism spectrograph giving a dispersion of 66 A/mm. at $H\gamma$.

The velocities are based on the system of wave-lengths published in D.D.O. Publications, Vol. I, No. 3, but were corrected so that the sum of the residuals for each line of this particular star was zero. In all, 30 lines were used in obtaining the velocities given in Table I.

TABLE I

J.D. 242	Vo Km./sec.	Phase from final T	Vc Km./sec.	Vo−Vc Km./sec.
8082.822	+52.4	1.105	+51.6	+ 0.8
8432.830	+19.2	0.946	+14.6	+ 4.6
8784.879	+02.8	0.175	+05.1	− 2.3
8838.764	+22.1	1.005	+30.7	− 8.6
9146.892	+31.4	0.084	+31.6	− 0.2
9167.862	+57.0	1.158	+57.8	− 0.8
9188.823	+09.1	0.897	+00.8	+ 8.3
9189.833	−61.2	0.581	−66.0	+ 4.8
9191.792	+67.6	1.213	+60.1	+ 7.5
9197.756	−64.6	0.545	−67.2	+ 2.6
9199.817	+63.6	1.280	+56.8	+ 6.8
9200.788	+08.7	0.924	+08.3	+ 0.4
9201.845	−57.0	0.655	−58.5	+ 1.5
9202.667	+12.7	0.151	+12.4	+ 0.3
9202.886	−44.3	0.370	−49.2	+ 4.9
9208.707	+05.4	0.885	−03.1	+ 8.5
9209.727	−64.3	0.579	−66.2	+ 1.9
9214.756	−18.8	0.302	−32.8	+14.0
9222.731	−31.6	0.319	−37.3	+ 5.7
9223.681	+64.3	1.269	+57.5	+ 6.8
9224.694	+20.6	0.955	+17.2	+ 3.4
9247.616	+50.9	0.002	+49.7	+ 1.2
9261.590	−53.0	0.712	−48.5	− 4.5
9263.624	+27.0	0.094	+28.9	− 1.9

[1]Pub. D.D.O., vol. I, no. 3, 1939.

TABLE I—continued

J.D. 242	Vo Km./sec.	Phase from final T	Vc Km./sec.	Vo—Vc Km./sec.
9278.563	−70.2	0.442	−61.3	− 8.9
9283.520	+28.3	0.094	+28.9	− 0.6
9283.555	+21.7	0.129	+19.0	+ 2.7
9283.592	+06.3	0.166	+07.9	− 1.6
9283.626	−05.3	0.200	−02.6	− 2.7
9293.535	−31.6	0.824	−20.8	−10.8
9496.892	+52.6	1.243	+59.4	− 6.8
9500.845	+51.3	1.217	+60.1	− 8.8
9503.894	−33.2	0.287	−28.7	− 4.5
9510.892	−61.8	0.653	−58.8	− 3.0
9524.881	+37.9	0.052	+39.5	− 1.6
9530.904	−38.2	0.769	−35.4	− 2.8
9538.790	−55.2	0.697	−51.4	− 3.8
9539.844	−59.0	0.425	−59.0	+ 0.0
9542.791	−42.0	0.719	−47.0	+ 5.0
9543.793	−59.9	0.394	−53.9	− 6.0
9557.724	+40.3	1.061	+43.6	− 3.3
9569.787	+61.8	1.187	+59.6	+ 2.2
9570.790	−15.5	0.864	−09.3	− 6.2
9584.753	−20.3	0.236	−13.7	− 6.6

Column 1 gives the Julian date of the observation; column 2, the final velocities after the wave-lengths had been adjusted; column 3, the phase from the periastron time of the final orbit; column 4, the computed velocity from the final orbit; column 5, the residual O–C.

A preliminary orbit was derived graphically and corrections computed for all six elements. Owing to the small eccentricity the periastron time and angle are very uncertain and a circular orbit fits the observations fairly well.

Final Elements

Period	$P =$ 1.326390 days	± .000012
Eccentricity	$e =$ 0.024	± .013
Angle of periastron	$\omega =$ 32°.6	± 14°
Periastron passage	$T =$ J.D. 2429146.808	± .051
Velocity of system	$\gamma = -4.90$ km.	±0.56
Semi-amplitude	= 63.67 km.	±0.93
$a \sin i$	= 1.161×10^6 km.	
$\dfrac{m_1^3 \sin^3 i}{(m_1+m)^2}$	= .0355$\odot$	

The individual observations are plotted on the graph in Figure 1. The probable error of a single observation is 3.7 km.

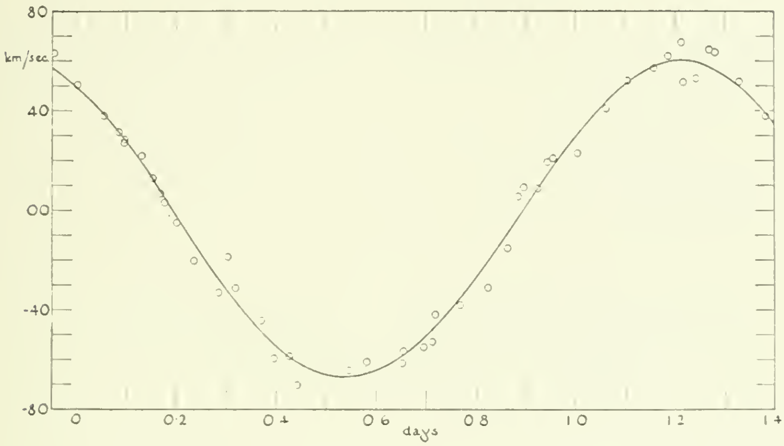


FIG. 1. Radial Velocity Curve of H.D. 22124

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THE SPECTRUM AND THE VELOCITY VARIATION OF H.D. 142926

BY

JOHN F. HEARD

1940
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THE SPECTRUM AND THE VELOCITY VARIATION OF H.D. 142926

By John F. Heard

The star H.D. 142926, R.A. (1900) 15^h $52^m.2$, dec. (1900) 42° 51′, vis. mag. 5.61, H.D. type B8, was announced as a spectroscopic binary by Plaskett[1] from eight Victoria spectrograms of 1919-20, the total range being from −3.2 to −34.9 km./sec. Plaskett remarked that "broad and diffuse hydrogen and broad faint magnesium are the only lines measurable in this spectrum".

From spectrograms taken here between 1936 and 1940 the velocity variation of this star has been confirmed[2] and emission lines in the spectrum have been detected.[3] The purpose of the present paper is further to describe peculiarities in the spectrum, to discuss the velocity variation, and to indicate a possible connection between the two.

The Spectrum

Forty spectrograms taken with the one-prism spectrograph fitted with the 25-inch camera lens (dispersion 33 A/mm. at $H\gamma$) have been used in this investigation. Most of these are on Astra II plates, a few on Eastman 40 and one (J.D. 2429659.9) on Eastman Process. As well, there are several Astra VIII plates showing $H\alpha$ fairly strong in emission. No spectrum variations have been detected on these plates which cover the period 1936-40. The Process plate shows greater detail than the others; on this plate the hydrogen lines appear as broad-winged absorption lines of total width about 30 Angstrom units with distinct sharp central absorption cores; the helium lines 4026 and 4471 are fairly prominent and are very broad and diffuse, other helium lines are faint, broad and indistinct; Mg^+4481 is slightly stronger than 4471 and not quite so broad; Ca^+3933 compares in intensity with 4026 but is, by comparison, much sharper; less prominent are many

[1]Pub. D.A.O. vol. 1, p. 287.

[2]Pub. D.D.O. vol. 1, no. 3, p. 71.

[3]Jour. R.A.S.C. vol. 33, p. 384, 1939 (Comm. D.D.O. no. 4).

fine lines due to Fe^+, ten of which are easily measurable and all of which are strikingly sharp by comparison with the helium lines. On the Astra II plates the broad wings and sharp cores of the hydrogen lines are evident, the broad 4026, 4471 and 4481 and the sharper 3933 are usually seen, and, of the sharp Fe^+ lines, only a few of the stronger, particularly 4233, are occasionally seen, depending on the quality of the plate.

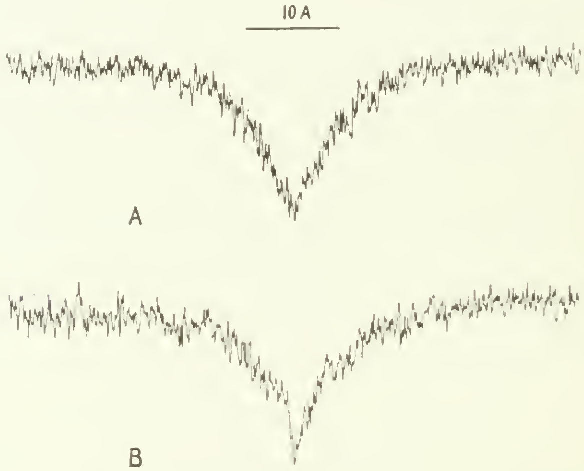

Figure 1—Microphotometer tracings of H_γ for H.D. 142926.
A—Victoria, J.D. 2422085.839.
B—Toronto, J.D. 2428304.651.

Struve and Swings[4] have called attention to the existence of a small group of B-type stars of peculiar spectrum characterized by hydrogen emission, sharp absorption cores of hydrogen with broad wings, sharp lines of ionized metals and broad diffuse lines of helium. They have interpreted the broad hydrogen wings and helium lines as arising from the reversing layer of the star, rotation accounting for the broadening of the helium lines, and the hydrogen cores and the sharp ionized metal lines as arising from an extensive atmosphere with less rapid rotation. This view found support in the anomalous sharpness of He 3964 in the spectrum of several of these stars.

The composite nature of the spectrum would seem to put H.D.

[4]Ap. J. vol. 88, p. 84, 1938.

142926 in this class of stars, with the broad helium lines and hydrogen wings originating in the reversing layer and the hydrogen cores and sharp Fe^+ lines originating in the shell. Ca^+ 3933 and Mg^+ 4481 which are of intermediate width may originate partly in the reversing layer and partly in the shell. He 3964 might be expected to be sharp as it is for some other stars of this class, but its region is obscured by the wide wing of Hϵ.

Plaskett's failure to remark on the hydrogen cores led to the suspicion that these had become accentuated since 1920. Through the kindness of Dr. J. A. Pearce the Victoria plates have been made available here. These plates do show spectral characteristics similar to those described above, but the cores of the hydrogen lines are decidedly less pronounced. Figure 1 reproduces microphotometer tracings of Hγ from two plates of comparable density, one from Victoria, one of ours. The tracing of the Victoria plate has been reduced photographically in one coordinate to make the scales of dispersion the same.

The Velocity Variation

The forty plates mentioned above have been measured for radial velocity. The hydrogen cores are easily measured and give accordant results. Other lines measured on some plates seemed to be much less reliable. Accordingly, in attempts to determine a period, the mean velocities from Hβ, Hγ and Hδ only were used. These velocities are given in Table I.

A period of 0.97625 day fits the observations. Longer and shorter periods are ruled out by several series of observations made during single nights. This period results in the velocity curve shown in Figure 2. If this be interpreted on the binary hypothesis the approximate elements of the orbit derived by the graphical method of R. K. Young are as follows:

$$
\begin{aligned}
P &= 0^{d}97625 \\
e &= 0.5 \\
\omega &= 0^\circ \\
K &= 15 \text{ km./sec.} \\
\gamma &= -18 \text{ km./sec.} \\
T &= \text{J.D. } 2428207.176 \\
a \sin i &= 174000 \text{ km.} \\
f(M) &= 0.00022 \odot.
\end{aligned}
$$

The eight Victoria observations have not been used in determining the period and, indeed, they do not fit well with this period. The fit, however, is not so poor as to rule out the period for the 1919-20 interval, especially in view of the poorer character of the lines at that time.

TABLE 1

J.D. 242	Velocity (km. sec.) H cores	He 4026 and 4471	Ca^+ 3933	Mg^+ 4481	J.D. 242	Velocity (km. sec.) H cores	He 4026 and 4471	Ca^+ 3933	Mg^+ 4481
8206.977	−20.8		−35.9		8342.606	−29.4	−51.5	−57.7	
8220.952	−15.4		−31.2	−68.8	8344.608	−16.1	−78.2	−28.1	+1.2
8221.940	−9.3	−23.2	−34.6		8348.594	−19.9	−56.3	−22.0	−1.9
8228.949	−21.9		−43.9		8357.626	−8.2	−13.9	−27.3	−114.8
8262.854	+5.7		−40.2	−11.2	8359.584	−8.7		−26.5	
8280.753	−20.9		−27.0	−64.2	8616.758	−28.6	−19.1		−42.3
8281.747	−25.4		−55.6	−65.9	8616.917	−26.1	−46.7	−0.5	−87.7
8281.859	−21.1	−82.8	−43.3		8682.655	−3.4	−56.1	−9.2	−50.0
8281.901	−28.6	−31.2	−32.8	+17.7	8682.794	−16.3	−39.9	−22.6	−103.2
8282.760	−15.8	+2.3	−62.5	−36.0	8723.638	+11.2		−39.3	−18.3
8283.788	−24.6	−28.4		+2.6	8723.681	−1.0			
8285.783	−17.5	−31.1	−45.7	−50.5	8764.572	−8.0	−38.1		+6.6
8294.751	−18.7	−36.1	−19.7	−103.5	9424.675	−13.0	−54.5		−34.0
8296.744	−33.7	−47.5	−31.8	−15.6	9436.653	−32.3	−34.3	−48.4	−47.2
8297.648	−17.7		−10.3	−74.5	9438.619	−33.8	−62.7	−26.3	−15.0
8297.810	−23.7		−18.9		9455.598	−23.2	−35.8	−20.0	+24.4
8303.658	−13.1	−54.8	−10.2		9455.760	−7.9	−40.7		−17.2
8303.760	+0.9	−35.9	−1.1	−38.6	9659.913	−18.3	−68.3	−28.0	−28.8
8304.651	−17.5	−42.4	−22.8		9745.722	+0.3	−29.2		+13.8
8305.778	−4.2	−92.2	−28.9		9745.819	−0.4	−60.0		−49.9

It is immediately apparent that the combination of early spectral class, short period, small range and high eccentricity make this orbit improbable, to say the least. We must, therefore, consider the possibility of the velocity variation arising from some cause other than orbital motion. Some sort of pulsation of the shell is suggested by the fact that the velocities refer to the hydrogen cores which have originated in the shell rather than in the reversing layer.

This pulsation hypothesis would find support if the velocities from lines originating wholly in the reversing layer of the star failed to show variation similar to that from the hydrogen cores. Accordingly the broad helium lines 4026 and 4471 were measured whenever they appeared with sufficient distinctness; these velocities are shown in Table 1. At best these lines are difficult to set on, and no great reliance may be placed on any of the measures. However, unless some blending or other systematic effect has

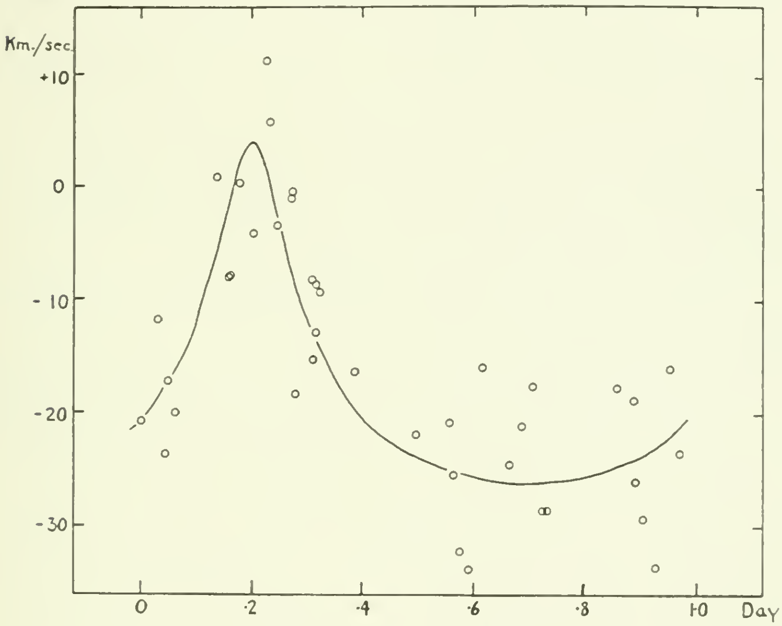

Figure 2—Velocity Curve for H.D. 142926.

affected the measures, it does appear certain that the helium velocities are distinctly more negative than those from the hydrogen cores, the average of the 29 helium velocities being −44.4 km./sec. compared with −16.8 km./sec. for the average of the corresponding hydrogen core velocities. With regard to the question of variation of the helium velocities the following test may have some significance: ten of the helium velocities are from observations with phases between $0^d.10$ and $0^d.35$, namely on the "high" part of the velocity curve; the average of these is −48.9 km./sec.; the average of the others is −42.1 km./sec.; the corresponding averages from the hydrogen core velocities are −6.2 and −22.4 km./sec. respectively. Although the evidence is inconclusive because of the poor quality of the helium lines, this does suggest that the helium lines fail to show velocity variation similar to that shown by the hydrogen cores.

In like manner Ca^+ 3933 and Mg^+ 4481 have been measured where possible. The results, which show very large scatter especially for the broader 4481, are given in Table 1. For the 32 calcium velocities the mean is −29.8 km./sec., for the 29 magnesium velocities it is −37.0 km./sec., the corresponding hydrogen core velocity means being −17.0 and −15.6 km./sec. respectively. So it appears that the calcium and magnesium lines, which have breadths intermediate between the sharpest and broadest lines, have velocities which are intermediate between the hydrogen core velocities and the helium velocities. Tested with reference to phase neither the calcium nor magnesium velocities show any tendency to vary with the 0.97625-day period.

The sharp Fe^+ lines are too weak to measure on most plates; from the Process plate of J.D. 2429659.9 the mean velocity from ten Fe^+ lines is −31.0 km./sec.

The observation of greater negative velocity from the broad helium lines than from the sharp hydrogen cores is of particular interest aside from the question of variation in either. This, on the shell hypothesis, means that material of the reversing layer and material of the shell are approaching each other. Cherrington[5] has recently investigated velocities from sharp and nebulous lines for 13 super-shell stars and has found that in each case the opposite is true—velocities from sharp lines originating in the shells are more negative than velocities from broad lines originating in the reversing layers. He puts this down to expansion of the shells and points to a relation between these stars and novae. H.D. 142926, therefore, would appear to constitute an exception to Cherrington's rule.[6] For this star either the shell is suffering a net contraction or material of the reversing layer is being driven outwards towards the shell.

[5]P.A.S.P. vol. 52, p. 116, 1940.

[6]Another super-shell star being investigated by the writer, namely H.D. 12302, exhibits a similar effect to a greater degree. From five plates the average hydrogen core velocity is +39.2 km./sec. while the average helium velocity is −55.1 km./sec.

Although H.D. 142926 had not been recorded as a variable, the possibility of minor variations with the 0.97625-day period was considered. Dr. C. M. Huffer of the Washburn Observatory kindly made a series of observations with the photoelectric photometer in the summer of 1938 and reported the star as constant in light.

In view of Beals' recent suggestion[7] that α Cygni and P Cygni stars develop from stars with spectra showing both broad and narrow lines it will be of interest eventually to observe whether the sharpening of the hydrogen cores recorded here be periodic or secular.

Summary

Super-shell characteristics have been detected in the spectrum of H.D. 142926 and are found to be present to a greater degree now than in 1919-20. The velocity variation from the hydrogen cores has a 0.97625-day period, but the velocity curve leads to an improbable orbit. Failure to detect similar velocity variation from the broad lines suggests that the variation arises from the shell alone. Mean velocities from the broad lines are more negative than those from the hydrogen cores, indicating that materials from reversing layer and shell are approaching each other.

[7] P.A.S.P. vol. 52, p. 278, 1940.

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THE SPECTRA OF PECULIAR STRONTIUM STARS

BY

A. F. BUNKER

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PLATE XXVII

Typical Spectra of Peculiar Strontium Stars.

The enlargements shown are, *a*) ι Cass A5p; *b*) β CorB F0p; *c*) γ Equl F0p; and *d*) the normal star σ Boot F0.

The scale of the microphotometer tracing of the spectral region of ι Cass near Hδ and Sr II 4077 is 3.3 times that of *a*). It is a 0.4 reduction of the original tracing.

THE SPECTRA OF PECULIAR STRONTIUM STARS*

By A. F. Bunker

(With Plate XXVII)

ABSTRACT

The equivalent widths of the spectral lines of seven peculiar strontium stars (A2p-F0p) and three comparison stars have been measured. Curves of growth have been constructed and values of log X, the optical depth, and turbulence found. The abundances of Sr II atoms in the lower states have been found. The ratio of the log X's of the peculiar stars and comparison stars has been plotted against excitation potential to determine the differential excitation temperature. In general, the peculiar stars were found to be cooler than the comparison stars, while the degrees of ionization were nearly the same.

THE theory of equivalent widths developed by Menzel[1] and the method employed by Goldberg[2] of determining the absolute abundances of elements offer a means of studying the spectra of the stars with abnormally strong ionized strontium lines. By constructing curves of growth, and fitting these to the theoretically determined curves, the optical depth, log X, of any line can be found. A study of these values should reveal whether atmospheric conditions are abnormal, or if there is simply an abnormal abundance of strontium atoms. In this paper the condition of temperature is compared by the method used by Russell.[3]

Observational Material

In the present program, the seven peculiar strontium stars, Boss 3506 A2p, Boss 2443 A3p, ι Cassiopeiae A5p, γEquulei F0p, βCoronae Borealis F0p, θ^2Tauri F0, and τCygni F0, and the comparison stars βTrianguli A5, γBootis A5, and σBootis F0, were studied.

The stars chosen for the comparison are as nearly identical to the peculiar stars in spectral type, absolute magnitude and line width as could be found within convenient reach of the 74-inch telescope with contrast slow plates. The data concerning these stars are given in Table I.

*A paper submitted in partial fulfilment of the requirements of the degree of Master of Arts at the University of Toronto.

TABLE I

Name	H.D.	Type	M_t	M_s	T	Line width
Boss 3506	118022	A2p	1.2	1.4	9200	11
Boss 2443	78209	A3p		1.8	7000	10
ι Cass	15089	A5p	1.3	1.0	8100	15
γ Equl	201601	F0p	1.5	1.1	7000	10
β CorB	137909	F0p	1.3	0.9	7200	9
θ^2 Taur	28319	F0	0.7	1.3	8400	20
τ Cygn	202444	F0	2.3	2.4	6900	17
γ Boot	127762	A5	2.0	2.0	7800	20
β Tria	13161	A5	−1.3	1.4	8600	19
σ Boot	128167	F0	3.5	3.2	8200	9

The columns give Henry Draper number, the spectral types, the trigonometric and spectroscopic magnitudes from Schlesinger,[4] the colour temperature corrected by Kuiper[5] to represent the effective temperature, and a measure of the line width determined by averaging the values of $\Delta\lambda/(1-r_c)$ for several unblended lines. Here r_c is the residual intensity at the centre of the line.

Plates were taken at the David Dunlap Observatory with the one-prism spectrograph attached to the 74-inch telescope. Only the 25-inch camera was used, giving a dispersion of 33A per millimetre at $H\gamma$. Most spectra were taken on Eastman process plates, while a few were taken on Eastman 33. The 11-spot tube-sensitometer of the observatory was used with a blue filter to impress the sensitization spots on the emulsions. The plates were tray-developed for eight minutes in the routine manner of the observatory.

METHODS OF REDUCTION

Tracings of the spectra were made by the Beals[6] type microphotometer constructed at the David Dunlap Observatory. With this machine the galvanometer deflection is recorded on a fogged background cut by regularly spaced unfogged lines parallel to the length of the paper. The fogging light was extinguished at every half-millimetre of the plate, leaving an unfogged reference line. Tracings were made using a magnification of 50, at the second highest speed, requiring about 15 minutes to record from λ3950 to λ4600. The circuits were left closed for about an hour previous to a run to insure constancy of the zero point and sensitivity, thus increasing the accuracy and ease of reduction. The characteristic curve of each plate was determined in the usual way. Much tedious reduction was eliminated by replotting the log I of the characteristic curve on a strip cut from the tracing. By placing this strip on the tracing, being sure that the lines of each were coincident, the log I of the continuous background and the centre of a line could be read directly. To measure the widths of lines, a scale was made and reduced photographically so that the distance between the half-millimetre reference lines was divided into fifty equal parts. The number of Angstrom units per division for each spectral region was computed.

The equivalent widths of the narrower absorption lines were computed by assuming, after other workers, that the lines can be considered as triangles. For lines strong enough for damping broadening to be effective, several points on the profile had to be measured, and the area found by a summation.

Two problems of equivalent width measures are the drawing of the continuous background, and the correction for blending. The continuous background can be drawn with a fair degree of confidence by following the rule of drawing it tangent to the tops of the lines in many-line spectra and through the plate grain in the cases of earlier type spectra.

The problem of blending was not solved in this work. Bad blends were either measured as a unit or discarded. In the cases of lesser blends the lines were reconstructed by noting the shape of other unblended lines. With the small dispersion and resolving power available, blending is a serious handicap, as most lines have some degree of blending. Lines blended with the hydrogen lines are difficult to evaluate, as Thackeray[7] has shown that a weakening results if the profile of the blending line is used as the continuous background. When it seemed desirable to measure such lines to complete the multiplet, a value of the continuous background above the blending profile was used. The accuracy of such measurements is admittedly low.

An indication of the consistency of the measurements was obtained by applying Peter's formula for probable errors to fifteen consecutive lines of Boss 2443. Five measurements of each line were available. The probable error of the fifteen determinations of $\Delta\lambda$, the width of the spectral line at the continuous background, and r_c were averaged to give an average probable error.

TABLE II

		Boss 3506			Boss 2413			ι Cass			γ Equl			β CorB		
λ	E.P.	r_c	W	log X	r_c	W	log X	r_c	W	log X	r_c	W	log X	r_c	W	log X
4077	0.00	0.63	712	...	0.51	1080	...	0.56	1345	...	0.42	1925	...	0.50	1200	...
4161	2.93	0.76	288	...	0.77	282	...	0.84	187	...	0.66	429	...	0.68	423	...
4215	0.00	0.67	454	...	0.67	444	...	0.65	863	...	0.47	1110	...	0.63	465	...
4305	3.03	0.82	146	...	0.81	262	...	0.83	189	...	0.74	314	...	0.71	390	...
4005	1.55	0.77	178	0.7	0.54	547	2.9	0.82	163	0.7	0.73	316	1.9	0.57	498	2.7
4045	1.48	0.75	258	1.8	0.56	590	3.0	0.80	236	1.5	0.59	661	3.2	0.55	621	3.0
4052	3.35	0.81	154	0.5	0.83	130	−0.1	0.88	286	−0.1	....	...	...	0.73	248	0.5
4063	1.55	0.79	211	1.1	0.63	540	2.9	0.80	254	1.8	0.68	527	3.0	0.61	557	2.9
4067	2.82	0.82	168	0.6	0.64	450	2.5	0.845	236	1.4	0.74	330	2.1	0.66	453	2.5
4071	1.60	0.82	175	0.7	0.70	446	2.4	0.85	208	1.1	0.76	276	1.5	0.71	400	1.4
4132	1.60	0.70	366	2.6	0.65	501	2.7	0.77	290	2.3	0.65	476	2.8	0.50	618	3.0
4143	1.55	0.77	320	1.7	0.65	575	3.0	0.86	239	1.4	0.76	396	2.4	0.69	299	0.8
4147	1.48	....	...	...	0.67	72	−0.5	0.87	117	0.2	0.87	885	−0.3	0.73	258	0.5
4150	3.32	....	...	...	....	...	...	....	...	...	....	...	...	....	...	...
4154	2.82	....	...	...	0.70	338	0.2	0.85	181	0.8	....	...	...	0.70	351	0.5
4158	3.42	....	...	...	0.72	316	0.6	....	...	...	0.76	235	1.0	0.71	262	0.5
4176	3.38	0.77	177	0.7	0.70	354	1.0	....	...	...	....	...	...	0.71	248	0.5
4181	2.82	0.76	252	1.5	0.74	252	0.4	0.88	128	0.3	0.80	230	0.9	0.70	342	1.0
4202	1.48	0.82	191	0.8	0.73	352	0.9	0.90	55	−0.3	0.80	204	0.6	0.74	285	0.6
4210	2.47	0.80	247	1.4	0.84	137	−0.1	0.87	169	0.1	0.83	150	0.1	0.80	181	0.2
4222	2.44	0.85	136	0.3	0.83	157	−0.1	0.92	76	−0.2	0.87	97	−0.2	0.85	126	−0.2
4235	2.42	0.83	194	0.7	0.77	293	0.6	0.88	146	0.5	0.83	206	0.6	0.79	194	0.2
4260	2.39	0.79	249	1.4	0.74	348	0.9	0.86	149	0.5	....	...	...	0.69	426	1.7
4454	2.82	0.84	175	0.5	0.82	273	0.4	0.87	191	0.8	0.68	592	3.0	0.70	519	2.6

TABLE II—*Continued*

		θ^2 Taur			τ Cygn			γ Boot			β Tria			σ Boot		
λ	E.P.	r_c	W	log X	r_c	W	log X	r_c	W	log X	r_c	W	log X	r_c	W	log X
4077	0.00	0.72	676	...	0.75	726	...	0.74	604	...	0.72	553	...	0.72	376	...
4161	2.93	0.89	127	...	0.85	168	...	0.88	122	...	0.87	109	...	0.86	94	...
4215	0.00	0.81	303	...	0.76	480	...	0.86	263	...	0.85	222	...	0.75	238	...
4305	3.03	....	...	...	....	...	...	....	...	...	....	...	...	0.80	168	...
4005	1.55	0.80	401	1.8	0.73	573	2.1	0.87	239	0.5	0.79	322	2.6	0.67	330	2.1
4045	1.48	0.78	415	2.1	0.66	675	2.8	0.84	236	0.5	0.77	333	2.7	0.59	449	2.8
4052	3.35	....	...	...	....	...	...	....	...	...	....	...	...	0.88	90	0.3
4063	1.55	0.79	359	1.3	0.73	561	2.1	0.85	257	0.6	0.80	261	1.8	0.70	305	1.7
4067	2.82	0.84	242	0.3	0.78	392	0.6	0.88	152	−0.1	0.85	191	0.8	0.81	206	0.6
4071	1.60	0.81	320	0.9	0.78	394	0.7	0.84	266	0.7	0.83	234	1.3	0.77	234	1.0
4132	1.60	0.79	457	2.4	0.74	620	2.3	0.81	306	0.8	0.83	235	1.3	0.77	226	0.9
4143	1.55	0.82	335	1.0	0.74	501	1.3	0.84	253	0.5	0.83	303	2.0	0.75	246	1.0
4147	1.48	....	...	...	....	...	...	....	...	...	....	...	...	0.93	41	−0.7
4150	3.32	....	...	...	0.85	208	−0.5	....	...	...	0.90	104	0.0	....	...	...
4154	2.82	0.84	193	0.1	0.80	250	0.1	....	...	...	0.88	111	0.1	0.78	233	0.1
4158	3.42	....	...	...	....	...	...	....	...	...	....	...	...	0.84	125	0.0
4176	3.38	0.81	401	1.5	0.76	515	1.4	....	...	...	....	...	...	0.78	178	0.4
4181	2.82	....	...	...	....	...	...	....	...	...	....	...	...	0.79	195	0.5
4202	1.48	0.82	219	0.2	0.78	354	0.5	0.87	163	0.0	0.87	171	0.7	0.81	171	0.3
4210	2.47	....	...	...	....	...	...	0.89	112	−0.3	....	...	...	0.83	140	0.1
4222	2.44	0.91	108	−0.3	....	...	...	....	...	...	....	...	...	0.88	71	−0.4
4235	2.42	0.88	148	−0.2	0.81	287	0.2	....	...	...	0.91	122	0.2	0.81	171	0.3
4260	2.39	0.84	288	0.6	0.78	424	0.8	0.87	246	1.3	0.89	212	1.0	0.73	278	1.3
4454	2.82	0.84	326	0.6	0.80	519	1.2	0.85	317	0.8	0.91	284	0.7	0.79	307	1.5

$$\text{P.E.} = 0.845 \frac{\Sigma v}{n\sqrt{n}} = 0.076 \Sigma v$$

Av. P.E. for $\Delta\lambda = 0.11$A

Av. P.E. for $r_c = 0.69$ of 1 per cent.

These values do not, of course, give any idea of errors due to blending which is the greatest source of error, or any systematic errors.

It was originally intended that four plates of each star be taken and measured. Only one plate each of γEquulei and τCygni was obtained and two of σBootis. In other cases, in which fewer than four measurements were made, plates were discarded because exposures were either too weak or too strong, or characteristic curves too poorly determined. In Table II the equivalent widths of the Sr II lines and the neutral iron lines used later in the temperature comparison are tabulated. The three columns give: r_c, the average value of the residual intensity at the centre of the line; W, the equivalent width expressed in milli-Angstroms determined by $W = \Delta\lambda(1 - r_c)/2$, and for the Fe I lines, log X, the optical depth determined from the curves of growth.

For use in constructing the curves of growth, the values of log W/λ were computed for all lines. Between 60 and 150 lines per star were measured in the region $\lambda 3900 - \lambda 4600$. For identifying lines, wave-length measurements were made on six plates of different stars for about 120 lines. These were averaged to give the wave-lengths of the important lines. For other lines, the wave-lengths were found by direct interpolation on the tracing. Identification was determined by wave-length, presence of other members of multiplets, and multiplet intensities. Much valuable information was obtained from Miss Moore's multiplet tables.[8]

Construction of Curves of Growth

The theoretical relation between the equivalent width of a spectral line and the number of atoms above the photosphere that are producing the line has been developed by Menzel.[1] Assuming a definite radiating surface surrounded by an atmosphere transparent to all wave-lengths, except those near an absorption line, the expression $r(\nu) = 1/(1 + Na_\nu)$ is adopted as an approximation of the ratio of the spectral intensity at a frequency ν inside the line to the intensity outside the line. The atomic absorption coefficient a_ν is given by

$$a_\nu = \frac{\pi\epsilon^2}{mc} f \left[\frac{1}{\sqrt{\pi}} \frac{c}{v\nu_0} e^{-(\nu-\nu_0)^2 c^2/\nu^2_0 v^2} + \frac{\Gamma}{4\pi^2} \frac{1}{(\nu-\nu_0)^2} \right]$$

where f is the oscillator strength, v the root mean square kinetic velocity and Γ the damping constant of the atomic transition. The first term arises from the Doppler effect, while the second arises from the radiational or collisional damping.

The expression for the equivalent width, $\Delta\nu = \int_0^\infty \frac{Na_\nu}{1+Na_\nu} d\nu$, has been solved for three cases, when Na_ν is small, intermediate, and large. The resulting relations are

$\log W/\lambda = 1/2 \log \pi + \log v_0/c + \log X_0$

$\log W/\lambda = \log 2 + \log v_0/c - 1/2 \log 0.434 + 1/2 \log \log X_0$

$\log W/\lambda = 1/4 \log \pi - \log 2 + \log v_0/c + 1/2 \log \Gamma/\nu + 1/2 \log X_0$

The X_0 introduced is the optical depth of the line. In quantum mechanical terms it is

$$X_0 = \frac{N_a}{b(T)} e^{-\chi/kT} \frac{1}{3\pi R} \frac{\pi\epsilon^2}{mc} \frac{c}{v_0} \phi S \frac{s}{\Sigma_s}.$$

$e^{-\chi kT}/b(T)$ gives the Boltzmann distribution of electrons in the various states of the atom. $\phi Ss/\Sigma s$ expresses the spectroscopic strength of any line, ϕ being the square of the radial integral divided by $4l^2-1$ representing the strength of the transition, S the relative multiplet strength and $s/\Sigma s$ the strength of a line within a multiplet. The v_0 is the kinetic velocity of the atoms and equal to $1.289 \times 10^4 \sqrt{T/\mu}$. N_a is the number of atoms of one element in a given stage of ionization per square centimeter above the photosphere.

To determine the theoretical curve of growth for A2-F0 stars, it is necessary only to substitute the proper values in the three equations, plot $\log W/\lambda$ against $\log X_0$ and draw a smooth curve through the three sets of points. For these stars the assumed values are, $T = 8000^0$, and $\mu = 56$, since iron lines were used most frequently in determining the empirical curve of growth. The value $\Gamma/\nu = 1.52 \times 10^{-6}$ which Menzel[9] found to give the best fit in the case of the sun, was adopted. Using these values the equations reduce to:

$\log W/\lambda = \log X_0 - 5.04$

$\log W/\lambda = 1/2 \log \log X_0 - 4.83$

$\log W/\lambda = 1/2 \log X_0 - 5.73.$

For the construction of the actual curves of growth of the stars, Russell's[10] table of multiplet intensities was used as the main source of relative line strengths. The method of construction was that used by Allen[11] in making the curve of growth of the sun. It consists of plotting the log W/λ of a line as observed in the star against the logarithm of the strength of the line within the multiplet. After the lines of several multiplets have been plotted, each multiplet was moved horizontally as a unit. Guided by the slope of the multiplet and its height, the various multiplets were combined to form as smooth a curve as possible. The scatter of the points is considerable because of the blending effects, errors in measurement, and any irregularities in the multiplet intensities because of the failure of the *LS* coupling. This scatter and the relatively few multiplets made it necessary to seek other sources of material. A satisfactory source of spectroscopic data is contained in Allen's[12] tables of the equivalent widths in the solar spectrum. By using the curve of growth of the sun computed by Menzel,[13] the value of log X_0 can be read for each value of log W/λ from Allen's work. The X_0 contains the spectroscopic data of the line, the abundance of the element in the sun, and the Boltzmann factor. When the lines of one element are used, only the Boltzmann factor need be changed when applying the data to stars of different temperatures. The change can be effected by putting the desired temperature in the factor

$$e^{-\chi(1/k[1/T-1/T_0])}.$$

For the temperature change $4500° - 6500°$ the correction to log X_0 is simply 0.343χ. With this material additional lines were utilized which were unclassified or in weak multiplets. These lines were plotted and moved horizontally as a unit and combined with other multiplet lines.

In view of the small number of plotted points, usually defining only a portion of the curve of growth, it seemed inadvisable to draw a curve through the mean position of the points and accept that curve as the curve of growth of the star. A better method, the one finally adopted, is to use the plotted points to define a particular theoretical curve of growth and accept this as the true curve of growth of the star.

In a study of B-type stars, Goldberg[14] found that many stars had curves of growth whose intermediate sections were higher than the theoretical one for a given temperature. Presumably this was the result of a turbulent motion of the atoms in the stellar atmospheres. This effect was introduced into the curve of growth equations by the turbulence factor $V = \log v' - \log v_0$, giving

$$\log W/\lambda = \log X_0 - 5.04 + V$$
$$\log W/\lambda = 1/2 \log \log X_0 - 4.81 + V$$
$$\log W/\lambda = 1/2 \log X_0 - 5.73 + V/2.$$

The method of selecting the proper curve of growth is, then, to plot several curves with different values of V and move the plotted observed points horizontally until the best fit is obtained with some computed turbulence curve. The curve was traced through the points and used as the curve of growth of the star. The curves and observed points are reproduced in Figure 1.

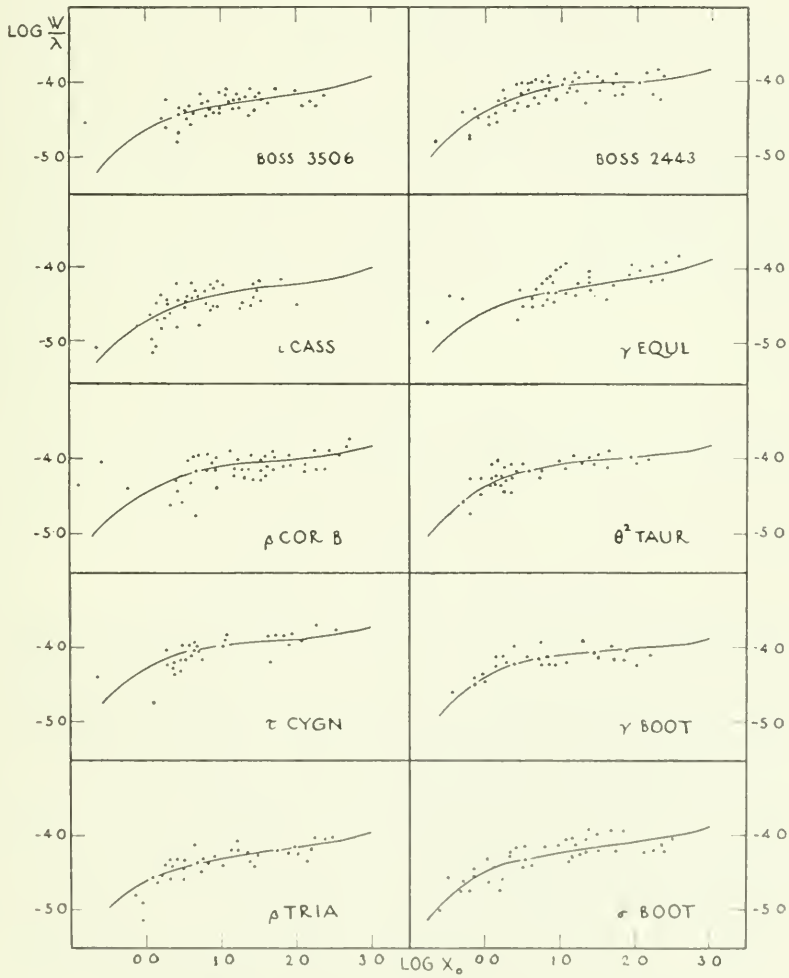

Figure 1—Curves of growth of peculiar and normal stars.

In choosing the proper curve, the turbulence in the stellar atmosphere is determined. In all cases, the values are positive and lay between 0.5 and 0.9. These have been plotted against a colour temperature corrected by Kuiper[5] to represent the effective temperature of the star. A definite correlation between temperature and turbulence was found, and is shown in Figure 2. The turbulence is greater for lower temperatures. It is interesting to note that the opposite effect was found for the O and B stars.

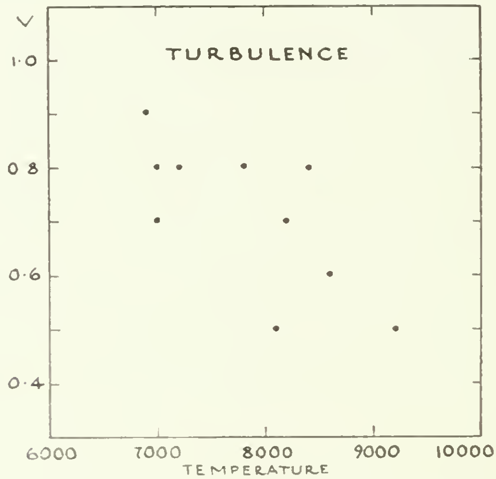

Figure 2—Correlation between turbulence and temperature.

The Curve of Growth for Sr II

Goldberg[15] has shown how the absolute abundance of an element may be found when the curve of growth of the element and the absolute strengths of the lines are known. The same method is applied here to determine the abundance of ionized Sr atoms, but small changes have been made to meet the varied conditions.

Thus to determine the abundance of Sr II atoms, two things must be found: the value of $\phi Ss/\Sigma s$ for the transitions involved, and the form of the curve of growth, for which the value of Γ, the damping constant is required.

It has been possible to compute the absolute strengths and damping constants of Sr II lines through the generosity of Dr.

Leo Goldberg, who kindly made available values of ρ, the radial quantum integral for the transitions involved. Thus since

$$\phi=\rho^2/(4l^2-1),$$
$$S=(2S+1)(2L+1)(l)(l-1),$$

and $s/\Sigma s$ can be found from Russell's table of multiplet strengths, the necessary values can be found easily.

	λ	ρ	$\phi S \frac{s}{\Sigma s}$
$5s-5p$	4077	5.62	1.62
	4215	5.62	1.32
$5p-6s$	4305	1.59	0.53
	4161	1.59	0.23

The damping constant can be found knowing the strength of the line. Γ is equal to the sum of the reciprocal mean lives of the two levels involved. For the transition $^2S_{1/2}-^2P^0{}_{1\,1/2}$, the reciprocal mean life of the term $^2S_{1/2}$ is zero, for it is the ground state. For the $^2P^0{}_{1\,1/2}$ term only the transition to the ground state need be included in the summation. Thus for the line λ4077

$$\Gamma=3.15\times10^8.$$

For use with the curve of growth

$$\log\ \Gamma/\nu=-6.37.$$

With the value of $\log\Gamma/\nu$, the theoretical curve of growth of Sr II can be computed. When $\mu=88$ and $T=8{,}000°$, the equations reduce to:

$$\log W/\lambda=\log X_0-5.14+V$$
$$\log W/\lambda=1/2\log\log X_0-4.90+V$$
$$\log W/\lambda=1/2\log X_0-6.05+V/2.$$

The factor V was added since turbulence is present in the atmosphere. These theoretical curves were plotted, using several different values of V.

It follows from the previously used equation that for Sr II

$$\log X_0=-11.452+\log N_a/b(T)-\frac{5040}{T_{ex}}\chi-1/2\log T+\log\phi S\frac{s}{\Sigma s}$$

or if $\log X'_0=\log\phi S\dfrac{s}{\Sigma s}-\dfrac{5040}{T_{ex}}\chi$ and there is turbulence present,

$$\log X_0=-11.452+\log N_a/b(T)-1/2\log T-V+\log X_0'$$

since X_0 is inversely proportional to V.

In the paper cited the value $\Delta = \log X_0 - \log X_0'$ was introduced, which here becomes

$$\Delta = -11.452 + \log N_a/b(T) - 1/2 \log T - V.$$

This gives the means of determining the absolute abundance of atoms in certain states in the atmosphere.

$$\log N = \log \omega + \log N_a/b(T) - \frac{5040}{T_{ex}} \chi$$

or, by substitution, and letting $T = 8{,}000°$

$$\log N = \log (2S+1)(2L+1) + 13.40 + \Delta + V - \frac{5040}{T_{ex}} \chi.$$

To evaluate this equation Δ and V must be found by a comparison of the theoretical and observed curves of growth. The observed curve is constructed by plotting the observed $\log W/\lambda$ of the Sr II lines against $\log X_0'$.

The values of $\log X_0' = \log \phi\, S \frac{s}{\Sigma s} - \frac{5040}{T_{ex}} \chi$

for the different lines can now be found since $\phi Ss/\Sigma s$ has been computed. The value $T_{ex} = 7{,}000°$ has been assumed as the excitation

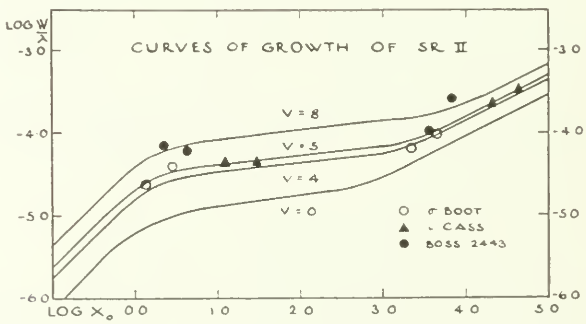

Fig. 3.

temperature which is lower than the effective or kinetic temperature. The values used are then

λ	$\log X_0'$
4077	1.62
4215	1.32
4305	−1.60
4161	−1.90

The observed curves are moved horizontally until the best fit is obtained with some theoretical turbulence curve. The values Δ and V become known immediately as the best fit is found. With these evaluated, the log N for any state can be found. The determined values of the logarithm of the number of Sr II atoms per square centimetre above the photosphere are tabulated.

TABLE III

Star	Sp	Δ	$V_{Sr\ II}$	log $N(^2S)$	log $N(^2P^0)$	$V_{gen.}$
Boss 3506	A2p	2.4	0.5	16.6	14.9	0.5
Boss 2443	A3p	2.2	0.8	16.7	15.0	0.8
ι Cass	A5p	3.0	0.5	17.2	15.5	0.5
γ Equl	F0p	3.0	0.7	17.4	15.7	0.7
β CorB	F0p	2.3	0.8	16.8	15.1	0.8
θ^2 Taur	F0	2.1	0.6	16.4	14.7	0.8
τ Cygn	F0	2.3	0.6	16.6	14.9	0.9
β Tria	A6	2.1	0.5	16.3	14.6	0.6
γ Boot	A5	2.1	0.5	16.3	14.6	0.8
σ Boot	F0	2.0	0.4	16.1	14.4	0.7

The tabulated abundances of the Sr II atoms in the $^2P^0$ states are not independent of the temperature, and have been evaluated on the assumption of $T_{ex}=7{,}000°$. The temperatures of the individual stars differ from this value, making the $^2P^0$ column only an approximation.

Better fits between the observed equivalent widths and theoretical curves of growth would have been obtained had individual temperatures been used, but these values were not available. In Figure 3 the values of log W/λ of the Sr II lines of Boss 2443, ιCass and σBoot are shown plotted on theoretical curves.

Comparison of Excitation Temperature and Ionization

Having determined the numbers of Sr II atoms in the normal and peculiar stars, and the optical depths of lines of other elements, an attempt has been made to find out whether abnormal conditions exist in the atmospheres of the peculiar stars or whether one is forced to accept a difference in chemical composition. Two conditions, excitation temperature and electron pressure, can be compared by a comparison of the intensities of spectral lines in the two kinds of stars.

The excitation temperature may be compared by the method used by Russell. The fundamental relation used is the Boltzmann factor:

$$N=\omega\frac{N_a}{b(T)}e^{-\chi/kt}$$

or logarithmically,

$$\log N=\log\omega+\log\frac{N_a}{b(T)}-\frac{5040}{T}\chi.$$

If similar equations are written for two stars and the differences taken, the following equation is obtained:

$$\log\frac{N}{N'}=c+5040\chi(1/T'-1/T).$$

The values of $\log N/N'$ can be found from the ratios of the log X_0's of the two stars determined from the curves of growth, since the log X_0 contains the abundance, N. When the ratios of one element in the same state of ionization are plotted against the excitation potential of the lower level, the slope of the resulting line is a measure of the difference in temperature of the two stars. In this way, the peculiar stars were compared with the normal stars. Figure 4 shows four typical comparisons.

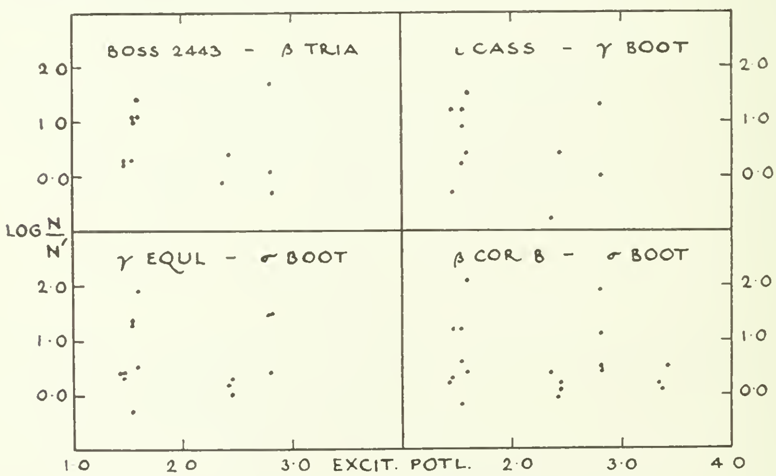

Figure 4—Comparison of excitation temperatures.

Unfortunately the number of suitable lines for comparison is very small. Only the neutral iron lines were sufficiently abundant to make a comparison profitable. Since only 20 iron lines were used, after blends were excluded, the determined slopes are subject to some uncertainty. The slopes were used in view of this uncertainty, to tell which of two stars is the hotter and not to determine the exact difference in temperature. In this way, by numerous inter-comparisons, the stars used have been arranged in order of decreasing temperature, as follows: γBoot, ιCass, Boss 3506, σBoot, βTria, βCorB, τCygn, θ^2Taur, γEqul, and Boss 2443 being the coolest. The most noticeable characteristic of the order is that the peculiar stars are cooler than the comparison stars of the same spectral class. Thus ιCass, A5p, is cooler than γBoot, A5, and γEqul, F0p, and βCorB, F0p, are cooler than σBoot, F0. One exception is βTria, which is cooler than σBoot. This phenomenon of a temperature decrease in passing from normal stars to peculiar stars of the same spectral class might be a clue to the explanation of the abnormal abundance of Sr II atoms. Since the second stage of ionization is small, in A2-F0 stars, the rise in intensity of λ4077 with advancing spectral type is due mainly to the change in electron concentration from the higher states to the ground level. The lower temperatures of the peculiar stars would then produce an increase in the strength of the Sr II lines of lower excitation potential.

For normal stars a decrease in temperature would infer a simple change to a later spectral type. For a star to have a lower temperature than the average for a spectral class, there must be some difference in the electron pressure so that the degree of ionization remains nearly the same. To test this, the electron pressures have been computed for as many stars as measurements of the K line of calcium II are available. Only on plates of βTria, ιCass, and θ^2Taur were the K lines exposed strongly enough to be measured. Values for γBoot, βCorB, and σBoot were used from Hynek's[16] paper on F-type spectra. The equivalent widths of CaI 4227 were measured for all stars.

Adapting the Saha formula for use with the curve of growth, the equation becomes for Ca II, the primes referring to the ionized states:

$$\log P_e = \log X_0 - \log X_0' - 5.92 \frac{5040 I}{T} + 5/2 \log \mathrm{T}$$

since

$$\log \frac{x}{1-x} = \log \frac{N'}{N} = \log \frac{X_0'}{X_0} \frac{b'T}{b(T)} \frac{\phi S\, s/\Sigma s}{\phi' S' s'/\Sigma s'} = \log X_0' - \log X_0 - 0.28$$

which is believed to be a close approximation. The log X's were found from the curves of growth and substituted in the equation. The values derived by this equation are:

	T	Pe
β Tria.........	7,000	2.5×10^{-3}
	8,000	1.2×10^{-2}
	9,000	5.0×10^{-2}
ι Cass........	7,000	6.3×10^{-4}
	8,000	3.2×10^{-3}
	9,000	1.2×10^{-2}
γ Boot......	8,000	4.4×10^{-3}
	9,000	4.0×10^{-2}
	10,000	9.5×10^{-2}
θ^2 Taur........	7,000	2.0×10^{-4}
	8,000	1.0×10^{-3}
	9,000	4.0×10^{-3}
σ Boot........	6,000	2.4×10^{-4}
	7,000	1.9×10^{-3}
β CorB........	6,000	2.1×10^{-4}
	7,000	1.7×10^{-3}

From these values and assuming temperatures in accordance with the results of the temperature comparisons, the most likely conditions in the atmospheres of ιCass and γBoot are: ιCass, T = 8,000°, Pe $=3.2\times10^{-3}$, γBoot, T = 9,000°, Pe $=4\times10^{-2}$. If now, the temperature of γBoot were reduced to 8,000° while holding the degree of ionization constant, an electron pressure of 4.4×10^{-3} would result, which is approximately the pressure in ιCass. This indicates the same degree of ionization in each star. In a similar manner, σBoot and βCorB can be shown to have the same degree of ionization, yet a difference in temperature. Thus peculiar Sr II stars of a given spectral class have a lower temperature than normal stars but approximately the same degree of ionization.

βTria, A6, which was noted previously to be an exception in that it was cooler than σBoot, F0, has an electron pressure and degree of ionization characteristic of F0 stars.

It is regretted that a quantitative value of the thermal differences could not be extracted, for it would show definitely whether the difference is the sole cause of the peculiarity or merely a contributing cause. In a plot of temperature order against abundance of Sr II, most of the stars fall in a roughly defined curve, while ιCass and γEqul are much displaced toward greater abundances. This suggests that some peculiar stars might be produced by a lower temperature, or an absolute magnitude effect, while others require some further explanation.

In determining the abundances of Sr II atoms, it was noted that for normal stars and a few peculiar ones of somewhat lower abundance, the turbulence value found by the Sr II atoms was less than the turbulence found by the general curve of growth. Since little is known of the cause of turbulence, it is difficult to see the real significance of this difference. It might be suggested that it is the result of a stratification of Sr II atoms at different layers in the atmosphere. This scheme, however, leads to many serious objections.

It is a pleasure to acknowledge my indebtness to Dr. Leo Goldberg of Harvard College Observatory for making available quantum mechanical evaluations invaluable to the present work.

David Dunlap Observatory,
Richmond Hill, Ontario,
February, 1941.

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THE LIGHT CURVES OF FOUR VARIABLE STARS IN THE HERCULES CLUSTER MESSIER 13

by

HELEN B. SAWYER

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THE LIGHT CURVES OF FOUR VARIABLE STARS IN THE HERCULES CLUSTER MESSIER 13

by Helen B. Sawyer

THE globular cluster Messier 13 (NGC 6205) in Hercules is one of the best known objects in the sky, and is frequently shown in telescopes, both big and little, and frequently photographed. But for all our familiarity with this rich cluster as a beautiful object, our knowledge of the variable stars in it has been amazingly scanty.

Bailey[1] in 1902 published the discovery of two bright variables. Barnard[2] in 1900, hearing of Bailey's discovery before publication, independently found Variable No. 2, and made a series of 36 visual observations of this star, from which he determined that the period was 5.1 days. In 1909[3] he commented that he had determined a period of 6.0 days for Bailey's Variable No. 1, and had also found a third variable. In 1915, Shapley[4] announced the discovery of four additional variables, and gave the magnitudes[5] of all seven variables as measured on seven plates. For twenty-five years the sum total of all our knowledge of the variables in the Hercules cluster was that there were seven; of these, one had a period of 5.1 days as deduced from the series of published observations, and one a period of 6.0 days, but with no published observations.

A recent paper[6] from this observatory increased the number of known variables to 11, and a preliminary report[7] on the periods was presented to the American Astronomical Society in 1940.

Eleven years ago at the Dominion Astrophysical Observatory the writer began accumulating large scale plates on this cluster. Although the variables are quite bright—all of them as bright as 15.0 at minimum, a large telescope is necessary for the investigation because of the crowding in the cluster. The program has been continued at the David Dunlap Observatory, and a total of 150 plates is now available. For assistance in taking the plates I am indebted to Dr. F. S. Hogg, Mr. T. T. Hutchison, Mr. Gerald Longworth, and others.

Of the eleven variables, light curves are given in this paper for four. Of these four periods now determined, three are long period Cepheids, and one is a cluster type variable. Series of plates from several seasons showed at once that Barnard's period of 5.1 days for No. 2 is correct. The period derived by the writer is 5.11003 days. But the present series of observations showed also that Barnard's period of 6.0 days for No. 1 is quite erroneous. Figure 1 shows Barnard's observations as computed from his period for No. 2; and shows for No. 1 several years of the writer's observations with phases computed from Barnard's period of 6.0 days.

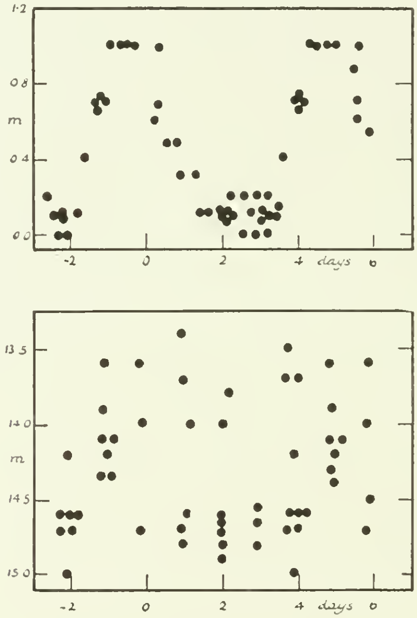

FIGURE 1

Upper: Barnard's visual observations of Variable No. 2 with phases computed from his period of 5.1 days.

Lower: Recent series of observations of Variable No. 1 with phases computed from Barnard's period of 6.0 days.

Obviously this period is quite untenable, and all attempts to correct it by a small refinement failed. When sufficient observations had accumulated in series over large hour angles, the true period for No. 1 was determined to be almost exactly one quarter of that given by Barnard, namely 1.45899 days.

A third long period Cepheid is now added to the other two as Variable No. 6 has a period of 2.11283 days. Variable No. 8, found by the writer, is a cluster type variable with good range and period of three quarters of a day.

Considerable work has been done to determine the periods of the other variables. For Variable No. 7 a period of 0.428024 day or 0.299724 day fits practically all the measures, and it appears impossible on the basis of existing data to decide which is the true and which is the fictitious period. Since the effective range is only about 0.3 magnitude, the star is a difficult one for period determination. Variables 3 and 4 are faint stars with small ranges, and rather near the limiting magnitude of many of the plates. Variables 5 and 9 are the components of a close double which is resolved only under very good seeing conditions. Both of these are probably cluster type variables. Variables 10 and 11 are bright stars with small ranges. It is possible that they belong to the bright irregular class. It is planned to keep the cluster on the observing list until more of the cluster type periods have been determined.

The sequence used was that given in a previous paper, with the magnitudes determined earlier by Shapley.[5] This sequence has now been checked by two sequence plates of 2 and 6 minutes' exposure time on Selected Area 61. The values of the comparison stars as estimated on these plates corroborate Shapley's values.

Table I gives the elements of the variables, with maximum,

TABLE I

ELEMENTS OF FOUR VARIABLE STARS IN MESSIER 13

Var.	Max.	Min.	Med.	Epoch	Period
				2,400,000+	
1	13.2	15.0	14.1	27685.763	1.45899 d
2	12.6	14.1	13.3	27308.868	5.11003
6	13.5	14.8	14.1	27274.867	2.11283
8	14.2	15.6	14.9	28038.654	0.750306

minimum, and median magnitudes. Table II gives the observations of the variables with phases computed on the basis of the elements derived. The plates through Julian Day 2427728 were taken at the Dominion Astrophysical Observatory; although there are 51 plates, only 27 observations are published. On dates on

TABLE II

OBSERVATIONS OF VARIABLE STARS IN MESSIER 13

Plate	Julian Day	Var. No. 1 Mag.	Var. No. 1 Phase	Var. No. 2 Mag.	Var. No. 2 Phase	Var. No. 6 Mag.	Var. No. 6 Phase	Var. No. 8 Mag.	Var. No. 8 Phase
20573	6923.83	13.9	1.12	13.6	3.33	14.4	1.80	14.6	.13
20599	25.84	14.1	0.22	12.6	0.23	14.4	1.70	14.5	.64
20612	30.745	14.7	0.74	12.8	0.02	13.6	0.26	14.9	.243
20648	44.81	14.0	0.21	13.2	3.86	14.4	1.65	14.5	.10
20678	46.79	14.8	0.74	12.9	0.74	14.7	1.52	15.2	.58
21388	7273.83	14.3	0.96	12.9	0.74	14.1	1.08	15.1	.49
21403	74.87	14.5	0.54	13.0	1.77	13.6	0.00	14.3	.02
21418	75.89	13.6	0.11	13.6	2.80	14.3	1.03	14.9	.30
21516	306.80	14.3	0.37	14.0	3.04	13.8	0.24	15.0	.44
21530	07.71	13.5	1.28	13.3	3.95	14.4	1.15	15.1	.60
21559	08.86	14.2	0.98	12.6	5.11	13.6	0.19	14.7	.26
21575	09.858	14.5	0.51	12.8	0.99	14.2	1.19	15.1	.502
23075	597.924	14.0	1.16	13.6	2.89	14.4	1.91	15.1	.450
23173	638.917	13.4	1.30	13.8	3.01	13.6	0.64	14.8	.176
23179	39.805	14.6	0.73	13.2	3.90	15.0	1.53	15.0	.314
23221	52.861	14.6	0.65	12.9	1.32	14.2	1.91	15.0	.615
23222	.867	14.7	0.66	12.9	1.63	14.4	1.92	15.0	.621
23243	58.867	14.6	0.82	13.5	2.52	14.8	1.58	15.0	.618
23257	59.853	14.3	0.35	13.8	3.50	13.7	0.45	14.6	.104
23311	64.853	14.4	0.97	13.7	2.39	14.4	1.23	15.2	.602
23401	85.763	13.1	0.00	13.5	3.86	14.4	1.01	15.0	.503
23402	.772	13.2	0.01	13.3	3.87	14.0	1.02	....	.512
23403	.780	13.2	0.02	13.2	3.88	....	1.04	....	.520
23524	713.692	14.0	0.21	12.9	1.13	14.5	1.47	14.5	.671
23527	14.619	13.9	1.14	13.7	2.06	13.7	0.28	14.7	.097
23536	15.628	14.7	0.69	13.7	3.07	14.8	1.30	15.0	.356
23598	28.603	14.6	0.53	12.9	0.71	14.8	1.59	15.1	.576
190	8038.654	13.7	1.27	13.0	4.16	14.1	1.06	14.1	.000
193	.719	13.2	1.34	12.8	4.23	14.4	1.12	14.6	.065
222	43.656	14.6	0.44	13.6	4.05	14.2	1.83	14.9	.500
225	44.699	13.6	0.02	12.7	5.10	14.1	0.76	14.5	.043
826	309.603	14.9	0.85	13.0	4.28	14.8	1.56	14.6	.089
832	.705	14.7	0.95	13.0	4.38	14.4	1.66	14.9	.191
1116	65.781	14.0	0.13	13.1	4.25	14.1	0.69	14.3	.744
1129	66.781	14.0	1.13	12.7	0.14	14.3	1.69	14.9	.243
1231	91.715	13.7	1.26	12.7	4.63	14.5	1.27	15.0	.417
1246	92.735	15.0	0.82	12.6	0.54	13.8	0.18	14.6	.687
1270	98.632	14.5	0.88	13.0	1.33	14.2	1.85	15.1	.581
1277	.794	14.0	1.04	13.0	1.49	14.0	2.01	14.3	.743
1289	99.669	14.6	0.46	13.3	2.36	14.2	0.78	14.6	.118
1975	688.615	14.7	0.53	12.8	0.04	13.6	0.26	14.8	.196
1979	.683	14.5	0.59	12.7	0.11	13.5	0.33	14.9	.264

TABLE II—*Continued*

OBSERVATIONS OF VARIABLE STARS IN MESSIER 13

Plate	Julian Day	Var. No. 1		Var. No. 2		Var. No. 6		Var. No. 8	
		Mag.	Phase	Mag.	Phase	Mag.	Phase	Mag.	Phase
1987	8688.856	14.7	0.77	12.9	0.28	13.6	0.51	....	.437
1988	89.612	13.8	0.06	13.0	1.04	14.7	1.26	15.5	.443
1992	.676	14.0	0.13	12.9	1.10	14.7	1.33	15.3	.507
2004	92.612	14.1	0.15	13.9	4.04	13.8	0.04	15.4	.441
2008	.664	14.0	0.20	13.2	4.09	13.8	0.09	15.5	.493
2017	93.836	13.4	1.37	12.6	0.15	14.6	1.26	14.7	.165
2027	96.605	13.9	1.22	14.1	2.92	14.6	1.92	14.6	.683
2030	.636	13.7	1.25	14.0	2.95	14.2	1.95	14.2	.714
2042	.849	13.6	0.00	14.1	3.16	13.6	0.05	14.7	.177
2107	715.626	13.6	1.28	13.1	1.50	14.4	1.92	14.9	.196
2118	.819	13.1	0.02	13.0	1.69	13.6	0.00	14.9	.389
3245	9071.614	13.8	1.27	12.7	4.90	14.2	0.84	15.1	.539
3255	.841	14.0	0.04	12.8	0.11	14.2	1.07	14.3	.016
3267	72.847	14.4	1.04	13.2	1.02	14.4	2.07	14.9	.271
3268	73.594	14.4	0.33	13.2	1.77	14.2	0.71	14.8	.268
3272	.628	14.5	0.37	13.3	1.80	14.0	0.74	14.8	.302
3282	.847	14.6	0.58	13.6	2.02	....	0.96	14.9	.521
3283	76.593	14.6	0.41	12.9	4.76	....	1.59	14.7	.266
3286	.622	14.6	0.44	12.9	4.79	14.5	1.62	14.9	.295
3295	.845	14.9	0.66	13.0	5.02	14.1	1.85	15.3	.518
3297	77.601	13.6	1.42	12.9	0.66	14.0	0.49	15.6	.523
3299	.633	13.5	1.45	12.9	0.69	13.6	0.52	15.2	.555
3308	.837	14.3	0.20	12.9	0.90	14.0	0.73	14.5	.009
3311	78.603	15.0	0.96	13.3	1.66	14.4	1.49	14.4	.025
3313	.633	14.6	0.99	13.1	1.69	14.3	1.52	14.6	.055
3323	.822	13.8	1.18	13.1	1.88	14.5	1.71	15.0	.244
3326	79.611	15.0	0.51	13.9	2.67	14.0	0.39	15.2	.283
3329	81.830	13.9	1.27	12.7	4.89	13.8	0.49	14.9	.251
4576	429.607	14.2	0.35	12.8	0.08	14.5	1.77	14.7	.636
4579	30.603	13.6	1.35	13.1	1.07	14.0	0.65	14.6	.131
4691	63.606	14.7	0.79	14.0	3.42	14.2	1.96	14.6	.121
4701	64.599	14.6	0.43	13.0	4.41	14.2	0.84	15.2	.364
4799	87.746	14.0	0.13	13.6	2.01	14.4	0.75	14.7	.251
4803	89.569	14.7	0.49	14.0	3.83	14.0	0.46	15.4	.574
4804	.583	15.0	0.51	14.5	3.84	13.9	0.47	15.6	.588
4809	.735	14.6	0.66	13.6	3.99	14.2	0.62	14.3	.740
4816	90.583	13.9	0.05	12.9	4.84	14.7	1.47	14.3	.087
4817	.597	14.1	0.06	13.0	4.86	14.7	1.48	14.6	1.01
4826	91.569	14.7	1.04	13.0	0.72	13.9	0.34	15.0	.323
4969	518.572	14.6	0.32	13.3	2.17	14.3	1.99	14.9	.315
4976	19.599	13.5	1.31	14.0	3.20	14.0	0.91	15.3	.591
4981	20.685	14.3	0.97	13.0	4.28	14.2	1.99	14.6	.177

TABLE II—*Continued*

OBSERVATIONS OF VARIABLE STARS IN MESSIER 13

Plate	Julian Day	Var. No. 1 Mag.	Var. No. 1 Phase	Var. No. 2 Mag.	Var. No. 2 Phase	Var. No. 6 Mag.	Var. No. 6 Phase	Var. No. 8 Mag.	Var. No. 8 Phase
5698	9785.692	14.5	0.44	14.1	3.57	14.1	0.78	15.3	.326
5708	86.637	13.7	1.39	13.1	4.51	14.4	1.73	14.9	.520
5719	.846	14.0	0.14	13.0	4.72	14.0	1.94	14.1	.729
5722	87.635	14.8	0.93	12.9	0.40	13.9	0.61	14.5	.018
5723	.642	14.8	0.93	12.9	0.41	13.9	0.62	14.3	.025
5724	.689	14.7	0.98	12.9	0.46	13.9	0.67	14.5	.072
5805	813.615	14.6	0.64	12.9	0.83	14.3	1.24	15.1	.487
5807	.647	14.7	0.68	12.9	0.86	14.3	1.27	15.1	.519
5813	.801	14.6	0.83	12.8	1.02	14.4	1.43	14.6	.673
5816	14.600	14.2	0.17	13.1	1.82	13.8	0.17	14.4	.722
5819	.644	14.2	0.21	13.1	1.86	13.5	0.16	14.2	.016
5828	.824	14.2	0.39	13.1	2.04	14.0	0.34	14.7	.196
5831	15.600	14.0	1.17	13.8	2.82	14.4	1.11	14.7	.221
5834	.642	13.6	1.21	13.6	2.86	14.5	1.15	14.8	.263
5838	16.598	14.7	0.71	13.8	3.82	13.9	2.11	15.1	.469
5841	.645	14.7	0.76	13.8	3.86	13.8	0.04	15.1	.516
5851	.826	14.6	0.94	13.2	4.04	13.9	0.22	14.5	.697
5938	40.586	13.2	1.35	13.3	2.25	14.2	0.74	15.0	.447
5942	41.593	14.6	0.90	13.4	3.26	14.4	1.75	14.5	.704
5953	.810	13.8	1.12	13.8	3.48	14.2	1.97	14.6	.171
5957	42.581	14.8	0.43	13.5	4.25	14.1	0.63	14.6	.191
5965	.722	14.6	0.57	13.4	4.39	14.3	0.77	14.9	.332
5972	43.579	13.7	1.43	13.0	0.14	14.4	1.62	15.0	.439
5981	.747	13.7	0.14	12.7	0.30	14.2	1.79	15.1	.607
6832	0169.603	14.7	0.64	13.6	4.23	13.5	0.16	14.4	.080
6835	.665	14.6	0.70	13.3	4.29	13.5	0.22	14.5	.142
6841	.825	14.6	0.86	13.2	4.45	13.9	0.38	14.8	.302
6843	70.610	14.1	0.19	12.8	0.13	14.2	1.17	15.2	.337
6846	.673	14.0	0.25	12.7	0.19	14.4	1.23	14.8	.400
6852	.818	14.4	0.39	12.8	0.33	14.6	1.37	15.0	.545
6854	71.606	14.0	1.18	13.0	1.12	13.8	0.05	15.0	.582
6857	.643	13.6	1.22	12.9	1.16	13.8	0.09	15.1	.619
6858	.661	13.7	1.24	12.9	1.18	13.7	0.10	14.9	.637
6867	72.603	14.8	0.72	13.2	2.12	14.4	1.05	14.5	.079
6871	.653	14.6	0.77	13.2	2.17	14.3	1.10	14.5	.129
6879	.838	14.8	0.96	13.5	2.35	14.6	1.28	14.9	.314
6924	97.588	14.6	0.90	13.1	1.55	14.3	0.68	15.0	.304
6932	.764	14.1	1.08	13.0	1.73	14.3	0.85	15.0	.480
6934	99.597	13.4	1.45	13.7	3.56	14.2	0.57	14.3	.062
6941	.806	14.2	0.20	14.0	3.77	14.2	0.78	14.7	.271
6945	200.590	14.6	0.99	12.9	4.56	14.6	1.57	14.9	.304
6955	.786	13.8	1.18	12.8	4.75	14.4	1.76	....	.500

which the Julian Day is given only to the second decimal a mean of several plates taken in quick succession is given. The 99 plates later than J.D. 2427728 were taken at this observatory.

Figure 2 shows the light curves of the four variables. For

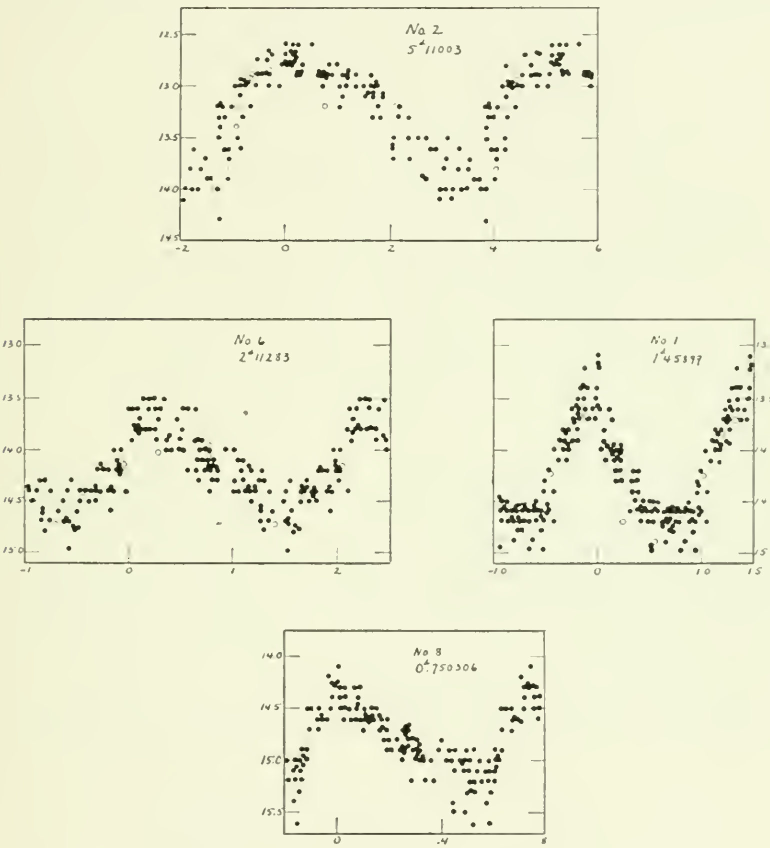

FIGURE 2

The light curves of four variable stars in Messier 13; three are long period Cepheids, and one a cluster type variable. Early observations by Shapley are indicated by open circles.

Variables 1, 2 and 6, Shapley's observations are indicated by open circles. The scatter of the points for No. 6 is probably increased by the presence of a moderately bright star close to the variable.

The four periods so far determined outline a good period-luminosity relation in this cluster, as shown in Figure 3. The correct determination of the period of No. 1 removes a discrepancy which existed in the period-luminosity relation when, according to Barnard's work, a Cepheid with period of 6 days had a brightness fainter by one magnitude than a Cepheid of 5 day period.

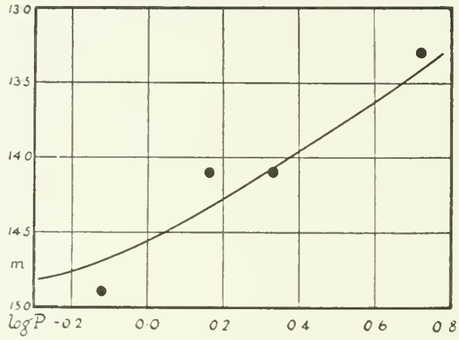

FIGURE 3

The period-luminosity relation in Messier 13.

Messier 13 is now the seventh globular cluster in which both long period and cluster type Cepheids are found, and in which a good period-luminosity relation is defined. Table III summarizes these clusters. It is important to note that no cluster so far investigated has afforded evidence against the validity of the period-

TABLE III

CLUSTERS IN WHICH A PERIOD LUMINOSITY RELATION IS ESTABLISHED

Name	NGC	No. Long Period Cepheids
Omega Centauri..	5139	6
Messier 3........	5272	1
Messier 5........	5904	2
Messier 13.......	6205	3
Messier 14.......	6402	3
Messier 15.......	7078	1
Messier 2........	7089	4

The references can be found in Pub. D.D.O. Vol. I, no. 4, 1939.

luminosity relation. In the one case, NGC 362, in which long period Cepheids were found by the writer[8] to be of the same brightness as cluster type variables, the evidence indicates that the long period Cepheids are actually members of the Small Magellanic Cloud, rather than of the cluster. Most of the clusters listed are very rich in cluster type Cepheids; Messier 13 is the only one in which there are so few.

Although in no cluster does the period-luminosity relation rest on an abundance of evidence, the corroboration from globular clusters, one by one, may be considered important because two effects which increase the scatter of the relation in the Magellanic Clouds and in extragalactic nebulae are reduced to a minimum in globular clusters; namely, a great depth of the system itself, and large amounts of obscuring nebulosity in the system.

The distance of the Hercules cluster as determined from this study of the variables is somewhat smaller than that determined earlier.[9] A mean modulus of the cluster from these four variables is 14.8, corresponding to 9.2 kiloparsecs, to be compared with the previous modulus of 15.07 or 10.3 kiloparsecs (both uncorrected for absorption, which is probably small at galactic latitude +40°). To include the other variables which are almost certainly cluster type, but whose periods are not yet definitive would not change the modulus appreciably. At this distance the cluster has an absolute photographic magnitude of −8.0 independent of absorption, as computed from Christie's schraffierkassette magnitude[10] of 6.78. This is bright for a globular cluster, but not in a class with 47 Tucanae, determined recently by Shapley[11] to be of absolute magnitude −10.2.

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VARIABLE STARS IN THE GLOBULAR CLUSTER MESSIER 80

by

HELEN B. SAWYER

1942
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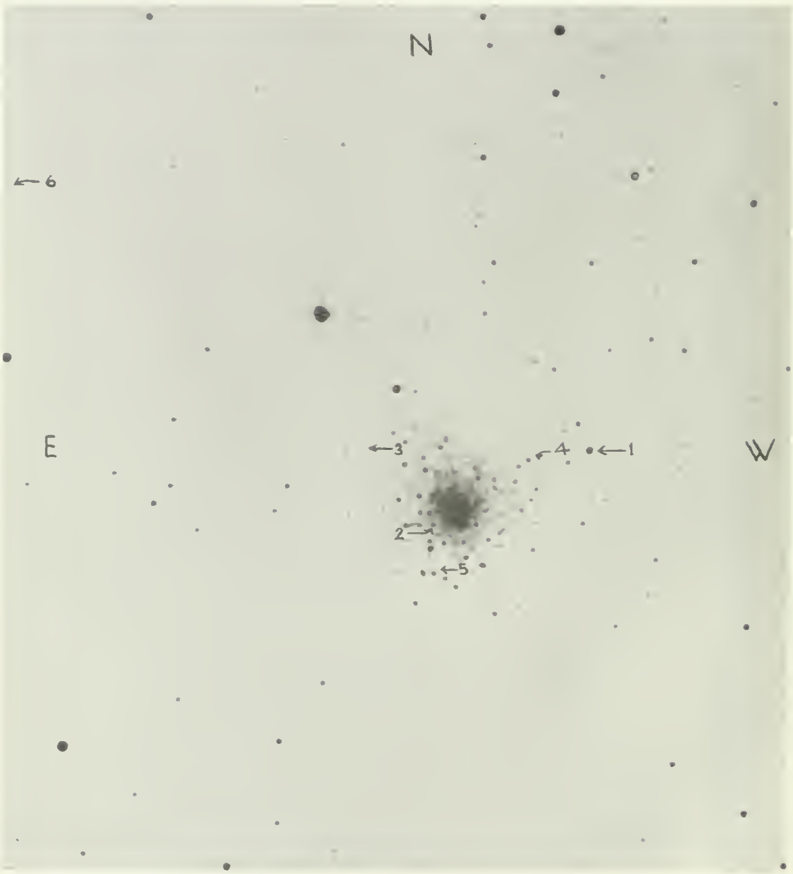
PLATE XXVIII



The globular cluster Messier 80, NGC 6093, showing six variable stars. Variable No. 1, a long period Cepheid, is at maximum.

Scale, 1 mm = 8.″1. Enlarged from Steward plate 4444, taken 1939, June 23.

VARIABLE STARS IN THE GLOBULAR CLUSTER MESSIER 80

By Helen B. Sawyer

(With Plate XXVIII)

THIS is the first paper in a series of short reports on variable stars in southern globular clusters. The material for these investigations consists of 279 direct photographs. These were taken by the writer in 1939 with the 36-inch Steward reflector of the University of Arizona at Tucson, through the kindness of the Director, Dr. E. F. Carpenter. The expedition was made possible by a grant from the National Academy of Sciences. The writer wishes to express her appreciation to those who made this study of southern globular clusters possible. Useful material was obtained on fourteen clusters. This material is intended as a preliminary survey only, to show the number of variables a cluster may contain, with special attention to long period Cepheids. For no cluster are the plates sufficient for an exhaustive investigation of the light curves of the variables. Imperial Eclipse plates were used.

Messier 80 (NGC 6093) is already well known as being the only globular cluster in which a nova has been seen. This cluster is situated in a rich region in Scorpio, R.A. $16^h14^m.1$, Dec. $-22°52'$ (1950), galactic latitude $+18°$, on the edge of a region of obscuring nebulosity. It was in 1860 that a nova flared forth in the very centre of the cluster, reaching apparent magnitude 6.8. It is still not known whether the nova was definitely associated with the cluster, and no identification of it exists to-day. Its position as determined visually in 1860 does not correspond to that of any of the variables in the cluster. If it was in the cluster, it was an unusually bright nova.[1]

Only two variable stars, besides the nova, have been known in this cluster. These were announced by Bailey[2] in his comprehensive work in 1902. The cluster is an exceedingly compact and congested object, of concentration class[3] II, so that the search for variables is difficult. From a search of the 26 available plates with a blink microscope recently constructed by Dr. R. K. Young at this observatory, the writer has found four additional variables. With one exception, these have small ranges. It is possible that other variables of small range have escaped detection, but it is unlikely that any other variables with range as large as one magnitude exist in the cluster. The positions of these variables have been measured on a suitable plate by means of a reseau, oriented by a trail in declination, and referred to the same centre used by Bailey. The scale of the plates taken with the 36-inch reflector using the zero-power Ross corrector, as determined by Dr. E. F. Carpenter from measures of a Pleiades plate is $44''.42 \pm 0''.06$ per millimetre.

Magnitude values for the comparison stars selected by Bailey were determined from two sequence plates, both of sixteen minutes exposure, on Kapteyn Selected Area 132. The magnitudes of the stars used in the selected area are those given by Seares, Kapteyn, and van Rhijn.[4] The values obtained for the comparison stars are as follows: a, 12.5; b, 12.5; c, 13.2; d, 13.5; e, 13.9; f, 14.1; g, 14.5; h, 14.7; k, 15.2; l, 15.3; m, 15.5; n, 15.6; o, 15.9; p, 16.3; q, 16.7.

Table I gives the positions of the variables, including the two found by Bailey, and their maximum, minimum, and median magnitudes. The variables are marked on Plate XXVIII. Variable No. 6, which is 9′ from the cluster centre, is probably a field variable. The angular diameter of this cluster as measured by Shapley and Sayer[5] is 14′.3.

The variables have been estimated on all the 26 plates available to the writer. The average exposure time of each plate is sixteen minutes, and the limiting magnitude of the better plates is about 16.8. From the small ranges and day to day changes it may be inferred that Variables 3, 4, and 5 are cluster type, though the plates, taken of necessity near the meridian at the same hour angle do not suffice for period determination. No information can be

TABLE I

Variable Stars in Messier 80

Var.	x	y	—Magnitudes— Max.	Min.	Med.	Remarks
1	−137″	+79″	13.1	14.5	13.8	Long period Cepheid
2	+22	−19	14.7	15.3	15.0	Type unknown
3	+104	+56	15.6	16.3	16.0	Probably cluster type
4	−85	+61	15.6	16.2	15.9	" " "
5	+14	−67	15.7	16.2	16.0	" " "
6	+520	+296	14.1	15.8	—	Long period variable, probably field star.

gleaned as to the type of variability of Bailey's Variable No. 2, because of small range and congestion. No. 6 is shown to be a long period variable. Starting at magnitude 14.1 on the earliest plate in the series, taken on May 18, 1939, it drops steadily to magnitude 15.8 on the last plate, taken June 24, 1939. Probably these values do not represent the real maximum or minimum of this star.

For Variable No. 1 the plates suffice to indicate that the star is a long period Cepheid with period of about 16 days. Table II gives the observations of this star. Since there is no series taken throughout one night, these observations cannot prove that this is not a short period star; but in view of the large range and great brightness,

TABLE II

Observations of Variable No. 1 in Messier 80

Plate	Julian Day 2,420,000.+	Mag.	Plate	Julian Day 2,420,000.+	Mag.
4180	9402.820	14.1	4305	9425.728	13.3
4181	.847	14.1	4308	.779	13.3
4191	03.840	13.8	4318	26.728	13.4
4192	.854	13.8	4323	27.801	13.8
4204	05.824	13.2	4340	29.821	14.5
4205	.840	13.2	4351	30.799	14.5
4220	06.817	13.1	4383	33.835	14.3
4232	07.817	13.2	4392	34.728	14.3
4246	08.805	13.3	4406	35.724	13.9
4262	09.833	13.4	4409	.840	13.8
4274	11.849	13.7	4430	37.726	13.0
4285	22.790	13.2	4444	38.755	13.0
4294	24.790	13.3	4454	39.703	13.0

the writer considers such a circumstance unlikely. The observations are perfectly represented by a sixteen day period. The star reaches maximum three times during the interval covered by the observations. Figure 1 shows the light curve of this variable as computed from the formula

$$\text{Maximum} = \text{J.D. } 2429406.8 + 16^{d}.0 \text{ E.}$$

The presence of this Cepheid along with that of the three variables assumed to be cluster type gives a period-luminosity relation in this cluster, from which the distance of the cluster may be derived. As a Cepheid of 16 day period has a median absolute magnitude of -2.3[6], the modulus of the cluster from this variable is 16.1;

while the modulus from the three variables assumed to be cluster type is 16.0. Both of these values are in good agreement with the previous value[7] of the modulus determined from the brightest stars, 16.22. Assuming a modulus of 16.05 from this study of the variables, the distance uncorrected for absorption is 16 kiloparsecs. Doubtless this must be substantially corrected for absorption, because Stebbins and Whitford[8] find a colour excess of +0.10 magnitude for this cluster. The actual correction to be applied seems in doubt, as the cluster falls in an intermediate group of clusters showing small obscuration. Baade's counts[8] show the number of nebulae to be less than normal, though the number of stars in the field is normal.

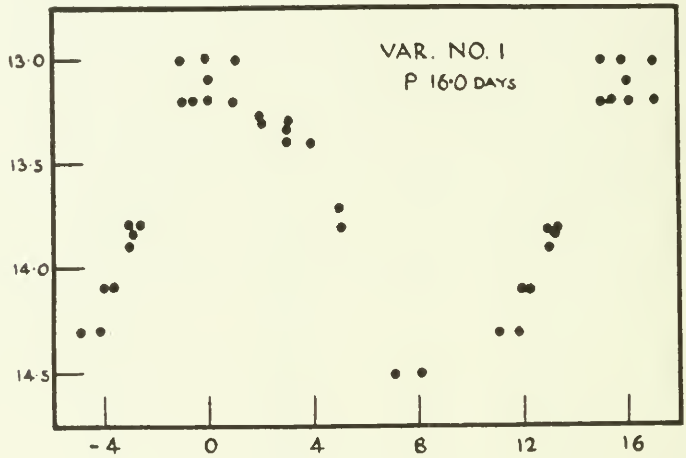


FIGURE 1.

Messier 80 is therefore a distant cluster, poor in variable stars. The few that it contains support the period-luminosity relation; and it contributes another long period Cepheid to the rather scanty number known in globular clusters.

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THE RADIAL VELOCITIES OF 374 STARS

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THE RADIAL VELOCITIES OF 374 STARS

THE stars contained in this publication complete the observation of all stars in regions 6 x 6 degrees square whose centres are the Kapteyn regions in the northern hemisphere. The photographic magnitude limit was set at 7.59. In an earlier publication from this observatory velocities were furnished for areas 4 x 4 degrees square and the present list extends this area to 6 x 6 degrees. With very few exceptions the spectrograms have been secured with the 12½-inch camera which gives a dispersion of about 66 A per mm. at Hγ. Observation was begun about March 1939 and completed in May 1942. No changes in the methods of observation or measurement and reduction have been made and systematic errors should be the same for the present list of stars as for the first list of 500.

Between the two lists there are now 122 stars which have been observed at other observatories. A comparison of these yields the results in Table I. The various columns in this table are:

1. Type.
2. No. of stars available for comparison when list of 500 was published.
3. Algebraic residual of these.
4. Probable error.
5. No. of stars now available.
6. Algebraic residual based on the new more extensive comparison.

TABLE I

Type	No. Stars	Alg. Residual	p.e.	No. Stars	Alg. Residual
B	5	− 2.9	0.8	13	− 2.0
A	9	− 0.4	1.3	45	+ 0.1
F	14	+ 0.3	0.5	23	+ 0.4
G	10	+ 2.3	0.7	13	+ 2.2
K	17	+ 0.2	0.3	24	+ 0.3
M	4	+ 2.5	0.2	4	+ 2.5
All types	59	+ 0.40		122	+ 0.33

The observation and measurement, as in the last programme, have been undertaken by the members of the staff conjointly. Owing to war conditions the staff has been changing quite frequently and many have contributed to the final results—F. S. Hogg, P. M. Millman, J. F. Heard, G. H. Tidy, A. F. Bunker, W. F. M. Buscombe, W. S. Armstrong, G. F. Longworth, R. M. Cunningham,

Miss R. J. Northcott, Miss E. M. Fuller. My thanks are especially due to Miss R. J. Northcott who has watched over the measurement and broken in so many new hands to the task of measuring and to Mr. G. F. Longworth who has taken a major part in the observations and kept the telescope in good running order.

The results for all the stars are included in Table II in which the columns have the following meanings.

1. The serial number in the Henry Draper catalogue.

2-3. The right ascension and declination for the epoch 1900.0.

4. The visual magnitude from the H.D. catalogue.

5. The H.D. type.

6. The type as estimated from our spectra. The criteria for estimating the type has been made as simple as possible and agree in general with the Harvard system and more particularly with the system adopted at Victoria as given in the Transactions of the International Astronomical Union, Vol. 5.

   For the A-type—A0, K 0.1 times Hδ; A2, K 0.4 times Hδ; A5, K 1.2 times Hδ; A9, K 2.0 times Hδ. In the F-type attention was centered on the line 4227; F3, 4227, 0.1 times Hγ; F7, 4227, 0.8 times Hγ; F8, 4227 = Hγ; G0, 4227, 3 times Hγ. For the later types the absolute intensity of 4227 was compared with typical spectra from G0—K8 and for the M-type the strength of the titanium oxide bands was used as a criterion.

7. The velocity of the star, i.e., the weighted mean velocity from all the plates if the velocity seemed constant or the variation small or not reasonably certain. Those stars in which the variation was fairly definitely established are marked "Var."

8. The probable error of the mean computed by the formula

$$\text{P.E.} = 0.845 \frac{\Sigma V}{n\sqrt{n}}$$

9. The number of plates.

10. The minimum and maximum number of lines measured.

11. The average probable error of a plate. The probable error of each measure was computed from the agreement of the lines when the plate was measured. ē is the mean of these for the various measures.

12. Published velocities at other observatories. W refers to the Mount Wilson lists in Ap. J., Vol. 87, p. 516 and Vol. 88, p. 35;

V, the Victoria lists, D.A.O. Publications, Vol. VI, No. 10 and Vol. VII, No. 1; P, the Pulkova list, Pub. Pulkova Obs., Ser. II, Vol. XLIII.

13. References. R indicates that there is a note to this star at the end of the table. III indicates that the velocities as determined from the individual plates will be found in Table III. In this column also reference is made to a number of stars which show a considerable range. Such stars are indicated either by * or by a number. In the former case the velocity is uncertain, the range being judged due to the poor character of the spectrum for measurement. In the latter case the velocity range is indicated by the number and the star is judged to have a greater range than the character of the lines would lead one to expect.

The velocities for the stars which are variable are shown in Table III. There are 37 of these stars; 1 in 10 was judged to be variable. With the low dispersion employed, the velocity variation is not established unless it is about 30 km. or more. Column 1 gives the H.D. number, right ascension and declination for 1900, visual magnitude and type; Column 2, the Julian date and fractional part of the day; Column 3, the measured velocity and repeat measures; Column 4, the number of lines measured; Column 5, the probable error of the plate as indicated by the agreement of the various lines; Column 6, the measurer, N—Miss R. J. Northcott, F—Miss E. M. Fuller, T—G. H. Tidy, B—A. F. Bunker, C—R. M. Cunningham, Bs—W. F. M. Buscombe, Y—R. K. Young, L—G. F. Longworth, A—W. S. Armstrong.

TABLE II

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Pub. Velocity	Ref.
	h m	° ′										
448	00 03.9	+17 40	5.69	K0	K0	−20.1	0.6	4	15–27	1.5	−23.9 ± 1.2 W	
487	04.3	45 50	7.00	B9	B9	−07.2	2.2	6	3–5	5.0		
743	06.7	47 36	6.30	K0	K4	+15.5	1.2	5	14–23	1.9	+17.1 ± 0.2 V	
1359	12.7	75 43	7.12	B9	B8	−05.0	1.0	5	3–4	5.0		
2739	25.8	43 24	6.64	B8	B8	−07.4	1.2	5	3–6	3.6		
2888	00 27.1	+42 57	6.43	A0	B9	−23.8	3.6	6	3–4	8.5	−19.9! V	R
3264	30.7	48 00	7.42	A0	B2	Var.		4	6–14	3.4		III
3881	36.3	59 23	7.35	A3	A6	Var.		6	7–21	2.9		III
3924	36.7	58 13	6.13	B9	B9	−03.5	2.3	5	4–8	3.1		
4362	40.9	59 02	6.49	G5	G7	−15.5	0.7	4	20–26	2.0		
4666	00 43.6	+77 25	6.75	A5	A6	−15.9	1.3	5	10–15	4.5		
5343	50.2	57 26	6.43	K2	K3	−29.3	1.1	4	19–27	1.1		
5526	52.0	45 18	6.24	K0	K0	+06.1	0.7	5	13–24	1.3	+5.4 V, +5.2 P	
5551	52.2	63 11	7.7	B2	B1	−51.5	2.4	5	6–11	3.2	−51 W	
5596	52.6	45 03	7.17	A3	A3	−19.5	1.3	6	8–14	4.2		
5638	00 53.0	+46 31	6.75	A0	B2	Var.		7	7–13	3.5		III
5764	54.2	47 29	7.00	B8	B2	−04.6	0.7	4	6–12	3.1		
5813	54.6	57 50	7.15	A3	A3	−04.8	2.0	4	4–8	4.9		
5944	55.8	57 17	6.74	A2	A2	−09.3	0.8	4	7–13	3.2		
6676	01 02.4	57 44	5.70	B8	B8	−04.4	2.4	4	4–6	4.2		

TABLE 11—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	$\bar{e}$	Pub. Velocity	Ref.
	h m	° ′										
8272	01 17 0	+ 57 37	6.45	F5	F5	+ 07.0	0.5	4	10–19	2.0		
8671	20.4	42 57	6.08	F5	F5	+ 30.4	1.0	8	9–16	1.4	+ 29.1 ± 0.8 V	
8710	20.8	43 11	6.93	F2	F2	+ 06.6	1.6	7	6–13	3.2		
8862	22.3	43 32	6.56	B9	B9	Var.		6	4–9	3.0		III
9800	30.7	47 49	7.26	F0	F0	− 06.5	0.9	5	12–19	2.7		
11884	01 51.7	+ 46 36	6.53	K0	K0	− 06.1	0.8	5	12–28	1.9		
13201	02 03.9	16 46	6.43	F5	F3	+ 10.5	0.9	4	9–17	2.1		
14739	17.5	17 09	7.26	A2	A2	− 09.7	1.5	6	3–12	6.2		
15365	23.3	45 34	6.77	G5	G8	+ 35.0	0.8	4	11–28	1.5		
15510	24.7	45 57	6.97	A5	A6	− 11.3	2.7	6	6–12	5.4		
15579	02 25.3	+ 46 09	7.06	F2	F2	+ 22.7	1.4	5	7–15	2.5		
15814	27.5	14 36	6.07	F5	F8	Var.		5	15–19	1.5	− 3.3 W, Sp. B, P	III
16108	30.2	41 58	6.72	B8	B9	− 16.0	0.7	5	3–4	3.4		
16780	36.3	47 51	6.56	G5	G5	− 04.1	0.7	4	15–26	1.4		
16855	37.1	43 07	6.66	A2	A2	Var.		6	12–26	1.8		III
17086	02 39.5	+ 60 09	6.68	A5	A5	− 14.6	1.3	5	20–23	1.9		
17088	39.5	57 19	7.54	B2	B5	− 42.6	2.2	4	7–10	2.5		
17330	41.8	29 17	7.19	B9	B6	− 03.2	1.0	5	6–12	2.7		
17591	44.3	63 00	6.94	G0	F8	− 11.2	1.1	5	16–22	1.5		
17688	45.2	60 03	7.36	A3	A6	+ 01.8	1.3	4	18–24	1.7		

TABLE II—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Pub. Velocity	Ref.
	h m	° ′										
17818	02 46.5	+48 09	6.51	K0	K2	+00.1	1.2	4	20–25	1.5		
17922	47.7	42 11	7.01	F5	F8	+25.5	1.0	5	9–20	2.7		
18040	48.8	47 56	7.20	A2	A2	−08.5	3.0	6	3–4	3.7		*24, R
18155	49.8	46 45	6.13	K0	K2	−12.2	0.3	4	11–19	2.3		
18876	57.1	62 38	7.42	B8	B5	−02.9	1.6	4	5–9	2.6		
19789	03 05.9	+12 40	6.44	G5	G6	+11.7	0.5	5	18–27	2.0		
20193	09.6	32 29	6.34	F0	F2	+10.6	1.1	4	10–18	1.8	+13.7 V, +14.4 P	
20277	10.5	31 49	6.05	K0	G5	+17.5	1.8	5	15–19	1.6		
20367	11.5	30 46	6.53	G0	G0	+05.3	1.0	5	15–19	1.5		
20500	12.8	12 28	7.64	B8	A0	+15.1	1.4	6	3–11	3.0		
21051	03 18.7	+12 17	6.22	G5	K0	+21.5	1.7	5	13–27	2.3		
21203	20.2	59 54	6.48	B8	B9	+03.8	3.7	6	3–5	6.5		*
21427	22.2	59 02	6.06	A0	A2	+08.9	1.5	6	3–6	3.1	+21.1 V	
21540	23.4	46 42	7.00	B8	B8	+05.4	0.8	4	3–6	2.5		
21541	23.4	14 39	7.32	A0	A0	+07.1	1.5	5	2–5	4.7		
21590	03 24.0	+16 25	7.02	A0p	A0p	+00.4	1.8	5	5–7	2.7		
21641	24.5	47 31	6.77	B9	B9	+14.0	2.4	5	3–5	4.5		*R
21700 s.p.	25.0	27 23	8.0	B9	A0	+16.5	2.2	5	2–6	4.0		R
21700 n.f.	25.0	27 23	7.8	B9	A0	+06.7	3.0	5	3–5	3.8		
21743 f.	25.3	27 14	6.54	A0	A0	+02.2	2.4	6	3–5	3.8	+7.8 V	R

TABLE II—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Pub. Velocity		Ref.
	h m	° ′											
21769	03 25.5	+58 26	6.27	A2	A3	+07.4	1.6	5	11–19	2.9	+3.4	V	
21794	25.7	57 32	6.41	F5	F5	−68.0	0.8	4	7–18	1.6			
21844	26.2	47 36	6.69	F0	F2	+37.8	0.8	5	9–18	2.5			
21970	27.4	75 24	6.38	G5	G5	+28.9	1.1	4	18–23	1.6			
22402	31.2	42 15	6.30	B8	B8n	−01.9	3.1	7	2–6	9.0			*33
22521	03 32.2	+42 13	6.95	G0	F8	−39.2	2.0	4	14–24	1.9			
22766	34.5	28 27	6.86	A0	A0	+10.0	1.5	6	2–7	5.1			
22860	35.2	28 23	6.89	B9	B9	+04.4	0.8	6	4–7	4.4			
24701	50.5	43 02	7.20	A0	A0	−00.6	2.7	7	3–5	5.5			
28354	04 23.2	27 10	6.61	A0	A0	+19.0	3.1	6	2–3	5.1			*30
28447	04 24.1	+27 55	6.64	G5	G3	+23.5	1.5	4	14–21	1.8			
28459	24.2	32 14	6.19	B9	B9	+18.9	2.7	6	2–3	7.0			
29224	31.0	27 43	7.38	A0	B8	−03.5	3.1	7	2–5	6.7			*32
29537	34.0	29 47	6.92	F0	F1	+24.3	1.4	4	13–15	3.6			
29646	35.0	28 25	5.68	A0	A0	+23.0	1.9	6	2–5	5.0	+25.2	V	
31151	04 48.3	+61 36	6.90	G0	G5	−20.4	1.5	4	19–23	2.0			
31590	52.0	73 55	6.00	A2	A0	−13.7	1.9	6	3–5	5.1	−2.2*	V	
32784	05 00.5	62 21	6.74	A5	A7	−03.0	1.0	5	15–19	1.8			
31441	05.2	62 59	6.74	F0	F0n	−16.6	0.9	5	6–15	4.4			
34021	09.2	12 25	7.5	A0	A0	+15.5	1.1	4	3–7	9.6			*

TABLE II—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	$\bar{e}$	Pub. Velocity	Ref.
	h m	° ′										
34109	05 09.9	+ 85 35	6.55	A0	A0	− 15.2	4.7	4	3–4	5.0		*32
34250	10.9	28 49	6.89	F0	F0	+ 01.3	1.4	5	11–22	2.5		
34255	11.0	62 33	5.88	K2	K2	− 05.9	0.9	5	18–22	1.9	− 05.3 W	
34384	11.9	28 41	7.25	A3	A5	− 23.9	1.8	4	13–18	2.8		
35544	20.4	43 17	6.75	A0	A0	− 01.8	4.0	5	3	6.3		*37
35761	05 21.9	+ 42 12	6.76	G5	G5	− 09.6	0.9	4	16–20	1.7		
35802	22.2	17 10	6.04	K5	K5	− 22.0	0.8	4	16–20	1.8		
35815	22.3	62 55	7.46	A0	A0	+ 12.4	1.2	6	6–12	3.2		
35956	23.2	12 29	6.81	F8	F8	+ 09.0	1.7	4	11–16	1.4		
36104	24.2	12 12	7.00	B8	B5	+ 14.2	3.0	4	3–7	6.7		
36162	05 24.7	+ 15 17	5.78	A2	A2	− 15.6	2.0	7	3–4	7.4	− 06.6* V	*
36404	26.4	42 02	6.30	B8	B8	+ 00.1	2.6	4	3–9	3.4		
36425	26.5	31 48	7.26	A2	A2	+ 04.5	1.3	5	3–4	3.9		
36484	26.9	32 44	6.50	A0	A2	Var.		4	9–14	2.2		III
36859	29.6	27 36	6.47	K0	K5	Var.		5	13–25	2.4		III
37136	05 31.2	+ 61 53	6.65	A5	A5	− 16.0	1.0	5	5–16	3.0		
37366	33.0	30 50	7.52	B5	B3	Var.		5	7–9	3.2		III
37519	34.1	31 18	5.96	B8	B9	− 08.3	3.2	6	3–4	5.4		*
37574	34.4	32 51	6.80	F8	F5	− 10.3	2.3	5	6–17	2.2		20
37646	35.0	29 26	6.75	A0	B8	Var.		6	3–5	6.7		III

TABLE II—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Pub. Velocity	Ref.
	h m	° ′										
37647	05 35.0	+ 29 27	7.45	A0	A0	+ 18.1	1.5	5	3-5	3.7		
38258	39 4	47 26	7.38	B8	A0	− 03.9	1.4	5	3-6	2.8		
38358	40.1	42 30	6.41	K0	K2	− 15.3	1.8	6	13-20	2 0		20
39863	50.2	45 53	6.56	G5	G5	+ 03.8	1.0	4	18-22	1.3		
40143	52 0	45 37	6.60	A0	A2	− 13.0	2.6	5	3-5	2 7		22
42180	06 04.2	+ 14 52	7.29	B9	B9	+ 15.1	3.5	5	3-6	5.2		*41
42476	05.8	17 24	6.91	A0	A0	+ 28.1	2.2	5	2-5	2.9		
42477	05.8	13 40	5.86	A2	A0	+ 11.4	3.2	5	3-4	6.2	+ 11.6 V	
43335	10.6	17 12	6.47	K0	Ma	+ 39.4	1.6	5	7-18	2.5		
43537	11.7	28 02	7.42	A0	A0	+ 10.6	1.0	4	7-11	2.6		
43646	06 12.2	+ 29 49	6.86	A0	A0	+ 10.7	0.7	4	4-7	2.3		
43819	13 2	17 21	6.17	B8	B9	+ 03.1	2.2	5	3-8	2 5		21
44071	14 7	29 25	6.91	F0	F2	− 10.5	1.1	4	9-18	1.8		
44234	15.6	17 49	6.46	K0	K0	+ 11.4	1.2	4	12-22	2.1		
44497	17 0	12 37	5.97	F0	F2	+ 18.2	1.8	5	12-31	2.5		
45192	06 21 0	+ 32 38	6.43	K0	K0	+ 58.2	1.6	6	10-20	2.4		18
45504	22 7	27 02	6.49	F5	F5	− 06.8	0.5	4	11-18	1.4		
45757	24.2	17 59	7.33	A0	A0	+ 35.3	2.2	4	3-5	9.2		*
45899	25.1	32 14	6.91	B9	B8	− 04.4	1.7	4	5-6	4.0		
46148	26.6	15 47	7.13	F5	F8	Var.		4	8-20	2.2		111

TABLE II—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Pub. Velocity	Ref.
	h m	° ′										
46641	06 29.4	+ 32 22	7.23	A2	A2	+ 15.3	2.9	5	3–8	3.4		
47256	32.6	27 53	7.20	A2	A4	+ 41.0	1.4	6	5–21	2.8		
47731	35.0	28 18	6.54	K0	K0	− 06.5	1.5	4	17–20	2.0	− 3.8 ± 0.3 W	
50384	47.9	45 57	6.48	K0	G7	+ 31.7	1.9	5	12–21	1.7		
50551	48.7	57 41	6.13	K2	K2	− 53.9	1.2	4	20–23	1.3		
50658	06 49.1	+ 46 25	5.80	B8	B8	− 42.1	1.3	5	3–4	5.2		
50763	49.5	46 49	6.03	K0	G8	+ 40.0	2.0	4	18–25	1.1		20
51418	52.2	42 26	6.61	A0	A0	− 23.5	1.9	5	6–8	3.9		R
54901	07 05.6	15 30	7.26	F0	F2	Var.		5	13–18	2.3		III
56222	11.1	31 53	6.68	B8	B9	+ 21.7	1.1	4	4–8	5.4		
56386	07 11.7	+ 31 09	5.98	B9	B9	+ 33 2	4.3	5	3–5	4.4		*36
57069	14.6	29 55	7.11	A2	A2	+ 03.6	1.5	6	3–6	8.9		*
58244	19.7	32 06	6.81	A0	A0	− 15.1	2.8	6	2–3	9 0		*
58917	22.6	62 43	6.77	A0	A0	+ 00.5	1.6	7	3–7	5.0		
59033	23.1	61 58	6.75	G5	G5	− 00.8	1.2	4	20–23	1.3		
59150	07 23.6	+ 14 34	7.04	A3	A0	− 07.3	1.7	5	3–6	8.0		*
59152	23.6	12 58	6.59	A5	A5n	+ 25.0	3.1	5	5–10	5.7		
59764	26.4	12 53	6.59	G5	G8	+ 60.0	1.1	5	13–24	2.4		
60293	28.7	60 44	6.86	A0	A0	− 12.7	2.6	5	3–4	4.6		
60406	29 2	61 46	7.17	F5	F5	− 41.2	0.8	5	10–18	2.1		

TABLE II—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	$\bar{e}$	Pub. Velocity	Ref.
	h m	° ′										
61295	07 33.5	+ 32 14	6.14	F0	F2	Var.		5	16–24	1.9	+ 31.4 ± 0.4 P	III
63887	46.1	71 57	7.52	A0	A0	Var.		4	1–4			III
64106	47.2	47 38	6.38	K0	G8	− 60.6	1.2	4	13–21	1.8		
64958	51.3	44 15	6.47	K0	K0	− 48.3	1.5	5	13–26	1.8		
67959	08 05.3	14 56	6.14	A0	A2	+ 23.6	1.1	6	4–14	2.1	+ 20.2 V	
68332	08 06.8	+ 14 19	6.40	A5	A8	− 10.4	2.0	4	13–17	2.7	− 9.7 V	R
68703	08.5	17 58	6.43	F0	F0	− 03.8	1.5	4	19–21	2.5		
70566	17.6	32 38	7.48	A3	A3n	− 03.4	1.9	5	4–7	4.8		
70843	19.1	17 32	7.04	F5	F7	− 15.5	0.8	4	12–19	1.7		
71150	20.7	27 16	6.32	A2	A3n	− 29.4	2.1	4	3–7	3.6		R
71151	08 20.7	+ 27 16	6.30	A2	A3n	− 32.4	1.5	5	3–10	4.0		
71537	22.9	33 02	6.60	A0	B9n	− 12.2	3.1	5	3–4	4.3		*
72392	27.5	47 28	6.62	A0	A0	− 19.5	1.3	5	3–7	5.6		
72778	29.6	42 56	6.98	A2	A2	− 30.5	2.4	4	11–23	2.7		
73596	31.1	32 19	6.11	F2	F2	+ 12.0	1.4	5	8–22	3.0		
73971	08 36.1	+ 47 16	6.21	G5	G5	− 06.0	0.6	4	16–23	1.4		
74057	36.6	32 13	7.04	F8	F8	− 00.4	1.1	7	6–18	3.6		
74292	38.1	32 26	6.92	A2	A3n	− 09.4	1.2	5	6–12	4.1		
74546	39.5	28 48	7.24	F2	F3	+ 02.1	3.2	5	9–16	3.1		*22
75486	45.2	62 20	5.72	F0	F0n	− 31.3	2.3	7	5–23	3.0		*27

TABLE II—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Pub. Velocity	Ref.
	h m	° ′										
75487	08 45.2	+ 59 26	6.08	F0	F0	+ 09.1	1.1	5	14–34	1.5		
75556	45.6	42 23	6.14	K0	K0	+ 58.9	1.6	6	14–20	2.1		
76704	52.7	46 09	6.61	A0	A0	+ 02.0	1.7	7	3–5	6.8		
77986	09 00.6	16 15	7.27	B9	A0	+ 00.9	4.6	6	2–4	8.2		*
78661	04.4	11 58	6.46	F0	F0	− 16.3	1.5	6	7–17	3.4		
79929	09 11.8	+ 27 51	6.53	F5	F5	Var.		6	9–16	2.4		111
80064	12.5	11 55	6.29	A0	A2	− 01.8	2.5	5	10–20	3.1	− 06.8 V	
80390	14.4	57 08	5.98	Mb	Mb	+ 21.0	1.3	7	7–20	2.5		
80580	15.6	32 41	6.58	A0	A2	+ 07.7	3.1	6	2–4	5.3		
80652	15.9	17 02	6.79	A5	A8	+ 04.7	1.6	5	6–17	3.2		
81702	09 22.2	+ 56 41	6.94	F2	F2	− 02.8	1.0	6	7–13	2.2		
81995	24.1	45 12	7.12	A5	A5	Var.		5	10–17	2.9		111
82191	25.4	27 50	6.59	A0	A0	Var.		6	5–14	4.0		111
84004	37.0	32 44	7.18	F2	F2	+ 04.5	2.9	6	7–12	3.6		23
84005	37.0	30 35	6.68	A5	A5n	+ 00.2	2.5	6	3–14	3.4		
84107	09 37.7	+ 30 27	5.73	A2	A2s	+ 14.6	0.7	6	8–24	2.6		
84123	37.8	42 31	6.82	A3	A3	+ 15.3	1.8	7	16–32	2.4		20
86166	51.7	45 53	6.50	K0	K0	+ 06.1	1.3	6	11–22	1.9		
89239	10 12.6	27 55	6.46	B9	B9	+ 05.7	2.5	7	3–6	7.9		
90602	22.6	45 43	6.49	K0	K0	− 03.1	1.4	5	12–25	1.8		

TABLE II—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Pub. Velocity	Ref.
	h m	° ′										
91130	10 26.2	+ 32 51	5.83	B9	B9	− 10.9	1.7	5	3–6	5.8		
92278	34.2	47 22	7.30	A2	A2	− 08.3	2.0	5	3–7	5.8		
92371	34.8	28 02	6.93	A2	A0n	+ 05.9	3.8	8	3–5	10.5		*
93286	41.2	60 38	7.22	F0	A8	Var.		6	13–22	2.1		III
93817	44.9	56 46	7.34	B9	A0s	− 06.9	0.9	4	9–22	2.0		
93859	10 45.0	+ 57 07	5.76	G5	G5	+ 15.6	0.9	5	11–29	1.5	+ 15.6 ± 1.3 W	
93875	45.1	59 51	5.66	K0	K0	− 13.6	0.7	4	16–29	1.6	− 20.2 ± 0.5 W	
97214	11 06.5	14 56	6.29	A5	A5	+ 03.2	1.4	5	11–19	2.4	+ 7.5 V	
98547	15.2	17 52	6.87	A0	A2	− 01.8	4.2	4	3–5	6.1		*
99004	18.5	17 42	7.03	A2	A3	− 01.7	1.8	5	7–9	5.3		
99302	11 20.5	+ 27 19	7.15	A2	A3	Var.		7	14–21	2.6		III
99607	22.5	45 07	6.86	F0	F2	+ 16.7	1.2	5	13–22	1.7		
99983	25.1	57 17	6.96	F0	F2	− 03.5	1.2	5	5–15	4.2		
100054p	25.7	60 15	8.0	A5	A5	− 15.5	3.0	7	4–10	5.3		R
100054f	25.7	60 15	8.0		A2	Var.		6	10–18	2.0		III
100518	11 29.0	+ 11 35	6.46	A2	A0	− 04.1	1.8	4	12–20	2.3	− 9.7* V	
101091	32.9	32 27	7.13	F2	F2	− 13.4	1.7	5	10–15	2.7		
101133	33.2	47 23	6.25	F2	F2	− 23.9	0.5	5	13–28	1.7	− 25.7 V	
101620	36.5	41 48	6.84	F5	F5	− 08.3	1.5	4	12–16	1.5		
102056	39.6	29 13	6.98	A0	A0s	− 09.3	1.1	6	3–12	2.3		

TABLE II—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Pub. Velocity	Ref.
	h m	° ′										
102555	11 43.2	+28 59	7.21	F2	F2	+17.2	1.1	5	12–18	1.7		
102589	43.5	29 21	7.05	A2	A2	−06.8	1.8	5	5–10	4.7		
103483	49.9	47 02	6.46	A0	A2	−08.4	3.6	6	3–8	5.1	−16.9 V	R -
103498	50.0	47 01	6.81	B9	A0	−08.6	2.3	4	7–13	2.1	− 8* V	
103676	51.2	27 15	6.87	F2	F0	+09.3	1.7	5	10–17	2.8		
104904	11 59.7	+86 08	6.38	F5	F5	+07.0	0.7	4	17–23	1.1		
105262	12 02.1	13 33	7.00	B9	B9	+42.0	2.5	4	3–6	4.0		
106053	07.1	78 00	6.64	A0	A2	−15.8	2.3	6	2–7	5.0		
106223	08.2	30 51	7.46	A2	A2	−18.2	2.3	8	3–9	4.5		30
108399	22.1	72 29	6.44	K0	K0	+08.7	0.8	6	18–25	1.8		
108714	12 24.3	+17 53	7.52	A0	A0	+01.4	1.8	4	8–12	3.4		
109979	33.9	45 46	7.09	F2	F2	+07.4	1.9	4	8–14	2.1		
110093	34.6	86 17	7.07	F0	F0n	−12.4	2.2	4	9–16	2.9		
110500	37.5	46 25	6.94	A2	A2	−09.2	2.0	6	10–23	4.5	− 8.9 V	
120817	13 46.7	42 40	7.48	A2	A2	−16.1	4.0	6	5–11	5.4		*36
123845	14 04.9	+16 05	6.67	F5	F5	−00.6	1.5	6	6–16	3.1		
124586	09.4	31 40	7.25	A0	B8	−10.5	1.6	9	3–6	3.7		
124587-8	09.4	29 35	6.76	F0-A2	F0-A2	−08.8	0.3	4	18–27	1.5		R
124883	11.0	28 12	7.16	A2	A2	−05.0	2.2	6	10–30	3.4		
127539	26.9	18 05	7.16	F5	F5	−21.8	1.3	5	10–15	2.4		

TABLE II—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Pub. Velocity	Ref.
	h m	° ′										
128660	14 33.1	+ 43 16	6.70	F8	F8	− 02.0	1.4	5	11–18	2.3		
132560	54.7	58 02	7.13	F2	F5	− 10.0	0.9	6	13–17	2.3		
132890	56.5	62 04	7.04	A2	A2	− 00.1	3.8	7	3–8	7.1		*
133161	57.9	16 26	6.99	G0	G0	− 33.0	1.2	4	19–29	2.2		
133388	59.1	60 36	5.89	A2	A2	− 09.5	1.9	6	3–9	4.1		
136831	15 17.7	+ 12 56	6.20	A0	A0	+ 06.7	3.7	7	3–5	4.7		*40
138406	26.8	62 05	6.79	A0	A2s	Var.		6	14–32	2.2		III
140084	36.7	76 46	7.52	A2	A2	+ 20.0	2.2	4	3–5	7.0		*
140117	36.9	58 14	6.46	K0	K2	− 06.7	0.7	5	20–25	1.3		
140139	37.0	44 11	7.12	F0	F2	− 23.9	2.9	8	7–23	4.1		
143802	15 57.4	+ 85 35	7.05	A5	A5	− 11.5	3.3	3	11–15	2.5		
144839	16 02.8	13 36	7.18	F2	F2n	− 30.0	4.5	7	5–14	4.7		*33
145082	04.0	47 46	6.58	A0	A0	− 09.5	3.3	6	2–5	3.5		*
145976	08.7	26 56	6.37	F2	F2	− 09.0	0.7	5	13–18	2.5		
148317	22.1	16 12	6.77	G0	G0	− 33.5	0.9	4	9–15	2.0		
150010	16 33.2	+ 72 49	6.45	K0	K0	− 32.1	1.1	5	16–25	1.6		
152224	47.0	32 44	6.26	K0	K0	Var.		7	8–25	2.0		III
152303	47.5	77 41	6.01	F2	F2	+ 05.5	1.2	4	10–13	1.8		
153720	56.0	75 34	6.84	F0	F0	Var.		4	8–17	3.0		III
153845	56.8	77 00	7.19	F0	F2	− 02.0	0.9	5	14–21	1.8		

TABLE 11—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Pub. Velocity	Ref.
	h m	° ′										
153897	16 57.1	+ 27 21	6.37	F5	F3	− 32.7	0.8	5	11–21	2.9	− 31.3 ± 1.3 V	
154099	58.3	73 17	6.24	A5	A3n	Var.		5	3–9	6.0		III
154181	58.8	74 26	7.17	F5	F5	− 09.3	0.6	4	9–16	1.6		
154528	17 00.9	77 48	6.66	A0	A0	Var.		5	5–7	4.0		III
155513	07.0	61 17	6.69	F5	F5	− 07.5	0.8	5	13–22	1.8		
158013	17 21.7	+ 57 05	6.55	A2	A2	Var.		5	17–33	1.7		III
159870	31.9	57 38	6.17	F2	F5	+ 00.8	1.4	5	11–20	1.8		
160486	35.1	43 40	7.14	A2	A2	+ 12.9	0.9	4	10–12	2.7		
160740	36.5	44 04	7.19	A2	A2	− 31.2	2.2	7	3–6	5.7		
161959	43.4	28 58	7.36	A0	A0	− 10.0	3.3	7	2–7	9.1		*
163466	17 51.2	+ 60 25	6.82	A2	A5	− 16.7	0.7	5	8–24	3.7		
165398	18 00.7	27 06	7.16	A2	A3	+ 05.5	2.5	6	8–20	3.5		20
165623	01.8	42 57	7.20	A0	A2	− 21.6	2.6	5	8–13	2.6		
165910	03.2	13 03	6.46	A0	A0n	− 19.5	2.9	7	1–6	4.9	−10*V, −21.4 P	*
166435	05.5	29 56	7.01	G0	G5	− 12.7	1.5	5	13–22	1.4		
166868	18 07.5	+ 29 39	7.46	A2	A2	− 07.3	1.7	6	3–6	6.0		*
166976	08.0	12 22	7.27	F0	F0n	− 32.9	2.7	6	4–10	5.7		*
167944	12.4	12 02	7.13	F5	F5	+ 01.9	3.1	4	10–17	2.1		23
168440	14.6	12 30	7.34	B8	B2	− 01.6	1.6	5	6–10	3.1		
173415	40.1	47 29	6.89	A2	A2	− 18.0	1.4	5	12–21	2.5		

TABLE 11—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	$\bar{c}$	Pub. Velocity	Ref.
	h m	° ′										
174881	18 47.7	+28 39	6.43	K0	K0	−20.8	2.2	6	13–25	2.0	−23.3 ± 1.1 V	
175443	50.3	27 17	5.82	K2	K2	+16.3	1.1	5	11–24	1.6		
176466	55.3	32 59	6.85	A2	A2	−40.5	3.5	6	3–4	3.9		*38
176669	56.3	42 52	7.54	B8	B8	−21.9	0.9	4	5–9	3.3		
177152	58.4	44 14	7.42	B9	B9	−20.0	2.8	5	3–5	7.6		*
177459	18 59.7	+17 24	6.63	F5	F4	−64.6	2.5	5	6–18	3.2		
177595	19 00.3	27 10	7.05	B9	B9	−13.9	3.2	5	3–6	2.7		*
177599	00.3	15 35	6.84	A0	A0	−15.0	1.1	5	3–5	5.3		
177931	01.6	45 45	6.82	B9	B9	−10.5	0.7	6	3–6	3.5		
177983	01.8	15 42	7.24	A5	A5	−14.4	1.3	5	11–24	3.2		
178512	19 03.8	+12 57	6.97	B8	B5	−10.8	2.5	6	5–8	4.0		
178634	04.3	59 08	7.46	A2	A3	−11.8	1.2	5	8–23	2.3		
179586	08.1	17 50	7.22	F0	F0	−34.3	0.9	4	9–22	3.2		
180316	11.0	27 46	6.69	B8	B5	Var.		5	4–8	3.8		H1
180553	11.9	27 17	6.26	B9	B8	Var.		5	5–8	5.0		
180613	19 12.1	+31 04	6.75	B9	B3	+08.0	0.8	5	5–13	3.0		
180844	13.0	32 57	7.01	B5	B5	−28.8	2.4	4	4–9	4.2	−31.5 ± 0.8 V	
181119	14.1	30 50	6.48	A0	A0	−25.0	3.9	5	4–5	3.8	−27.7* V	R
181566	15.9	63 02	6.91	F5	F5	−00.3	1.4	5	14–19	2.4		
182010	17.6	17 34	6.84	A0	B5	−09.6	3.8	5	3–6	5.1		*40

TABLE II—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Pub. Velocity	Ref.
	h m	° ′										
182190	19 18.4	+ 57 28	6.10	Ma	Ma	− 21.7	1.5	3	10–23	2.1		
182440	19.6	57 33	6.50	K2	K2	+ 07.6	0.9	4	16–25	1.3		
183262	23.6	17 38	6.87	A2	A2	− 05.1	2.1	6	11–33	2.9		22
183339	24.0	57 49	6.46	B8	B8	− 22.9	2.2	6	4–10	4.1		
184602	30.2	45 50	7.40	A2	A2	− 23.6	3.6	5	5–11	5.0		
184905	19 31.5	+ 43 43	6.58	A0p	A0p	− 09.1	1.8	5	4–7	3.6	−10.0 V, −11.7 P	
186760	41.3	57 46	6.31	F8	F8	− 21.6	1.3	4	15–18	1.8		
187372	44.6	47 39	6.24	Ma	Ma	+ 07.8	1.0	5	10–22	2.3		
187748	46.5	59 10	6.66	G0	G0	− 02.8	0.3	4	16–24	1.2		
188074	48.3	47 09	6.24	F0	F0	− 21.9	1.5	4	14–16	3.2	− 13.7 V	
188876	19 52.2	+ 32 48	7.24	A0	B8	− 18.6	3.0	5	3–5	4.8		
189377	54.6	41 59	6.48	A2	A2	− 04.1	1.9	5	2–5	3.8	− 12.5 V	
190165	58.6	45 11	7.52	A2	A2	− 17.9	1.7	4	21–32	1.9		
190323	59.3	14 42	6.86	F8p	F8g	+ 27.2	1.4	5	11–24	2.4		
190338	59.4	16 51	6.83	A2	A2	− 29.3	2.9	4	6–11	5.5		
190405	19 59.7	+ 17 26	6.77	F8	F5	− 17.6	0.7	5	7–17	2.9		
190887	20 02.0	12 39	7.23	F2	F2n	− 04.3	2.4	4	10–21	3.2		
191855	06.9	30 29	6.72	B9	B9	− 14.9	2.0	5	5–12	3.3		
192684	11.0	32 33	6.71	B9	A0	− 31.5	1.6	5	3–8	4.0		
192954	12.6	15 33	7.34	B9	A0p	+ 19.5	2.2	4	4–7	2.7		R

TABLE II—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	$\bar{e}$	Pub. Velocity	Ref.
	h m	° ′										
193265	20 14.3	+ 72 34	7.11	F0	F0n	− 02.8	1.8	5	6–15	4.2		
193579	15.8	17 29	6.04	K5	K5	− 30.0	1.9	5	7–24	2.5		
194688	21.9	17 01	6.17	K0	K0	− 16.4	1.2	4	15–19	1.4		
196133	30.3	44 50	6.62	A0	A2	Var.		5	3–13	2.9		III
196216	30.8	43 01	7.04	F2	F2	− 07.4	1.4	4	10–18	2.1		
196359	20 31.8	+ 44 03	7.23	F0	F0n	− 14.8	2.3	5	4–26	4.7		
196687	33.9	42 38	7.06	A0	B8	− 10.6	1.2	5	2–6	3.6		
196833	34.8	43 58	6.57	B8	B8	− 19.7	0.8	5	4–8	4.0		
196865	35.0	47 43	6.64	G5	G5	− 23.9	0.6	4	20–32	1.3		
198195	43.6	42 03	7.06	B9	B9	− 21.2	1.7	5	2–7	6.4		
198480	20 45.5	+ 42 35	7.26	B8	B8	− 11.9	3.5	5	3–7	6.7		*
198690	47.0	42 01	7.20	B8	B8	− 24.6	1.9	5	2–5	3.8		
199154	50.2	47 53	7.09	A5	A5	− 23.2	0.7	4	9–21	1.7		
199355	51.6	42 08	6.89	B9	B5	− 23.3	3.2	5	5–8	4.5		
199890	54.9	47 13	7.25	B8	B8	− 22.8	0.9	3	2–10	2.4		
200039	20 55.9	+ 75 32	6.21	G5	G5	− 24.1	1.2	4	15–20	1.6		
200407	58.2	43 47	6.72	A2	A2s	− 08.8	1.5	4	14–24	2.1		
201032	21 02.0	62 59	7.26	A5	A5	Var.		5	18–24	1.7		III
201114	02.5	47 39	7.50	A0	A0	− 17.4	3.1	5	4	4.0		
201269	03.3	47 47	7.50	A0	A0	Var.		5	4–6	3.9		III

TABLE II—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Pub. Velocity	Ref.
	h m	° ′										
201345	21 03.9	+33 00	7.76	B0	B0	+20.3	2.8	5	5–11	5.4		*
201344	03.9	59 01	7.30	A0	A0	+10.0	3.2	4	3–6	4.3		*
201429	04.4	59 29	7.52	A0	A0	−12.6	2.2	5	4–11	6.6		*
201888	07.4	62 53	6.50	B8	B5	−25.6	1.9	5	5–8	2.8	−21.9* V	
201908	07.5	77 43	5.90	B9	B9	Var.		5	3–5	4.0		III
202313	21 09.9	+30 33	7.56	A0	A0	Var.		5	3–11	3.6		III
202345	10.1	71 50	6.96	F5	F5	−10.3	1.6	4	10–17	1.8		
202505	11.2	78 15	7.36	A2	A2	−15.2	0.7	4	5–10	4.7		
202519	11.3	57 53	7.02	A0	A2	−05.4	1.7	5	3–7	5.2		
203015	14.5	17 24	6.63	F2	F2	+04.8	1.1	5	6–14	2.9		
203836	21 19.6	+86 37	7.36	A3	A3	−03.6	3.0	4	3–6	5.1		*
203991	20.5	18 02	7.47	A0	A0	−03.1	2.9	4	3–5	11.0		*
204211	22.0	62 34	7.20	A0	A0	−12.2	1.9	4	3–4	8.0		*
204231	22.1	57 39	7.06	F8	F8	−41.3	0.9	5	12–22	1.7		
206212	35.5	45 43	7.58	B9	A0	−17.3	1.7	5	3–6	4.1		
206182	21 37.3	+57 08	7.08	F5	F5	−22.7	0.8	4	10–18	1.7	−13 to −32 W	
207978	48.0	28 20	5.62	F5	F2	+20.2	1.2	4	10–13	2.1	+16.3 W, +18.0 P	
207990	48.1	61 09	7.13	A2	A2	−30.4	0.7	4	8–18	2.5		
208878	51.1	42 46	7.38	B9	B8	−22.6	1.9	4	3–5	4.6		
209149	56.1	32 33	6.46	F5	F5	−01.6	1.4	4	11–15	2.5		

TABLE 11—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Pub. Velocity	Ref.
	h m	° ′										
209439	21 58.3	+32 54	6.87	A3	A3	−08.2	3.1	5	3–11	5.6		
209993	22 02.2	44 46	6.08	A2	A2	−03.9	2.2	5	2–4	4.1	−01.9 V	
210170	03.4	17 04	6.98	A0	A0	Var.		5	3–6	6.3		III
210208	03.7	42 27	7.52	B9	B9	Var.		5	2–6	7.9		III
211139	10.0	29 04	7.10	F5	F5	−16.1	1.9	5	8–16	2.3		
211460	22 12.1	+28 41	6.75	G5	G5	−37.5	1.0	4	11–19	2.4		
211474	12.2	29 35	7.59	B8	B8	−34.6	2.6	5	5–8	4.5		
212670	20.9	17 57	6.40	K0	K0	+23.3	1.0	5	18–23	2.0		
214557	33.9	45 19	7.07	F8	F8	−35.9	1.7	5	7–16	2.0		
214558	33.9	44 40	6.45	F8	G0	−04.0	1.6	7	10–18	1.8		
214946	22 36.7	+44 29	7.12	A5	A2	Var.		9	10–21	3.5		III
216562	48.8	30 14	7.46	A2	A2	−28.2	5.8	5	2–7	9.0		*
216716	50.0	30 56	7.41	A0	A0	−08.9	2.5	1	3–4	4.2		
216851	51.3	43 02	7.68	B5	B5	−20.1	1.3	5	4–5	6.0		
217695	57.4	47 24	7.50	A0	A0	−04.4	2.6	5	5–8	3.2		
218525	23 03.6	+44 01	6.36	A0	A2	−01.8	1.2	5	5–16	3.0	+4.7 V, −1 to +14	
219361	10.1	27 32	6.95	A0	A0	+01.1	0.8	5	4–10	2.1		
219699	12.8	30 29	7.16	F0	F0	−27.0	1.2	6	9–17	3.7		
221142	24.4	85 52	6.61	F0	F0n	−12.9	2.3	4	11–20	3.2		
221215	25.0	71 11	6.54	A0	A0	−17.8	1.7	4	3–10	3.6		

TABLE II—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Pub. Velocity	Ref.
	h m	° ′										
221405	23 26.8	+77 20	7.04	A0	A0	−01.6	1.6	4	3–6	3.1		
221537	27.9	77 15	7.08	A0	A0	−05.2	3.2	4	3–4	8.0		*
221829	30.4	85 38	7.18	A5	A3	−24.4	3.6	4	3–9	6.4		*
222143	33.0	45 39	6.56	G5	G5	+00.4	1.3	4	22–26	1.5		
222207	33.5	41 57	6.79	B9	B9	Var.		5	3–5	4.0		III
222407	23 35.2	+63 10	6.85	A2	A2	−18.0	1.1	4	7–15	2.2		
222416	35.3	44 31	7.47	B9	B9	−20.4	2.5	5	4–7	2.5		*23
222514	36.2	57 17	7.22	A0	A2	+07.5	1.4	5	13–25	2.2		
222555	36.5	46 18	7.25	B9	B5	−08.7	3.2	5	3–9	3.8		30
222642	37.3	44 13	6.90	F0	F0	+04.8	1.1	4	15–19	2.5		
223057	23 41.2	+62 45	7.54	A0	A0	−03.2	2.6	5	3–8	4.8		
223386	44.0	59 25	6.38	A0	A0	−19.1	2.6	5	5	3.3	−13.3 V	
224380	52.3	47 43	7.46	A0	A0	−12.2	2.8	5	2–4	5.6		
224890	56.5	73 03	6.52	A0	A2	−09.2	2.5	7	9–27	2.6		27
225093	58.3	72 36	7.52	A2	A2	Var.		8	5–16	3.5		III

NOTES TO TABLE II

H.D.

2888 - Wide faint λ3933, poor hydrogen and λ4481 are all the lines measurable on our spectra. Announced as a binary by Victoria, range − 8.5 to − 44.3 km./sec. with a mean − 19.9. Our plates show almost the same range but have a mean − 23.8. The velocity of the system, if the variation is real, might be taken as − 22 km./sec.

18040 - λ3933 is strong but fairly good for measurement; hydrogen lines are fair; λ4481 faint. Victoria results range from + 28.1 to − 6.7. Mean of all plates, Victoria and Toronto, is + 10.5 km./sec.

21641 - Extremely wide diffuse hydrogen; very faint K line; 4471, 4481 faint and diffuse; $H\beta$ has an emission core; agreement of plates better than to be expected and velocity is probably uncertain to 10 km./sec.

21700 - This and the following star form a wide double, separation about 44″. They are given in the A.G. catalogue as nos. 1713-14 but are not listed in Aitken's catalogue. Boss' catalogue of proper motions does not note the two stars. The spectra of the two stars are not identical, the s.p. star having sharper lines.

21743 - This is the fainter component of a double star, separation 11″. The two spectra are identical. Victoria publishes velocities + 0.5 and + 7.8 for the two components.

51418 - On three of the plates the lines are diffuse and look doubled but not resolved; on other two plates the lines are fairly sharp but give discordant results.

68332 Numerous but rather fuzzy lines. Victoria has 3 plates showing range − 15 to + 8.

71150 - This star and the next form a wide double. The stars have a common proper motion.

100054p - This and the following star is Aitken no. 8191 with a common proper motion. The following star seems to be variable. The average velocity of five plates is − 10.5 km./sec. for the following star.

103483 - 3 plates taken at Victoria give a range − 28 to − 7. Our own plates extend this range to + 4. Possibly variable. The lines are rather poor.

124587-8 This star is A9174, separation 1″.8. The spectrum in general looks like F0 but on well exposed plates K is sharp and about the strength of A2 type.

181119 - Poor spectrum for measurement. Victoria for four plates obtains range − 8 to − 47 with a mean of − 27.7. Our own plates range from − 9 to − 36.

192954 - Spectrum is peculiar. It is listed in H.D. as B9. Our spectra do not show any helium lines. Spectrum looks like α Cygni type.

TABLE III

Star H.D.	J.D. 242.... or 243....	Vel. Km./sec.	Lines	P.E.	M	Remarks
3264	9508.848	− 05.0	6	3.4	L	Sharp H and K, hydrogen and helium.
$00^h\ 30^m.7$		− 02.2	9	2.9	T	
48° 00′	9878.802	− 26.7	11	2.7	N	
7.42 B2		− 25.3	14	2.8	B	
	9905.697	− 35.6	7	3.0	N	
		− 30.7	5	4.8	A	
		− 35.1	10	3.9	C	
	0249.772	− 00.9	7	3.7	L	
		− 01.2	6	3.3	C	
3881	9539.766	+ 57.8	8	4.1	N	Numerous metallic lines which are of only fair quality. The last plate is weak.
$00^h\ 36^m.3$	9852.851	+ 87.2	23	1.9	A	
59° 23′		+ 80.6	11	2.3	N	
7.35 A6	9858.815	+ 00.6	21	2.9	B	
	9899.747	+ 52.9	18	3.3	B	
	9934.647	− 08.6	18	2.6	N	
	0018.512	+ 11.1	7	4.0	N	
5638	9503.803	+ 51.2	7	2.4	N	Sharp K line which does not seem to be interstellar. Numerous good lines of helium and good hydrogen.
$00^h\ 53^m.0$		+ 52.2	6	1.8	B	
46° 31′	9517.778	− 15.3	10	1.6	T	
6.75 B2	9635.453	− 46.6	12	4.6	Bs	
	9883.822	− 56.8	10	2.4	N	
		− 54.5	12	1.1	A	
	9901.766	+ 19.2	10	5.2	A	
	9919.670	+ 67.1	8	4.5	L	
		+ 52.1	8	8.1	L	
	9929.667	+ 35.1	11	2.9	B	
8862	9501.837	+ 12.5	5	2.2	B	Sharp K line and good hydrogen. Helium lines and 4481 are weak.
$01^h\ 22^m.3$	9571.652	+ 09.5	4	3.0	B	
43° 32′	9867.863	− 33.3	5	2.3	N	
6.56 B9		− 19.8	9	1.7	B	
	9905.737	− 00.2	7	2.6	Bs	
	0008.507	− 00.4	4	5.0	Y	
	0327.649	− 14.2	7	3.6	C	

TABLE III—*Continued*

Star H.D.	J.D. 242.... or 243....	Vel. Km./sec.	Lines	P.E.	M	Remarks
15814	9146.851	+16.2	16	2.3	T	Usual sharp lines. Mt. Wilson velocity is −3.3 ± 0.2. Pulkova publishes as a binary, range − 12 to + 15. Our observations seem to confirm variability.
02ʰ 27ᵐ.5	9507.885	+11.8	15	1.9	N	
14° 36′	9867.896	+06.4	15	0.7	B	
6.07 F8	9916.744	+21.5	19	1.3	B	
	0282.754	+08.6	16	1.5	N	
16855	9224.660	+13.8	16	2.3	B	Many very fine lines Range is rather small to be sure of variable character. The mean velocity is + 19.2 ± 2.6.
02ʰ 37ᵐ.1	9550.807	+26.5	26	1.7	B	
43° 07′	9883.871	+29.9	25	1.8	L	
6.66 A2	0036.487	+09.2	12	1.7	Bs	
	0261.781	+15.0	20	2.2	N	
	0323.627	+16.1	13	1.8	N	
36484	9525.918	+38.6	9	2.9	B	Many fine lines. The third plate is very weak.
05ʰ 26ᵐ.9	0029.624	+37.8	14	3.1	Bs	
32° 44′	0060.528	+17.4	4		B	
6.50 A2	0258.920	+47.4	14	1.7	Y	
	0289.875	+11.3	11	1.8	A	
		+12.7	9	1.2	Y	
36859	9311.578	−30.7	11	2.8	Bs	
05ʰ 29ᵐ.6		−26.6	13	1.7	T	
27° 36′	9556.851	−10.4	23	1.7	B	
6.47 K5	9918.895	−02.2	20	2.3	N	
		−01.3	25	2.1	Bs	
	0072.540	−14.1	19	3.3	N	
	0388.585	+10.6	14	3.2	N	
37366	9571.778	+34.9	7	3.2	Bs	Good hydrogen and helium. K is interstellar.
05ʰ 33ᵐ.0	9583.754	+55.8	6	3.0	T	
30° 50′	9952.837	+31.2	6	1.7	Bs	
7.52 B3	0316.843	+35.5	8	6.2	C	
	0388.604	−38.8	9	2.6	N	
		−28.3	7	2.7	C	

TABLE III—*Continued*

Star H.D.	J.D. 242.... or 243....	Vel. Km./sec.	Lines	P.E.	M	Remarks
37646	9620.681	+ 31.1	5	3.6	T	Only fair hydrogen and
$05^h\ 35^m.0$	0061.542	+ 7.3	3	13.	B	faint K. 4026 is seen.
29° 26′	0064.549	+ 14.8	3	14.	B	Published as variable by
6.75 B8	0066.521	− 01.7	4	5.2	B	Victoria + 23 to + 57.
	0282.947	− 19.5	3	1.3	N	Our observations con-
	0402.590	+ 27.9	3	3.3	N	firm the variability.
46148	0368.744	− 04.2	18	2.2	Y	Many fine lines. Range
$06^h\ 26^m.6$	0402.647	− 18.3	8	1.1	C	rather small. The mean
15° 47′	0410.603	− 02.1	13	3.3	N	velocity is − 13.4 ± 4.3.
7.13 F8	0415.590	− 29.0	20	2.0	N	
54901	9584.903	+ 35.0	13	3.0	T	
$07^h\ 05^m.6$	9621.800	− 13.1	18	2.1	B	
15° 30′	0323.876	+ 59.5	13	2.5	C	
7.26 F2	0365.726	+ 64.4	14	1.7	Y	
	0388.697	− 09.2	18	2.4	Y	
61295	9212.956	+ 30.4	16	1.9	T	Many fine lines. Pulkova
$07^h\ 33^m.5$	0060.662	+ 10.0	21	2.5	B	publishes velocity +31.4
32° 14′	0095.541	+ 14.2	24	2.0	B	±0.4 which combined
6.14 F2	0340.827	+ 15.7	22	1.8	N	with our results leaves
	0373.751	+ 20.5	16	1.4	N	little doubt of the vari-
						able character. Our
						mean velocity is + 18.2
						± 2.2.
63887	0359.828	− 116.0	1		Y	Double lines which are
$07^h\ 46^m.1$		+ 66.0	1			hard to separate with
71° 57′	0376.739	− 84.6	1		Y	our dispersion. Lines
7.52 A0		+ 11.5	1			are sharp.
	0442.581	+ 06.7	4	4.9	Y	
	0443.565	+ 116.0	3	2.6	Y	
		− 83.0	3	3.1		

TABLE III—*Continued*

Star H.D.	J.D. 242.... or 243....	Vel. Km./sec.	Lines	P.E.	M	Remarks
79929	8950.682	+ 02.6	16	3.6	P	Many fine lines.
$09^h\ 11^m.8$	9363.541	+ 19.0	9	1.8	T	
27° 51′	9370.583	− 03.6	11	1.9	T	
6.53 F5	9685.714	+ 18.3	10	3.5	A	
		+ 18.0	14	1.2	Bs	
	9726.585	+ 16.7	16	1.9	A	
		+ 18.0	16	1.7	Bs	
	9734.635	+ 17.0	9	4.1	B	
81995	9290.796	− 05.2	11	1.6	T	Good lines.
$09^h\ 24^m.1$	9637.833	+ 53.7	8	3.3	L	
45° 12′		+ 51.7	10	4.0	Bs	
7.12 A5	0002.943	− 09.6	17	3.1	N	
	0102.602	+ 18.8	12	2.2	B	
	0367.806	+ 20.5	12	3.3	Y	
82191	9341.699	− 17.8	8	7.5	T	Undoubtedly double line binary, though the lines are hardly resolved on our plates. Lines are sharp on 4th and 5th plates, almost resolved on last plate.
$09^h\ 25^m.4$	9385.570	− 06.8	6	4.7	T	
27° 50′	0029.776	+ 34.3	5	5.9	Bs	
6.59 A0	0073.618	+ 03.0	14	2.4	B	
	0087.583	+ 10.9	14	2.7	B	
	0367.821	− 30.0	5	4.2	N	
93286	9035.621	− 20.0	19	2.9	P	Many fine lines.
$10^h\ 41^m.2$	9361.650	− 00.2	13	2.8	P	
60° 38′	9393.592	+ 12.7	17	3.2	A	
7.22 A8		+ 06.2	13	1.1	P	
	9400.580	− 17.9	17	1.8	T	
	9770.601	− 20.0	22	1.8	B	
		− 18.3	28	1.6	A	
	0055.782	− 02.6	17	1.5	N	

TABLE III—*Continued*

Star H.D.	J.D. 242.... or 243....	Vel. Km./sec.	Lines	P.E.	M	Remarks
99302	9278.897	+11.6	18	2.4	T	Many very fine lines.
11h 20m.5	9289.893	+27.2	29	2.0	Bs	
27° 19′		+21.6	21	1.9	T	
7.15 A2	9303.868	+07.7	20	1.9	T	
	9403.578	+07.5	10	5.1	T	
	9625.912	+00.7	19	2.2	B	
	0438.725	−02.0	14	1.5	Y	
	0444.623	−03.8	17	2.5	C	
100054 f	9729.736	−00.9	10	2.8	N	Many fine lines.
11h 25m.7	0114.617	−24.3	18	2.0	C	
60° 15′	0376.859	−20.9	13	1.7	Y	
8.0 A2	0383.844	−22.8	10	2.7	Y	
	0429.721	−02.4	17	1.6	N	
	0431.667	+11.9	17	3.3	C	
		+04.1	21	1.3	A	
138406	8994.809	−18.4	22	2.4	MR	Many very fine lines.
15h 26m.8		−14.3	23	1.4	N	
62° 05′	9396.728	+06.1	16	1.6	T	
6.79 A2	9441.609	−02.4	14	2.0	T	
	9676.976	+01.6	18	2.1	N	
	9684.912	−05.6	16	2.3	N	
	9784.604	+09.1	19	1.5	N	
152224	9041.738	−10.5	25	1.9	P	
16h 47m.0		−14.2	14	1.7	T	
32° 44′	9048.771	−30.0	18	2.5	P	
6.26 K0	9391.816	−19.0	19	2.3	T	
	9748.804	−19.5	22	1.4	Bs	
	9812.647	−74.2	11	2.8	L	
	0113.788	−24.1	29	0.9	A	
	0493.780	−25.2	8	2.2	Y	

TABLE III—*Continued*

Star H.D.	J.D. 242.... or 243....	Vel. Km./sec.	Lines	P.E.	M	Remarks
153720	9386.860	− 12.0	8	3.7	T	Lines are double on last plate.
$16^h 56^m.0$	9400.817	− 15.1	19	1.8	T	
75° 34′	9414.773	− 03.4	13	5.0	T	
6.84 F0		+ 02.5	11	2.4	Bs	
	0055.942	− 12.8	17	3.7	N	
	0114.785	− 74.9	17	2.3	A	
		+ 70.0	13	4.5		
154099	9408.735	− 18.3	6	3.1	T	Victoria has 3 plates − 5 to − 25. This makes total range 42 km. but velocity variation is not certain. Lines are rather fuzzy.
$16^h 58^m.3$	9447.597	− 12.6	7	4.3	T	
73° 17′	9799.631	− 10.6	9	5.6	B	
6.24 A3	9808.649	+ 15.4	4	8.4	B	
	0134.828	+ 16.8	3	8.8	L	
154528	9362.879	+ 39.8	5	4.2	T	Good K line and fair hydrogen.
$17^h 00^m.9$	9742.843	− 33.9	5	3.0	T	
77° 48′	9799.679	+ 70.6	7	5.2	B	
6.66 A0	0067.910	− 34.5	5	4.1	B	
	0507.771	− 63.0	6	3.7	Y	
158013	9382.834	− 40.3	14	2.9	T	Many fine lines.
$17^h 21^m.7$	9759.823	+ 07.0	21	1.7	Bs	
57° 05′	9817.669	− 15.0	33	1.2	Bs	
6.55 A2	9824.658	+ 12.0	20	1.2	B	
		+ 18.7	17	1.3	Y	
	0132.822	− 09.5	22	1.6	C	
180316	9383.874	+ 10.3	7	1.8	T	Fair hydrogen and helium.
$19^h 11^m.0$	9777.839	− 48.0	6	5.2	B	
27° 46′	9820.738	− 50.4	4	7.8	Y	
6.69 B5	0226.583	+ 00.1	8	5.3	C	
	0257.528	+ 32.5	5	0.8	N	

TABLE III—*Continued*

Star H.D.	J.D. 242.... or 243....	Vel. Km./sec.	Lines	P.E.	M	Remarks
196133	9595.439	+ 02.8	5	4.2	N	Sharp faint lines.
$20^h\ 30^m.3$	9827.753	− 40.5	3	2.6	Y	K very sharp.
44° 50′	9874.637	− 08.6	13	1.8	B	
6.62 A2	9906.556	− 22.0	4	2.9	Y	
	0292.532	− 08.5	11	3.2	Y	
201032	9858.729	+ 30.9	19	1.4	B	Many fine lines.
$21^h\ 02^m.0$	9947.469	+ 13.7	18	1.6	B	
62° 59′	0239.749	+ 47.5	21	1.8	F	
7.26 A5		+ 54.3	22	1.5	C	
	0287.558	+ 03.7	24	2.1	N	
	0324.510	+ 17.8	21	1.7	N	
201269	9460.820	+ 00.1	6	0.9	T	Good K line, hydrogen,
$21^h\ 03^m.3$	9838.777	− 17.5	6	4.8	Bs	good 4481.
47° 47′		− 11.5	4	2.6	A	
7.50 A0	9877.698	+ 03.6	4	5.6	B	
	0316.503	+ 03.7	6	4.1	N	
	0333.535	− 30.3	6	5.5	N	
201908	9509.712	− 11.2	4	4.1	T	Fair K, hydrogen and
$21^h\ 07^m.5$	0227.649	− 39.2	3	6.0	A	4481.
77° 43′		− 34.7	4	0.6	N	
5.90 B9	0323.465	− 22.3	4	3.6	N	
	0327.435	− 11.7	5	4.1	N	
	0359.441	− 04.9	3	5.7	N	
202313	9468.782	+ 04.1	6	3.9	T	Fair K and hydrogen.
$21^h\ 09^m.9$	9512.650	− 17.6	5	6.3	B	Silicon 4128-30 are pres-
30° 33′	9937.597	+ 10.2	5	2.6	N	ent.
7.56 A0		+ 15.3	5	4.3	B	
	0282.565	− 02.1	11	3.1	N	
	0349.501	− 14.6	3	1.3	N	

TABLE III—*Continued*

Star H.D.	J.D. 242.... or 243....	Vel. Km./sec.	Lines	P.E.	M	Remarks
210170	9507.735	− 04.5	5	4.6	N	Lines only fair but range
22^h $03^m.4$	9524.683	− 07.8	4	8.5	N	seems too large for con-
17° 04′	9607.451	− 05.4	4	3.5	B	stant velocity.
6.98 A0	9828.824	− 24.8	3	4.1	A	
		− 36.5	6	6.8	N	
	9883.696	− 36.3	5	6.0	N	
		− 40.8	4	10.2	A	
210208	9508.674	− 20.2	2	4.8	T	Lines are poor and while
22^h $03^m.7$	9853.795	+ 50.5	3	6.4	N	range is large, velocity
42° 27′	0208.819	− 12.3	3	6.5	C	variation is not well es-
7.52 B9	0223.755	− 01.8	6	14.8	C	tablished.
	0280.602	+ 22.1	5	7.2	Y	
214946	9527.683	− 95.2	11	3.8	N	Double line binary; rather
22^h $36^m.7$		+ 104.6	4	2.3		difficult with our dis-
44° 29′	9528.721	− 29.5	14	2.3	B	persion.
7.12 A2	9537.677	− 35.5	9	4.4	B	
	9612.510	− 95.7	11	2.8	N	
		+ 43.8	3	4.9		
	9817.847	+ 25.9	10	6.4	F	
	9824.848	− 97.1	12	1.9	N	
		+ 80.8	10	8.7		
	9862.748	−113.3	11	4.0	N	
		+ 55.8	11	1.6		
	9903.665	− 92.1	11	2.6	N	
		+ 105.2	5	8.8		
	9921.560	− 40.1	17	3.9	F	

TABLE III—*Continued*

Star H.D.	J.D. 242.... or 243....	Vel. Km./sec.	Lines	P.E.	M	Remarks
222207	9481.798	+ 19.4	4	7.1	N	Fair K and 4481.
$23^h\ 33^m.5$		+ 28.2	3	1.6	B	Hydrogen rather poor.
41° 57′	9501.796	− 39.3	3	1.6	B	
6.79 B9	0256.697	− 15.4	5	6.4	C	
	0326.571	− 40.3	4	5.1	Y	
	0315.536	− 08.6	5	2.1	N	
225093	9981.521	+ 90.8	6	3.6	N	Double lines, intensities
$23^h\ 58^m.3$		− 117.6	6	3.9		nearly equal and the
72° 36′	0284.700	− 132.0	7	2.3	N	components cannot be
7.52 A2		+ 121.5	4	3.0		distinguished on spec-
	0293.685	− 19.4	14	2.6	N	trum. Velocity of sys-
	0314.619	− 20.2	16	1.8	N	tem seems to be about
	0316.574	− 19.9	13	3.1	N	− 18 km./cec.
	0323.592	− 132.4	5	10.	N	
		+ 98.6	6	5.3		
	0324.557	+ 95.0	6	8.3	N	
		− 133.1	8	6.2		
	0349.544	+ 135.8	6	7.0	Y	
		− 153.9	7	7.5		

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NEW VARIABLE STARS IN FOUR GLOBULAR CLUSTERS IN OPHIUCHUS

BY

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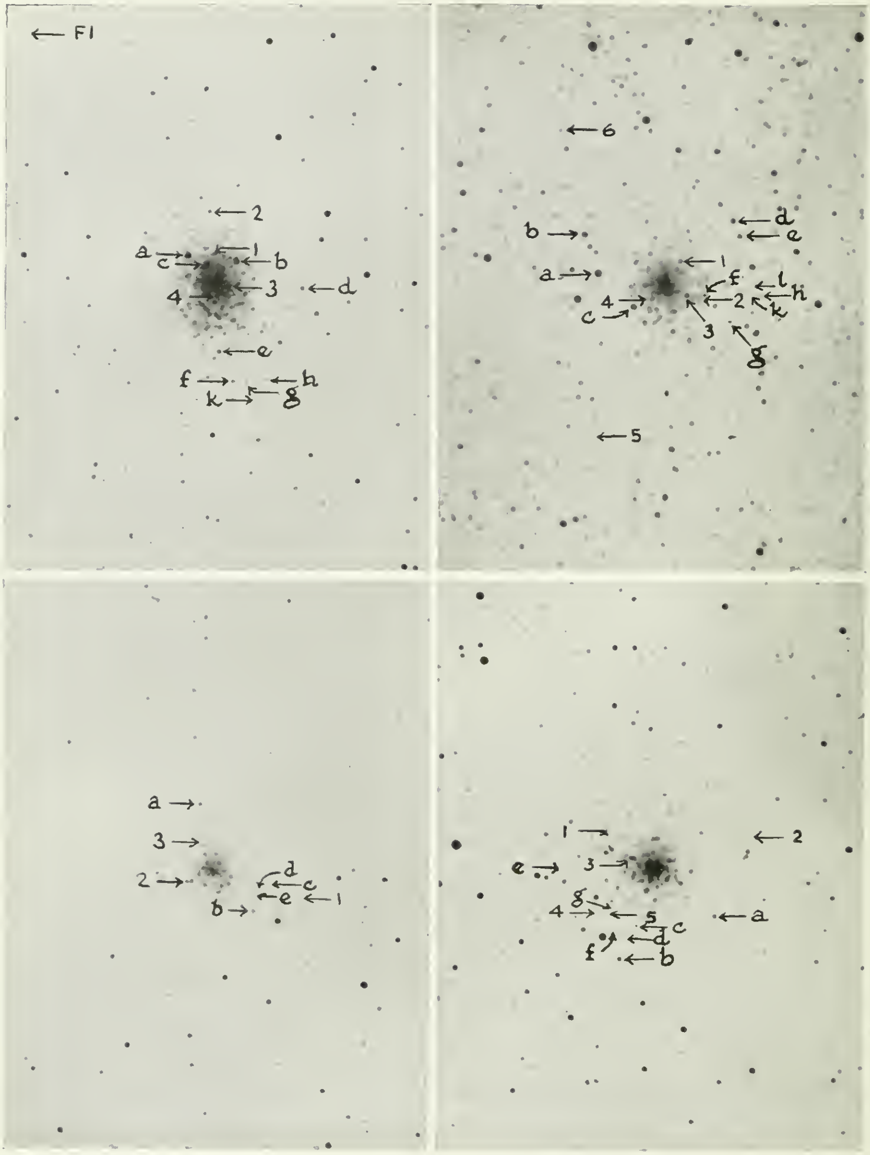

Upper left, NGC 6273   *Upper right*, NGC 6284
Lower left, NGC 6287   *Lower right*, NGC 6293

Scale, 13″ per mm. 3.5 × enlargement from Steward Observatory photographs of 20 min. exposure on 6273 and 6293, 30 min. on 6284 and 6287. NGC 6273 is the most elliptical globular cluster; NGC 6287 very heavily obscured.

NEW VARIABLE STARS IN FOUR GLOBULAR CLUSTERS IN OPHIUCHUS

by Helen B. Sawyer

THIS is the second[1] in a series of papers from plates taken by the writer at the Steward Observatory with the 36-inch reflector in 1939. This paper deals with four difficult objects which have previously been studied very little. These are the highly elliptical cluster NGC 6273 (Messier 19) and three exceedingly faint objects, NGC 6284, 6287 and 6293. These comprise a group of consecutive clusters in Shapley's catalogue[2] of globular clusters. In spite of their faintness they have been known for many years, since they were noted originally by Sir William Herschel. Only one of these clusters, NGC 6293, has been searched for variables;[3] and in none of them is there a record of the magnitudes of the bright stars.

All four of these clusters are very difficult objects for a scale as small as that of the 36-inch, that is, about 45″ to the millimetre. Furthermore, the high southern declinations of the objects, all of which lie between $-22°$ and $-26°$, make them hard objects to photograph from the United States and render magnitude determination uncertain. Nevertheless the writer felt that a little knowledge might be gleaned where none existed before. At least half a dozen plates, and one sequence plate, were obtained on each cluster. These have been studied carefully in the blink microscope. Twenty-seven new variables have been found, of which fifteen are within the cluster boundaries and twelve in the surrounding field.

The magnitudes of the 25 brightest stars, including the 6th and 30th, have also been determined. It must be emphasized that since the magnitudes depend on only one sequence plate for each cluster, with a second exposure on Selected Area 132, the magnitudes must be considered as preliminary.

1. *NGC 6273 = Messier 19*, R.A. $16^h\ 59^m.5$, Dec. $-26°\ 11'$ (1950). This cluster is noteworthy as having the greatest degree of ellipticity (6 on a scale of 10) of any globular cluster so far estimated.[4] Even on small scale photographs it is strikingly elongated. It is much the brightest of this group of four clusters and shows many more stars than the others on photographs of compar-

able exposure time. Twelve plates with average exposure of twenty minutes were available for a survey. There is no previous record of a variable search in this object.

Six variables were found, of which four are fairly close to the cluster centre and two are some distance from it. The positions and magnitudes of the variables and the comparison stars are given in Table I. For this cluster and the subsequent three, the positions

TABLE I

New Variable Stars in NGC 6273

No.	x″	y″	Max.	Min.	Remarks	
1	+ 4	+ 48	14.1	15.1		
2	+ 14	+ 123	13.4	14.7		
3	− 28	− 6	14.2	15.2		
4	− 2	− 24	15.1	15.7		
F_1	+ 347	+ 421	15.2	16.0	$16^h 55^m 20^s.5$	−25° 58′.0*
F_2	+ 546	+1119	15.3	[16.0	16 55 35 .2	−25 46.4

Comparison Stars

	x″	y″	m		x″	y″	m
a	+ 50	+ 40	12.6	f	− 38	− 179	14.5
b	− 36	+ 34	13.0	g	− 62	− 181	15.1
c	+ 16	+ 28	13.7	h	− 95	− 173	15.3
d	− 153	− 8	14.1	k	− 83	− 208	15.7
e	− 12	− 127	14.4				

*R.A., Dec., epoch 1875.

of those variables which are so far from the cluster centre that they are probably field stars have been measured from the nearest C.P.D. star and right ascensions and declinations derived. In Figure 1 will be found sketches of the regions sufficient to identify these field variables. Plate XXIX shows the cluster with the cluster variables marked.

Variables 1 and 2 should prove rather interesting objects since at maximum they are among the four brightest stars in the cluster region and their variations change the entire appearance of the cluster. Naturally the twelve available observations are insufficient to determine the nature of variation but these variables are possibly long-period Cepheids. Since there is a good series of observations which will help in future period work, these are published in Table II, which gives the magnitude estimates of the variables on all these plates. The sequence plate was of twenty minutes' exposure on the cluster, and twenty minutes on S.A. 132.

Because of the importance of the ellipticity of the cluster, the stars in the cluster region were counted on the best plate. Shapley,[5] in 1919, published a diagram of the ellipticity, but without the

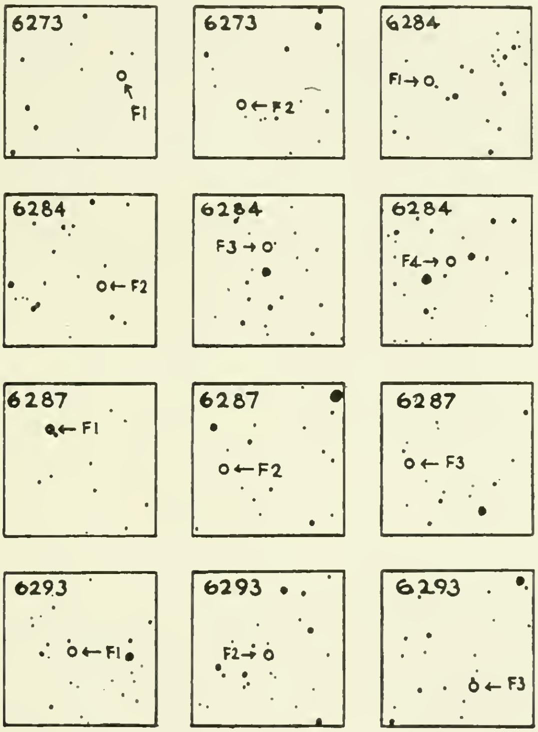

FIGURE 1

Charts to aid in identification of new field variables.
Positions are given in tables.

numbers of stars. The writer has counted a total of 910 stars within a rectangular reseau placed centrally on the cluster, in squares of 20″.156 to the side. These stars were then recounted according to sector by a circular protractor, a method followed in other clusters by Pease and Shapley.[6] A total of 805 stars fell within the circle of radius 200″. The plate was counted twice, reversed by 180° between the two counts. The means of the two counts are given in Table III; and Figure 2 shows the frequency of stars per 30° sector in the squares counted (20″.156 to a side). The position angle of the major axis is 15°, which is the value previously determined by Shapley.

2. *NGC 6284*, R.A. $17^h\ 01^m.5$, Dec. −24° 41′ (1950). This is an inconspicuous cluster in a heavy background of stars. Only about a hundred cluster stars show on plates of half-hour exposure. Eight such plates were available.

In a search of these plates ten new variable stars have been found, of which five are so far from the cluster centre that they are probably not members of it. All of these variables are faint. Table IV gives the position of the variables and their maximum

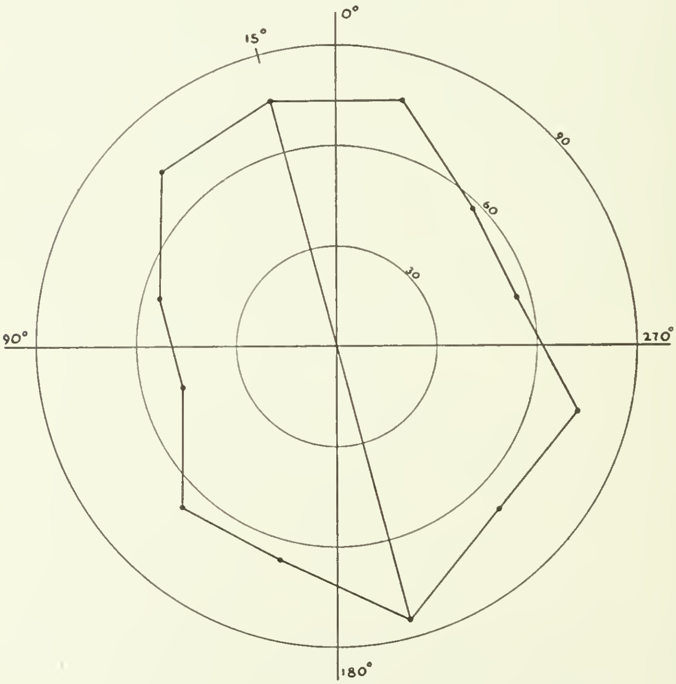

FIGURE 2

Diagrams of number of stars counted in thirty degree sectors in NGC 6273, the most elliptical of globular clusters. Numbers on the circles indicate numbers of stars. The position angle of the major axis is 15°.

TABLE II

Magnitudes of New Variables in NGC 6273

Plate	Julian Day	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
4193	9403.882	14.2	14.3	14.3	....	15.9	15.5
4194	.899	14.2	14.2	14.3	....	16.0	15.4
4208	05.888	14.1	14.5	....	....	15.7	15.5
4224	06.876	14.2	14.5	14.2	....	15.8	15.5
4236	07.886	14.5	14.7	14.5	....	16.0	[16.0
4249	08.876	14.5	14.6	14.5	15.2	15.5	15.4
4264	09.865	14.5	14.1	15.2	15.4	15.7	15.9
4275	11.868	15.0	13.4	14.5	15.1	15.2	15.3
4287	22.827	14.4	14.6	14.5	15.7	15.9	15.4
4324	27.821	15.1	13.5	15.1	15.6	15.2	15.5
4420	36.833	14.1	14.6	14.5	15.6	15.6	15.5
4456	39.739	14.2	13.7	14.5	15.7	15.4	15.5

TABLE III

Table of Star Counts in NGC 6273

Pos. Ang.	No. Stars	Stars/Sq.	Pos. Ang.	No. Stars	Stars/Sq.
15°	76	3.20	195°	85	3.32
45	74	2.93	225	69	2.95
75	55	2.20	255	75	3.00
105	48	1.98	285	56	2.26
135	67	2.58	315	58	2.50
165	66	2.68	345	76	2.81

and minimum magnitudes. The variables are marked on Plate XXIX for identification. The plates are too few in number to give any indication as to the nature of variability.

3. *NGC 6287*, R.A. $17^h\ 02^m.1$, Dec. $-22°\ 38'$ (1950). This is one of the most heavily obscured of all visible globular clusters. It lies on the edge of a region in Ophiuchus where the total photographic absorption as determined by Baker and Kiefer[7] is at least three magnitudes. The cloud which hangs over this region is apparently one end of the streamers from the Rho Ophiuchi region. Seven plates were available, of thirty minutes' exposure time, but fewer than fifty cluster stars show on any plate, even though stars to magnitude 17.5 are visible. A very large telescope is certainly needed to penetrate the obscuration in front of this cluster.

Six variable stars have been found, of which three are so far from the centre of the cluster that they are doubtless field stars.

TABLE IV

POSITIONS OF VARIABLE STARS IN NGC 6284

No.	x″	y″	Max.	Min.	Remarks
1	− 24	+ 36	15.6	16.1	
2	− 47	− 17	16.1	17.0	
3	− 28	− 13	15.3	15.7	
4	+ 22	− 18	15.4	16.3	Following comp. of double
5	+ 109	− 205	16.4	17.0	
6	+ 139	+ 221	15.9	16.4	
F_1	+ 553	+ 151	15.7	16.5	$16^h\ 57^m\ 30^s.8$ $-24°\ 32'.5$*
F_2	− 149	− 560	16.1	16.6	16 56 39 .9 −24 44 .6
F_3	+ 300	+ 926	15.4	16.4	16 57 11 .5 −24 19 .6
F_4	+ 356	+ 723	16.0	16.4	16 57 15 .8 −24 23 .0

COMPARISON STARS

	x″	y″	m		x″	y″	m
a	+ 93	+ 21	13.5	f	− 54	− 14	15.7
b	+ 111	+ 76	14.4	g	− 89	− 52	16.2
c	+ 46	− 26	14.6	h	− 131	− 15	16.4
d	− 96	+ 90	15.2	k	− 117	− 13	16.9
e	− 104	+ 66	15.5	l	− 112	− 4	17.2

*R.A., Dec., epoch 1875

TABLE V

NEW VARIABLE STARS IN NGC 6287

No.	x″	y″	Max.	Min.	Remarks
1	− 152	− 40	16.2	17.1	
2	+ 46	− 26	15.7	15.9	Although small, variation appears genuine.
3	+ 26	+ 44	16.1	16.8	
S	+ 32	+ 4	16.2	17.1	Bright on only one plate.
F_1	+ 38	+ 641	15.7	16.1	$16^h\ 57^m\ 41^s.2$ $-22°\ 21'.1$*
F_2	−1027	− 10	15.1	15.8	16 56 24 .3 −22 31 .8
F_3	+ 446	− 573	16.1	17.1	16 58 10 .0 −22 41 .5

COMPARISON STARS

	x″	y″	m
a	+ 30	+ 113	15.4
b	− 73	− 72	15.7
c	− 99	− 20	15.9
d	− 71	− 40	16.4
e	− 62	− 48	17.1

*R.A., Dec., epoch 1875.

A seventh possible variable is indicated, a star which has been found to be bright on only one plate, and is put down as a suspected variable. The magnitudes and positions of the variables and comparison stars are given in Table V, and the variables are marked on Plate XXIX. No clue as to the type of variation can be obtained from the few available plates.

4. *NGC 6293*, R.A. $17^h\ 07^m.1$, Dec. $-26°\ 30'$ (1950). This cluster is similar in brightness and appearance to NGC 6284. About two hundred stars are visible in it on the best Arizona photographs of twenty-five minutes' exposure. A careful search of the eight available photographs has shown only five more variables, in addition to the three previously announced by Shapley. Three of these new variables are so far from the cluster centre that they are doubtless field stars and are numbered as such. The positions of the variables, measured to conform as nearly as possible to the published positions of Shapley's three, are given in Table VI,

TABLE VI

VARIABLE STARS IN NGC 6293

No.	x″	y″	Max.	Min.	Remarks					
1	+ 81.0	+ 49.5	15.9	16.6	Found by Shapley					
2	− 135.6	+ 64.5	15.8	16.7	" " "					
3	+ 48.6	+ 18.6	15.5	15.8	" " "					
4	+ 92	− 81	16.1	17.1						
5	+ 78	− 83	15.7	16.5						
F_1	− 390	− 349	16.2	16.9	17^h	2^m	$57^s.4$	$-26°$	$31'.1$*	
F_2	− 395	+ 463	15.8	16.9	17	2	55 .5	−26	17 .6	
F_3	−1142	− 413	15.5	16.2	17	0	59 .0	−26	32 .1	

COMPARISON STARS

	x″	y″	m		x″	y″	m
a	− 110	− 96	15.0	e	+ 162	− 15	16.2
b	+ 52	− 161	15.1	f	+ 70	− 108	16.6
c	+ 24	− 101	15.5	g	+ 68	− 72	17.1
d	+ 47	− 124	15.7				

*R.A., Dec., epoch 1875.

together with the observed maximum and minimum magnitudes. The magnitudes are determined from one sequence plate, exposed for twenty minutes on the cluster, and twenty minutes on S.A. 132. The variables are identified in Plate XXIX. No conspicuous variation was found in Shapley's Variable No. 3, but the object blurs with a nearby star. The number of plates is insufficient to tell the nature of the variability of these stars but the similarity of magnitudes and small ranges suggest cluster type.

5. The Moduli of the Four Clusters. The distance moduli of these four clusters have previously depended entirely on measures of the integrated magnitudes and diameters[8] as no indication has been given of the brightness of the cluster stars themselves. It was hoped that the discovery of variable stars in these clusters would be of use in determining a modulus; but the variables are too few to be of help until their periods are determined. Measures of the bright stars have been made for all four clusters and these have been reduced by the method previously adopted[8] to give a distance modulus. Table VII gives the observed magnitudes for the mean

TABLE VII

Moduli of the Four Clusters

NGC	Gal. Lat.	No. Vars.	Obs. Mag. Max.	Obs. Mag. Min.	25 Br.	6th	30th	Modulus	D kpc*
6273	9°	4	13.4	15.7	14.80	14.4	15.1	15.93	15.3
6284	9	6	15.3	17.0	16.06	15.7	16.4	17.17	27.2
6287	10	3	15.7	17.1	16.08	15.9	16.4	17.33	29.2
6293	9	5	15.5	17.1	15.39	15.1	15.6	16.67	21.6

*Uncorrected for absorption.

of the 25 brightest stars, and the 6th and the 30th. The magnitudes of the variables in the cluster are given merely for comparison purposes. In each case, the maximum is that observed for the brightest variable; and the minimum is the faintest minimum observed for any variable.

It will be noted that the variables are much more comparable in brightness with the bright stars than is usual for most clusters. In most clusters, the median magnitude of the variables, which are preponderantly cluster type, is at least a magnitude fainter than the mean of the 25 brightest stars. The explanation may be that only the brightest variables, possibly long-period Cepheids or field stars, have been found in these objects; and that the cluster type variables still lie beyond the reach of these plates. One would expect that NGC 6273 is bright enough so that the cluster type variables would have been found; but it may not have many.

The moduli of the clusters are large, especially for NGC 6284 and 6287. They are all remarkably similar to the moduli previously determined from the integrated magnitudes and diameters. The distances corresponding to these moduli are given in the last column of the table, but these are almost certainly far from the true distances as these clusters are all in a region of absorption.[7] That the clusters are all in an obscured region is shown by the colour excesses of Stebbins and Whitford[9], which range from +0.12 for NGC 6293 to +0.34 for NGC 6287. The absorption varies rapidly from spot to spot in this region and may amount to as much as three magnitudes. Indeed, NGC 6287, the cluster farthest from the galactic plane of this group of four, is certainly the one with the greatest obscuration.

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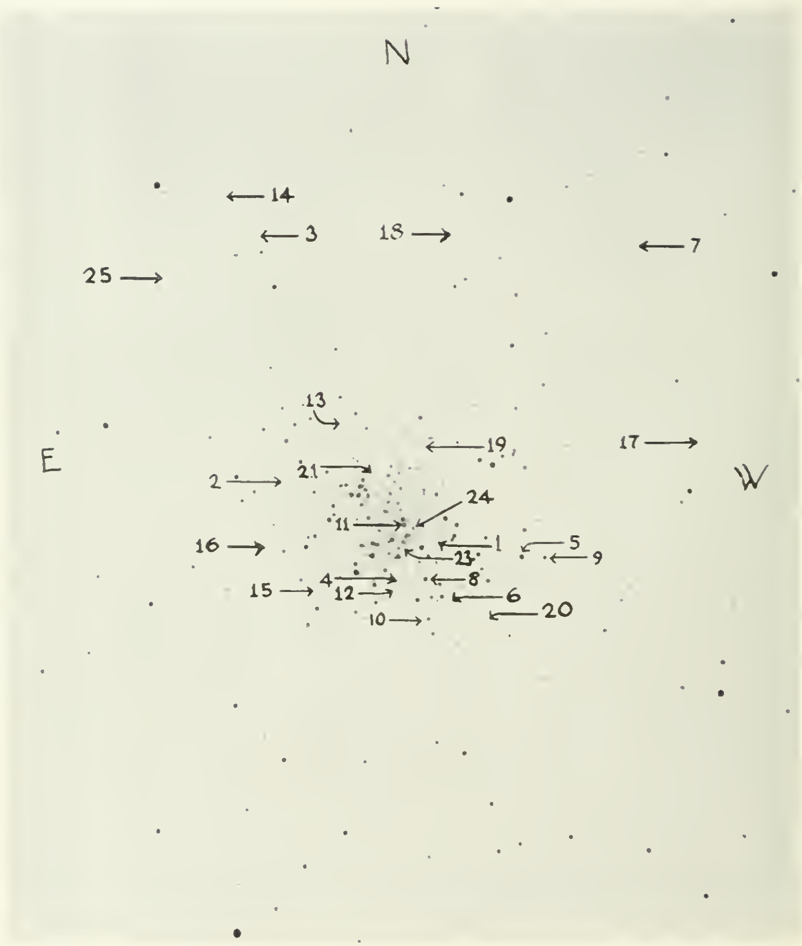
May 7, 1943.



The globular cluster Messier 22, with variable stars identified. Enlargement 4× from Steward Observatory plate 4410, June 20, 1939, exp. 10 min. Scale, 1 mm = 10″.8.

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VARIABLE STARS IN THE GLOBULAR CLUSTER MESSIER 22

BY

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By Helen B. Sawyer

(with Plate XXX)

One of the clusters placed on the observing list at the Steward Observatory in 1939 was the large, bright globular cluster Messier 22, NGC 6656. This is the third of a series of papers[1] presenting results derived from plates on southern globular clusters taken by the writer with the 36-inch reflector.

Messier 22, R.A. 18^h 33^m, Dec. $-23°$ $58'$ (1950), is well known among the globular clusters. The cluster was one of the first in which variable stars were noted. Bailey[2] announced the discovery of 16 variables in 1902. Bailey and his assistants did considerable work on the determination of periods in this cluster, but the only paper he published on them was a brief general summary[3] in which he stated that most of the variables had periods of two-thirds of a day. Exceptions to this rule were No. 3 with a period of about one-third of a day, and No. 14, of which the period is 200 days.

In 1927 Shapley[4] published a paper on the distance of Messier 22, with a summary of information about the variables as determined by Miss Swope, who had added a seventeenth variable. Seven periods were given to a considerable accuracy, five were dubious, one was irregular and four unknown. One period was suggested as possibly 7.097 days, thus making the star a possible long-period Cepheid.

The writer's principal interest in the cluster was in searching for additional variable stars and in investigating any long-period Cepheids which the cluster might contain. Considerable spread in the maximum magnitudes of the known variables suggested that the cluster might be a good one in which to test once more the period-luminosity relationship. A series of plates for this purpose was taken at the Steward Observatory, 19 plates (one of them red) on 14 nights. However, when the writer came to work over these plates, it was found that such a compact series afforded an excellent start for period determination of the cluster type variables and, with the help of Harvard material, this determination has now been completed.

I am greatly indebted to Dr. Edwin Carpenter for the use of the Steward telescope and to Dr. Harlow Shapley who placed at my disposal the existing Harvard plates on this cluster and the unpub-

lished measures of several observers, including Bailey, Gould and Miss Swope. With the help of this material I have been able to make a rather thorough investigation of the periods in this cluster, except for the determination of the actual size of the period changes of the c-type variables.

From a survey with a blink microscope of the Steward plates by the writer, eight new variables have been found, bringing to a total of 25 the number within the boundaries of the cluster. All the variables, both old and new, are identified in Plate XXX.

Two sequence plates of ten minutes' exposure time on both the cluster and Selected Area 134 were taken to check the sequence previously published[4]. In general the magnitudes determined from these plates agree with those previously given, but there is a deviation around magnitude 14.0. When the Arizona plates were measured with the new sequence they gave light curves in which the magnitude progression was more regular. For the measures published in this paper the new sequence was used as given in Table I. The letters of the comparison stars are those assigned by Bailey and identified in *H.A.* 38.

TABLE I

Magnitude Sequence in Messier 22

Star	Mag. Sawyer	Sawyer—Swope	Star	Mag. Sawyer	Sawyer—Swope
a	11.1	0.0	f	13.6	+0.4
b	11.2	0.0	g	14.0	+0.2
c	12.2	+0.1	h	14.4	+0.1
d	12.9	+0.1	k	14.5	0.0
e	13.2	+0.3	l	15.0:	+0.4

The period determination for most of the variables has been based on measures from 132 plates as follows: 73 X and 21 A plates from Harvard, 19 early Mount Wilson plates and 19 Steward plates.

Table II gives the data on the variables, arranged according to number. The second column of the table gives the number of the variable when included in Chevalier's catalogue[5]. The x and y co-ordinates, however, are those derived by Bailey and already published several times for the variables first discovered. For the new variables, co-ordinates were measured by the writer on this same system. More accurate co-ordinates may be found in Chevalier's catalogue, which uses a different centre.

The fifth and sixth columns give the maximum and minimum magnitudes indicated by all the plates. In the next column is given the mean, which is the mean of maximum and minimum magnitudes. For comparison, the following column gives a median magnitude, taken as the brightness which the star is above half the time. An epoch of maximum is given for most variables from the Steward plates. The last column gives the period. In most cases, a period given only to the fourth decimal place indicates a change of period. Notes on the individual stars accompany the table.

For three stars, Nos. 5, 12, and 17, no period is listed. The possible period of 7 days suggested by Miss Swope for No. 5 does not appear to be confirmed by the series of 16 nights of Arizona plates, which show only a small range for this star. The existing measures suggest a period longer than this, but the star may belong to the bright irregular class. The variability of No. 12, which Bailey himself doubted, is not confirmed by the Arizona plates. The star is one component of a double. Variable No. 17, classified as irregular by Miss Swope, is left in this classification. The observational material is much scantier for it than for the other stars because at maximum it is about the same brightness as the other variables at minimum.

Of the twenty-two periods listed, eighteen are of cluster type variables, one (No. 14) is a long-period variable, one (No. 11) is a typical Cepheid, and two (Nos. 8 and 9) appear to be a semi-regular type with periods of two and three months. Several of these stars require special comment.

Variable No. 11, previously noted as "short-period" would appear to be a long-period Cepheid, but since this star is located at almost the exact centre of the cluster it is an exceedingly difficult object on which to get reliable magnitude estimates. The scatter from any derived period is bound to be large, making it rather difficult to distinguish between true and fictitious periods. Of all the periods tested, the period 1.69050 days best represents all the observations. The star is 0.8 magnitude brighter in the mean than the cluster type variables and thus seems to afford additional evidence for the validity of the period-luminosity relation.

The three variables Nos. 5, 8, and 9 are conspicuous by reason of their brightness, averaging a magnitude and a half brighter than the cluster types. Their range is less than a magnitude and, since they tend to be overexposed, the magnitude estimates are not very reliable. Unfortunately the Arizona series contributes little information on these stars, except to show that the period of variation is long or irregular. For No. 9, an RV Tauri type of curve is suggested when a period of 87.71 days is used to compute the phases. This is represented in Figure 1. This type of variable is not shown to best advantage by combining observations from many different epochs but, in this case, the observations are too scattered to be treated in any other way. For No. 8, a period of 61.1 days represents many of the observations but a period as long as 73 days cannot be ruled out. For No. 5, no period is suggested. All three of these stars would merit further and more accurate observations.

TABLE II

VARIABLE STARS IN MESSIER 22

No.	Chev. No.	x''	y''	Max.	Min.	Mean	Median	Epoch Max.	Period
1	348	— 54.0	— 10.0	13.9	14.9	14.4	14.5	29425.892	0.615543
2	857	+158.6	+ 69.2	13.1	14.3	13.7	13.85	29436.917	0.6418
3	...	+214.7	+420.2	14.6	[15.2	15.0:	15.0	29434.918	0.340
4	465	— 4.0	— 68.0	13.6	14.6	14.1	14.3	29438.96	0.716391
5	158	—178.2	— 33.8	12.0	12.8	12.4		......	......
6	299	— 74.4	—100.0	13.6	14.5	14.05	14.25	29429.938	0.638547
7	82	—342.4	+411.2	13.5	14.5	14.0	14.2	29424.947	0.6495191
8	382	— 39.5	— 64.8	12.0	12.7	12.35		13373.6	61:
9	135	—211.2	— 35.0	12.7	13.3	13.0		16761.5	87.71
10	389	— 39.0	—125.0	13.5	14.6	14.05	14.3	29438.919	0.646020
11	461	— 14.4	+ 14.0	12.9	13.8	13.35	13.35	29436.917	1.69050
12	531	+ 0.8	— 77.8	14.2	14.5	Var?		...	......
13	719	+ 76.4	+158.9	13.5	14.5	14.0	14.25	29439.920	0.6725217
14	...	+250.8	+486.4	13.8	[15.5	...		18160.6	200.2
15	804	+115.3	— 83.2	14.0	14.5	14.25	14.2	29439.844	0.3721
16	877	+185.0	— 17.8	14.0	14.5	14.25	14.25	29429.938	0.3237
17	...	—438.0	+126.0	14.6	[15	....		.....	.....
18	259	— 86	+433	13.7	14.4	14.0	14.15	29425.892	0.3249
19	381	— 33	+130	13.9	14.5	14.2	14.25	29424.947	0.384010
20	221	—120	—123	13.7	14.5	14.1	14.1	29429.938	0.430061
21	601	+ 36	+ 88	13.8	14.8	14.3	14.1	29425.892	0.3265
22	...	—1089	+213	13.7	14.9	14.3	14.5	29424.947	0.624538
23	505	— 5	— 14	14.1	14.9	14.5	14.5	29432.919	0.3557
24	427	— 26	+ 10	13.8	14.2	14.0	14.1	29425.892	0.415:
25	952	+326	+375	13.9	14.4	14.15	14.25	29425.892	0.4023595

Remarks to Table II

1. Miss Swope's period of 0.615542 is virtually unchanged.
2. One of the brightest regular variables in the cluster, because a companion star contributes some of the light. This is the only variable with period greater than 0.4 day which shows a possible period change. The period 0.641789 satisfies almost all the observations.
3. The scarcity of measures on this very faint star leaves the period uncertain. Probably not a cluster member.
4. This star has the longest cluster type period in the cluster.
5. Miss Swope's suggestion of possible 7-day period is not confirmed. A longer period, or irregularity, is indicated.
6. A close companion makes magnitude estimates inaccurate.
7. Miss Swope's period is unchanged.
8. Existing observations do not permit a rigorous period determination, but a period between 61 and 73 days seems indicated.
9. Semi-regular variable, with RV Tauri characteristics.
10. Another variable which has a close companion.
11. Apparently a long period Cepheid, though, since it is the central star in the cluster, estimates are difficult, with a large error. The related reciprocal period 0.6283 gives a curve with larger scatter.
12. No evidence of variation from Arizona measures.
13. Only slight refinement of Miss Swope's period.
14. Definitely long period variable.
15. Period change. Period 0.372054 satisfies interval of several thousand days.
16. Period change. Period 0.323736 satisfies all but earliest observations.
17. Arizona observations contribute no further information to Miss Swope's 'Probably irregular."
18. Period change. Period 0.324863 satisfies a large number of observations.
19. The shortest period in the cluster which gives no evidence of period change.
20. The longest period of the c-type variables.
21. Period change. Period 0.326579 satisfies many observations.
22. No Arizona maximum, but period well determined.
23. Period change. Large scatter, because the star is in centre of cluster and one of most difficult variables to estimate.
24. Period determination based on Arizona plates only, so that the possibility of a fictitious period is not ruled out. This new variable was first supposed to be identical with Bailey's No. 1. When it was discovered that there really are two variables side by side in the centre of the cluster, it was too late to measure the star on the Harvard plates.
25. Curve shows great regularity despite the short period.

Table III gives the observations of all the variables from the Steward plates since they are a uniform series of measures on many consecutive nights. Figures 2 and 3 give the plot of the Steward measures on the basis of the adopted sequence and period, showing the light curves arranged according to increasing period length. The curve drawn is that obtained from the means of the measures on Harvard and Mount Wilson plates, representing over a hundred points. These points are not individually plotted because of inhomogeneity in the measures due to different series of plates and different observers. For most of the variables, the estimates from the Steward plates satisfactorily represent the course of light variation and the scatter indicates the difficulty of estimating the star in question.

Bailey's early statement in regard to the variables that "the majority of these have a period of about two-thirds of a day" holds true for the variables known at that time. The variables found later

TABLE III

Observations of the Variable Stars in Messier 22

Plate	Julian Day	1	2	3	4	5	6	7	8	9	10	11	12
4301	9424.947	14.8	13.8	[15.0	14.5	12.7	14.0	13.7	13.1	13.3	14.1	13.0	14.1
4312	25.892	14.0	13.9	[15.5	14.4	12.6	14.5	14.4	13.1	13.3	14.4	13.6	14.1
4315	.949	14.2	14.0	15.1	14.5	12.5	14.4	14.3	13.1	13.2	14.1	13.6	14.1
4329	27.949	14.5	13.2	[15.0	14.5	12.5	14.5	14.4	13.2	13.4	13.6	13.5	14.2
4345	29.938	14.7	13.1	14.9	14.3	12.4	13.7	14.5	12.9	13.2	13.8	13.2	14.1
4355	30.881	14.2	13.9	14.9	14.4	12.5	14.3	14.0	13.2	13.2	14.2	13.4	14.1
4358	.934	14.4	14.0	[14.8	14.6	12.6	14.4	14.0	13.0	13.3	14.5	13.4	14.1
4369	31.914	14.7	13.8	14.9	14.2	12.5	13.9	14.4	13.0	13.2	14.1	13.1	14.1
4375	32.919	14.6	14.2	14.9	14.4	12.4	14.5	14.1	13.0	13.4	14.6	13.7	14.1
4386	33.919	14.1	13.7	14.9	14.1	12.6	14.3	14.2	13.0	13.3	14.1	13.2	14.0
4394	34.806	14.6	14.1	[15.3	14.2	12.6	14.5	13.9	13.1	13.2	14.4	13.8	14.1
4400	.918	14.8	14.1	14.5	14.4	12.6	14.4	14.3	12.9	13.2	14.7	13.4	14.1
4410	35.853	14.4	14.0	[15.4	14.5	12.3	14.2	14.4	13.0	13.2	14.2	13.4	14.1
4424	36.917	14.4	13.0	[15.2	14.2	12.5	14.4	14.3	12.9	13.2	14.5	12.9	14.1
4438	37.917	14.8	14.0	15.2	14.5	12.5	14.3	13.8	12.9	13.3	14.3	13.8	14.1
4451	38.919	14.4	13.4	[15.2	14.1	12.5	13.9	14.4	13.0	13.4	13.6	13.2	14.2
4461	39.844	14.9	14.1	[15.0	14.2	12.6	14.4	14.3	12.9	13.3	14.4	13.7	14.1
4464	.920	14.9	14.0	[15.2	14.4	12.6	14.3	13.8	12.9	13.3	14.5	13.6	14.1

TABLE III—(*Continued*)

OBSERVATIONS OF THE VARIABLE STARS IN MESSIER 22

Plate	Julian Day	13	14	15	16	17	18	19	20	21	22	23	24	25
4301	9424.947	14.4	14.4	14.2	14.4	14.4	13.9	13.9	14.0	14.2	13.7	14.5	14.3	14.3
4312	25.892	13.8	14.5	14.4	14.4	14.5	13.8	14.4	14.1	13.9	14.8	14.5	13.8	14.0
4315	.949	14.1	14.5	14.2	14.4	14.4	14.0	14.4	14.1	14.2	14.6	14.5	14.1	14.0
4329	27.949	14.1	14.5	14.2	14.2	14.5	14.2	14.2	14.1	14.2	15.0	14.2	14.2	14.0
4345	29.938	13.8	14.6	14.4	14.1	14.6	14.4	13.9	13.8	14.1	14.1	14.4	14.2	14.0
4355	30.881	14.4	14.7	14.2	14.2	14.6	14.4	14.5	13.9	14.2	14.6	14.5	14.0	14.3
4358	.934	14.5	14.8	14.2	14.2	14.6	14.3	14.4	13.9	14.2	14.6	[14.6	13.9	14.4
4369	31.914	13.6	14.6	14.3	14.2	14.6	14.3	14.1	14.2	14.2	14.1	14.5	14.2	14.1
4375	32.919	14.4	14.7	14.4	14.3	14.6	14.3	14.2	13.9	14.2	14.9	14.2	13.9	14.3
4386	33.919	13.6	14.7	14.2	14.2	14.7	14.3	14.4	13.9	14.4	14.3	[14.5	14.1	14.2
4394	34.806	14.3	14.8	14.3	14.1	14.6	14.2	14.5	14.0	14.1	14.8	[14.8	14.2	14.1
4400	.918	14.5	14.8	14.2	14.3	14.6	14.1	14.0	14.1	14.2	14.4	14.8	14.2	14.2
4410	35.853	14.1	14.8	14.3	14.3	14.6	14.3	14.4	14.2	14.2	14.5	14.7	13.8	14.4
4424	36.917	14.3	14.7	14.2	14.4	14.8	14.0	14.2	13.8	14.0	14.2	14.9	14.2	14.2
4438	37.917	13.5	14.7	14.2	14.4	14.7	13.7	14.2	14.1	14.0	14.7	14.2	13.8	14.3
4451	38.919	14.4	14.7	14.4	14.4	14.6	14.0	14.4	14.1	14.1	14.3	[14.7	14.2	14.3
4461	39.844	14.4	14.8	14.1	14.5	14.7	14.0	14.1	13.8	14.1	15.0	[14.8	14.1	14.5
4464	.920	13.5	14.8	14.2	14.5	14.7	14.1	14.1	14.0	14.0	14.2	14.8	14.1	14.2

by the writer, however, are mostly c-type variables with periods of a third of a day. A selection effect operates here as the variables with smaller ranges were missed by the early observers.

Two important facts stand out from a study of these eighteen cluster type variables. The first is the remarkable distribution of their periods. Ten variables have periods which fall between 0.37 day and 0.43 day and eight periods lie between 0.61 and 0.71 day. But *no* periods were found between 0.43 and 0.61 day. This cluster is comparable with Messier 15, investigated by Bailey,[6] in which he found the same phenomenon. It should be pointed out that this interval in which there are no periods in Messier 22 is the

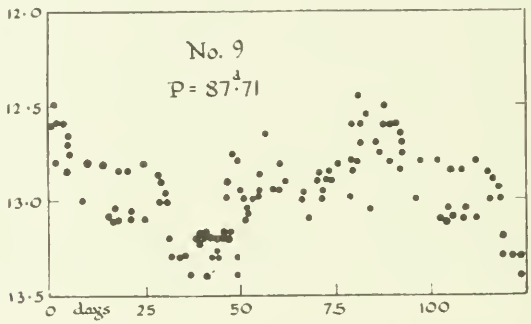

Fig. 1.—Light curve of a semi-regular variable in Messier 22.

easiest one in which to determine periods from plates taken on consecutive nights, so that any selection effect does not operate in the right direction to explain this gap. The subject of the frequency of cluster type periods in globular clusters will be summarized in a separate paper[7] appearing shortly.

The second important fact is that the cluster type variables with long periods show no evidence of period change while those with the shortest periods all give such evidence. All the variables whose periods lie between 0.32 day and 0.38 day inclusive are apparently shifting their periods. The periods are derived from so many sporadic observations rather than well-determined series, however, that the writer has not attempted to determine the amount of the period change. The earliest observations were in 1893 (J.D. 2412656) and the latest in 1939. A change of around one ten-thousandth of a day may be indicated in these intervening 46 years.

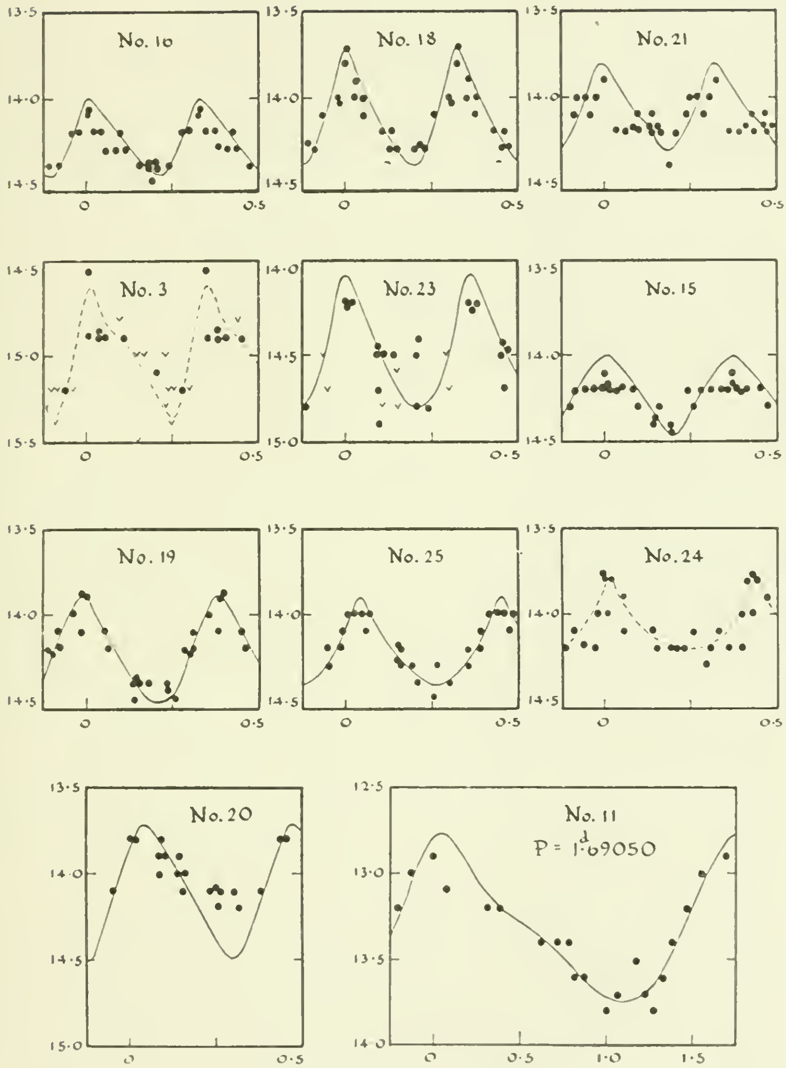

Fig. 2.—Light curves of cluster type Cepheids with periods less than half a day; and one long-period Cepheid.

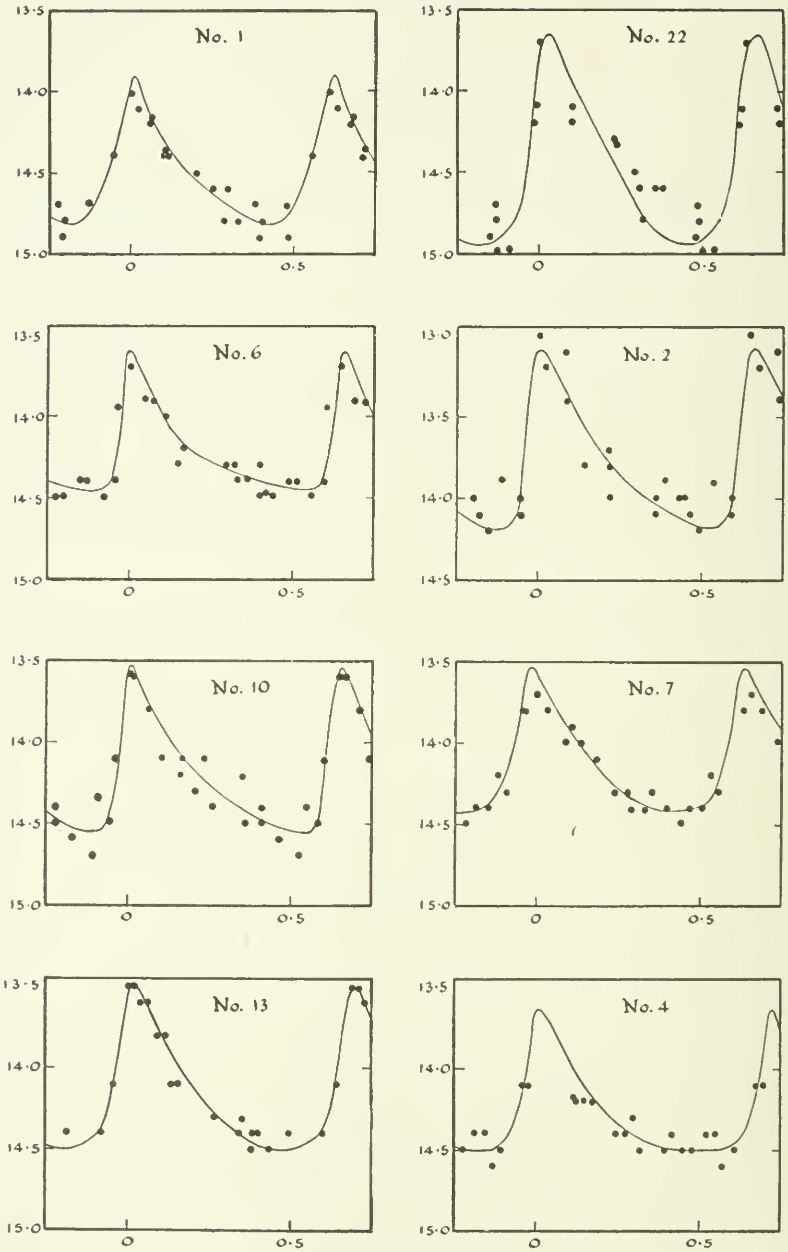

Fig. 3.—Light curves of cluster type Cepheids with periods greater than 0.6 day.

Only one variable not of the c-type shows a period change, namely No. 2, with period 0.6418 day, whose magnitudes are somewhat brighter than those of the other variables because a second component contributes light to the system. This period change is not so well confirmed as those of the c-type variables because a fixed period of 0.641789 days fits almost all the observations.

The value of the modulus of the cluster, uncorrected for absorption, as determined from the average mean magnitude of the cluster type variables (excluding Nos. 2 and 3) is 14.17. This agrees excellently with the modulus of 14.1 determined by Shapley 17 years ago. In computing the distance, however, there will be an absorption correction for this cluster as it is on the edge of a region of obscuration. The colour excess of Stebbins and Whitford[8] is 0.19; there are no nebulae in the field but the star count is normal.

Summary

1. From a study of plates taken at the Steward Observatory, eight new variables have been found in Messier 22.

2. Periods have been checked and determined for 22 variables. One is a long-period Cepheid which falls on the period luminosity relationship. One is a long-period variable, two are semi-regular variables and eighteen are cluster type.

3. The cluster type Cepheids show a remarkable frequency distribution of periods. No periods fall between 0.43 and 0.61 day.

4. The short-period cluster type Cepheids, whose periods lie between 0.32 and 0.38 day, all give evidence of period change, while, with one exception, the variables whose periods are longer than this show no such change.

5. The modulus of the cluster, 14.17, derived from the mean magnitude of the cluster type variables, confirms Shapley's modulus, giving a distance of 6800 parsecs, uncorrected for absorption.

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THE RADIAL VELOCITIES OF 681 STARS

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TORONTO, CANADA

THE RADIAL VELOCITIES OF 681 STARS

THE radial velocities of the 681 stars contained in this publication are of stars selected from Schlesinger's catalogue of bright stars and include all stars of types A0-M, north of the equator and of photographic magnitude brighter than 8.0, whose velocities have not been published. The observations were nearly all made with a one-prism spectrograph and a 25-inch camera, giving a dispersion at Hγ of about 33 A per mm. The velocities show a very marked gain in accuracy over those contained in Publications 3 and 13, which were made with a 12½-inch camera and the same prism. Owing to the fact that we have been able to aluminize the surface of both mirrors and have had all optical surfaces coated with a low-reflecting film, the speed of the present arrangement is somewhat greater than with the 12½-inch camera; this represents a remarkable gain in speed.

For none of the stars have we been able to find observations at other observatories and an investigation of the systematic errors cannot be made at the present time. Scattered observations of a few standard velocity stars indicate that the errors are small. While the same wave-lengths for the reduction tables have been used as in the former publications, namely, those recommended in the I.A.U. Transactions 1932, it is by no means likely that the systematic errors for the present list will be the same as for the former two lists. In the first place, we have introduced a change in the slit mechanism, bringing the comparison spectra closer to the star spectrum and reducing the curvature corrections to less than one km. per second and, in the second place, errors of measurement with the larger dispersion will probably be systematically a little different.

As in the previous lists of velocities many observers have helped in securing the spectrograms. The observers with the number of exposures are—Hogg, 760; Young, 674; Norris, 435; Longworth, 428; Miss Northcott, 237; others, 338. In all, 2872 measurable plates were secured, 192 of which were taken with the 12½-inch camera. An average of between four and five plates was obtained for each star with a minimum of four for each star. The measurement of the plates was also carried out as a joint programme. Those who have contributed to the measurement of the spectrograms are—Young, 1055; Miss Northcott, 608; Miss Fuller, 585; Norris, 474; others, 263.

The main results of all the stars are included in Table I, in which the headings of the various columns have the following meanings.

1. The serial number in the Henry Draper Catalogue.

2-3. The right ascension and declination for the epoch 1900.0.

4. The visual magnitude from the Henry Draper Catalogue.

5. The Harvard type.

6. The type as estimated from our spectra. The criteria for estimating the type have been the same as used at the Dominion Astrophysical Observatory, Victoria, and as given in the I.A.U. Transactions.

7. The velocity of the star. This is the mean of all the plates taken if the velocity seemed constant or if the velocity variation was not certainly established. Those stars showing a definite variation are indicated by "Var." in this column.

8. The probable error as indicated from the agreement of the various plates and computed from the formula

$$\text{P.E.} = 0.845 \frac{\Sigma v}{n\sqrt{n}}$$

9. The number of measurable plates taken.

10. The minimum and maximum number of lines measured on the plates. In the case of late type stars, if the minimum number is less than 17, it means that at least one plate was somewhat weak. In the case of the early types, the number of lines measured gives some idea of the spectrum. The letter n placed after the type in column 6 indicates that the lines are nebulous.

11. The average probable error of each plate as judged from the agreement of the lines measured. When some of the plates were taken with the 12½-inch camera the $\bar{e}$ refers to the mean from the 25-inch camera plates only.

12. In this column * means that the velocity is more uncertain than for the general run of stars, due to the character and number of the lines. A number following the * indicates the total range. We judge in these cases that the variation is somewhat greater than would be expected from the character of the lines. R means that there is a remark on this star in the notes at the end of Table I. II means that the individual velocities will be found in Table II. S means that for this star all the plates were taken with the 12½-inch camera.

Those stars for which the velocity seems to be definitely variable are given in Table II. This table gives the individual velocities for 36 stars—a very small number to be found variable in the observation of 681 stars. It is probably due to the fact that nearly all the stars of late type have orbital velocities which are often below detection with a small number of plates of one-prism dispersion. Many of those stars listed with an * (when followed by a number) in the last column of Table I are probably binary.

In Table II the various columns have the following meanings.

1. Identification of the star in Table I.

2. The Julian day of the observation. Most of the plates were taken after the epoch J.D. 2430000 but a few were taken between the epochs J.D. 2420000 and 2430000, hence the double heading.

3. The measured velocity. In some cases there is a repeat measure.

4. The probable error as judged from the agreement of the lines.

5. The number of lines.

6. The initial of the measurer of the plate—N, Miss Northcott; Y, Young; F, Miss Fuller; No, Norris; Ma, Matthews; B, Bunker; K, Mrs. Krotkov; T, Tidy.

7. Explanations which refer either to the character of the spectrum or to the nature of the variation.

TABLE I

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km. sec.	P.E.	Plates	Lines	$\bar{e}$	Ref.
	h m	° ′									
1075	00 09.9	+ 30 59	6.61	K5	K4	+ 03.3	0.5	4	18-21	0.9	
1419	13.2	+ 10 39	6.20	K0	G8	+ 09.6	0.2	5	16-23	0.7	
1527	14.4	+ 40 10	6.41	K0	K0	− 36.5	0.6	4	20-24	0.6	
2904	27.3	+ 70 26	6.36	A0	A0n	− 11.4	4.1	4	3	6.3	*
2913	27.3	+ 06 25	5.66	A0	A0n	+ 17.6	2.8	5	2-5	6.7	*
2924	00 27.4	+ 27 01	6.54	A0	A2	+ 00.9	0.4	4	7-17	0.9	
2952	27.7	+ 54 21	6.14	K0	G8	− 34.5	0.5	5	20-23	0.6	
3411	31.9	+ 23 28	6.44	K0	K1	+ 00.4	0.2	4	16-23	0.7	
3856	36.1	+ 65 36	5.92	G5	G7	− 01.0	1.0	4	14-22	0.7	
4295	40.3	+ 68 47	6.42	F2	F2	− 14.5	0.5	4	18-22	0.8	
4321	00 40.6	+ 54 45	6.52	A2	A3	− 09.3	0.6	4	14-18	0.9	
4440	41.6	+ 72 08	6.04	K0	G8	+ 00.9	0.4	4	19-22	0.6	
4881	45.8	+ 51 02	6.24	A0	A0	− 14.7	0.9	4	3-5	2.0	
5273	49.4	+ 48 09	6.60	Ma	M1	− 50.4	0.3	4	17-22	1.0	
5357	50.4	+ 68 15	6.38	F0	F2	− 08.9	0.6	4	11-24	0.8	
6028	00 56.5	+ 50 30	6.62	A3	A2n	+ 05.4	1.2	4	5	1.6	
6211	58.1	+ 51 58	6.27	K2	K2	− 06.0	1.0	4	20-23	0.7	
6480	01 00.7	+ 04 22	7.64	F2	F5	− 07.8	0.4	4	17-26	0.7	R
6497	00.9	+ 56 24	6.58	K0	K1	− 94.5	0.8	4	17-23	0.7	
6540	01.2	+ 52 58	6.49	K0	K0	+ 07.8	0.2	4	15-21	0.7	
6953	01 04.9	+ 24 56	6.06	K5	K6	+ 06.4	0.6	4	9-21	1.0	
7229	07.5	+ 29 33	6.40	K0	G6	+ 36.6	0.4	4	21-24	0.6	
7351	08.6	+ 28 01	6.63	Ma	M1	+ 05.8	1.4	4	18-20	1.3	*11
7389	09.0	+ 71 13	6.38	K0	K4	− 16.0	0.3	4	15-20	1.0	
7578	10.7	+ 32 36	6.31	K0	K0	+ 06.8	0.8	4	19-21	0.6	
7647	01 11.3	+ 44 23	6.48	K5	K5	− 50.0	0.1	4	17-20	1.0	
7724	11.9	+ 31 14	6.86	K0	K0	− 32.7	0.6	4	20-24	0.6	
7732	12.0	+ 77 02	6.38	G5	G3	− 75.6	0.4	4	16-23	0.7	
7758	12.2	+ 46 53	6.41	K0	K0	− 00.3	0.8	5	14-22	0.9	
7925	13.8	+ 75 43	6.45	A3	A3n	− 16.5	1.7	5	3-5	6.5	*
8375	01 17.9	+ 33 43	6.34	G5	G5	+ 03.8	0.6	4	17-22	0.6	
8388	18.0	+ 19 57	6.30	K5	K7	− 09.8	0.4	4	14-23	1.1	
8424	18.4	+ 70 27	6.52	A0	A0n	+ 09.9	1.1	5	3	6.0	
8949	23.1	+ 07 27	6.44	K0	K0	+ 02.6	0.4	4	15-23	0.6	R
9712	30.0	+ 40 34	6.39	K0	G8	+ 66.2	0.4	4	18-22	0.7	

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	$\bar{e}$	Ref.
	h m	° ′									
10110	01 33.8	+ 53 22	6.64	K2	K5	− 60.4	1.0	4	20-22	0.8	
11037	43.3	+ 03 11	6.00	G5	G8	+ 04.0	1.2	5	19-24	0.8	R
11613	48.9	+ 40 12	6.50	K2	K2	+ 32.6	1.0	4	18-21	0.6	
11624	49.0	+ 36 37	6.39	K0	K0	− 00.6	0.3	4	19-24	0.7	
11928	52.0	+ 27 18	6.02	Mb	M2	+ 00.5	0.6	4	12-22	1.2	
12005	01 52.8	+ 77 26	6.35	K0	G2	− 02.6	0.4	4	15-22	0.9	
12479	57.2	+ 13 00	6.28	Mb	M2	− 04.7	0.4	4	20-24	0.9	
12872	02 01.0	+ 07 46	6.66	Mb	M2	− 24.0	0.6	4	17-22	0.8	
13013	02.3	+ 43 58	6.50	G5	G5	+ 25.4	0.8	4	7-23	1.2	
13522	06.9	+ 23 43	6.19	K0	K2	+ 00.2	1.1	4	16-23	0.8	
13818	02 09.5	+ 47 21	6.44	K0	G8	+ 16.7	0.5	4	17-22	0.6	
14067	11.5	+ 23 19	6.50	G5	G5	− 12.0	0.4	4	13-22	1.0	
14221	12.9	+ 48 29	6.40	F0	F2	− 19.2	0.7	4	13-24	0.9	
14373	14.2	+ 29 45	6.60	K0	K0	− 00.1	0.2	4	16-24	0.8	
15138	21.2	+ 50 07	6.27	F0	F2	Var.		4	5-17		H
15152	02 21.3	+ 26 33	6.18	K5	K6	− 46.6	0.4	4	13-22	1.1	
15253	22.3	+ 55 05	6.56	A2	A0	+ 00.5	1.1	5	4-6	1.5	R
15328	22.9	+ 01 31	6.49	K0	G8	+ 18.7	1.1	4	11-21	1.0	
15453	24.2	+ 09 07	6.30	K0	K0	− 10.2	0.5	4	18-21	0.6	
15464	24.3	+ 33 23	6.25	K0	K0	+ 08.4	0.4	4	16-25	0.6	
16024	02 29.4	+ 65 19	6.07	K0	K3	+ 41.6	0.4	4	17-24	0.8	
16458	33.4	+ 81 01	5.92	K0	K0p	+ 23.5	1.5	4	15-20	1.1	R
16467	33.4	+ 03 01	6.37	G5	G8	+ 03.4	0.4	4	14-20	0.7	
17228	40.8	+ 35 35	6.38	G5	G5	+ 21.7	0.3	4	18-21	0.6	
17378	42.2	+ 56 40	6.53	F5p	A8p	− 37.0	0.6	4	14-19	0.9	R
17958	02 48.1	+ 63 55	6.57	K5	K3	− 20.8	0.3	4	15-21	0.9	
18153	49.8	+ 50 51	6.52	K5	K5	+ 06.1	0.5	4	20-24	0.8	
18339	51.7	+ 38 13	6.08	K0	K2	− 41.6	0.3	4	16-21	0.7	
18345	51.8	+ 04 05	6.31	Ma	M2	+ 53.5	0.6	4	18-20	1.0	
18482	53.2	+ 40 38	6.07	K2	K2	+ 32.9	0.5	4	17-21	0.7	
18700	02 55.3	+ 10 29	6.20	K5	K6	+ 19.8	0.3	5	15-21	1.0	
18832	56.7	+ 04 57	6.38	K0	G8	− 58.4	0.4	4	13-21	0.8	
18991	58.2	+ 55 41	6.50	K0	G8	− 09.9	0.3	4	17-21	0.6	
19066	58.9	+ 40 12	6.18	K0	K0	− 33.1	0.4	4	17-22	0.6	
19080	59.1	+ 15 29	6.59	K0	K2	− 30.6	0.7	4	16-23	0.9	

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Ref.
	h m	° ′									
19121	02 59.5	+ 01 30	6.05	K0	K0	+ 00.3	0.4	4	15-21	0.6	
19525	03 03.3	+ 08 05	6.44	G5	G8	+ 39.2	0.8	4	17-23	0.7	
20063	08.4	+ 42 08	6.16	G5	K0	+ 22.8	0.5	4	17-25	0.7	
20104	08.8	+ 65 17	6.35	A2	A2n	− 07.5	0.9	4	4	3.5	
20162	09.3	+ 44 58	6.42	Ma	M0	− 00.9	0.9	4	20-21	0.8	
21004	03 18.3	+ 53 35	6.39	F0	F0n	− 04.6	0.7	4	6-12	3.7	
21018	18.4	+ 04 31	6.47	G0	F8	Var.		5	17-23	0.8	II
21179	20.0	+ 71 31	6.83	Ma	M1	− 21.8	0.9	4	14-22	0.9	
21335	21.4	+ 18 25	6.45	A2	A2n	+ 30.3	1.8	4	2-5	4.9	
21794	25.7	+ 57 32	6.41	F5	F6	− 71.6	0.2	4	15-20	0.8	
22211	03 29.5	+ 06 05	6.52	G0	F5n	− 10.6	1.3	4	8-16	1.6	
23526	40.8	+ 06 30	6.12	K0	K0	− 24.5	0.6	4	18-22	0.7	
23626	41.5	+ 31 54	6.23	G0	F6	Var.		4	17-21	0.8	II
23887	43.5	− 00 04	6.10	K0	K1	+ 68.5	0.7	4	17-22	0.8	
24141	45.6	+ 57 40	5.79	A0	A2	− 05.9	0.8	4	17-20	1.2	
24154	03 45.7	+ 21 44	6.82	G5	G8	+ 63.9	0.9	4	11-22	0.7	
24164	45.8	+ 71 31	6.39	F0	F0	− 02.4	1.0	4	14-22	1.1	
24802	51.5	+ 24 12	6.38	K0	K0	− 12.4	0.6	4	21-24	0.6	
25274	55.9	+ 68 24	6.14	K2	K5	− 45.5	0.7	4	19-23	0.9	
25602	58.8	+ 53 45	6.42	K0	G6	− 07.0	0.6	4	18-22	0.6	
25877	04 00.9	+ 59 40	6.46	K0	G5	− 13.3	0.4	4	19-21	0.7	
25948	01.5	+ 54 34	6.28	F5	F2	− 05.5	0.3	4	13-19	1.0	
26076	02.6	+ 71 52	6.15	G5	G8	− 03.1	0.3	4	16-24	0.8	
26101	02.8	+ 68 16	6.41	K0	K0	− 22.5	1.8	4	18-23	0.6	*12
26311	04.6	+ 33 19	5.91	K0	K1	+ 19.9	0.5	4	18-24	0.8	
26605	04 07.4	+ 37 43	6.55	G5	G5	+ 30.2	0.4	4	18-21	0.7	
26913	10.1	+ 05 57	7.16	G0	G3	− 07.6	0.2	4	18-21	0.6	
26923	10.2	+ 05 57	6.54	G0	G0	− 08.1	0.4	4	19-22	0.6	R
27386	14.2	+ 09 53	6.62	K0	K2	− 26.2	0.3	4	15-23	0.9	
28191	21.8	+ 01 52	6.37	K0	K0	+ 22.4	0.4	4	20-23	0.6	
28322	04 22.9	+ 01 38	6.12	K0	G8	+ 31.1	0.5	4	20-22	0.6	
28505	24.6	+ 10 01	6.55	G5	G8	− 62.0	0.3	4	12-18	1.0	
28736	26.7	+ 05 11	6.43	F2	F2	+ 38.9	1.2	4	12-22	1.4	R
28930	28.4	+ 09 12	6.20	K0	G8	− 25.4	0.4	4	21-22	0.6	
29104	29.8	+ 19 41	6.56	F8	F8	Var.					II

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km. sec.	P.E.	Plates	Lines	$\bar{e}$	Ref.
	h m	° ′									
29606	04 34.7	+ 59 20	6.53	A3	A5n	+ 09.7	1.4	4	4-14	2.4	
30138	39.8	+ 40 08	6.12	G5	G5	+ 35.9	0.5	4	20-24	0.6	
30144	39.9	+ 55 26	6.34	F0	F0	+ 21.4	0.8	4	13-19	1.1	
30545	43.5	+ 03 25	6.20	K0	K0	− 18.4	0.3	4	20-24	0.7	
31411	50.6	+ 05 15	6.59	A0	A0n	+ 20.6	1.8	4	3-5	6.4	
31563	04 51.8	+ 73 37	6.76	K0	K2	+ 23.2	0.7	4	14-24	1.0	
32039	55.3	+ 03 28	6.95	A0	A0n	+ 29.7	3.3	4	3	2.9	R
32040	55.3	+ 03 28	6.63	A0	A0n	+ 41.4	6.1	4	2-4	3.4	*29
32263	56.7	+ 00 34	6.18	K0	K1	+ 21.9	0.3	4	20-25	0.8	
32406	57.9	+ 30 22	6.39	K0	G7	+ 18.9	0.6	4	19-22	0.7	
32482	04 58.4	+ 21 09	6.34	K0	K2	+ 48.8	0.4	4	15-21	1.0	
32518	58.7	+ 69 30	6.58	K0	K0	− 06.1	0.2	4	19-22	0.6	
32655	59.7	+ 43 02	6.21	F2	F2	− 12.7	0.2	4	13-20	0.8	
33541	05 05.9	+ 73 09	5.76	A0	A0	Var.		4	4-7	2.8	II
33946	08.7	+ 00 26	6.54	K2	K3	− 10.4	1.2	5	9-22	1.3	
34053	05 09.5	+ 22 10	6.16	A0	A2	Var.		4	4-6	3.2	II
34332	11.6	+ 40 21	6.32	K0	K2	− 16.2	0.3	4	13-22	0.9	
34498	12.8	+ 44 19	6.72	K0	K2	+ 14.4	1.2	4	13-23	0.9	
34499	12.8	+ 33 53	6.52	A5	A5n	+ 06.8	0.6	4	4-21	3.6	
34533	13.1	+ 46 52	6.48	F0-A	F2-A	+ 16.5	0.9	4	18-20	1.1	R
34653	05 14.0	+ 77 53	6.54	A5	A5n	− 19.0	1.2	4	14-17	1.4	
34810	15.0	+ 19 43	6.44	K0	K0	+ 01.1	0.7	4	20-21	0.6	
34904	15.7	+ 40 56	5.57	A3	A2n	− 14.7	3.0	4	4-5	5.5	
35295	18.6	+ 34 45	6.48	K0	K0	− 14.4	0.4	4	18-22	0.7	R
35519	20.2	+ 35 23	6.30	K2	K3	− 20.0	0.4	4	8-23	1.3	
35521	05 20.2	+ 33 11	6.30	K0	K0	− 07.7	1.0	4	20-22	0.8	
36040	23.8	+ 41 23	6.09	K0	K0	+ 14.5	0.7	4	20-23	0.6	
36041	23.8	+ 39 46	6.52	K0	G8	+ 12.5	0.0	4	19-25	0.4	R
36160	24.7	+ 22 23	6.49	K0	K1	+ 02.7	0.1	4	19-21	0.7	
36891	29.8	+ 40 07	6.18	K0	G5g	− 17.2	0.5	4	17-23	0.7	
37138	05 31.2	+ 33 30	6.43	K0	K2	+ 30.1	0.2	4	18-22	0.7	
37329	32.7	+ 26 34	6.47	K0	G8	+ 15.7	0.4	4	20-23	0.7	
37536	34.2	+ 31 52	6.72	Ma	M0	+ 06.3	1.0	4	15-24	1.4	
37784	36.0	+ 22 37	6.47	K2	K2	− 20.2	0.4	4	18-25	0.7	
38527	41.4	+ 09 29	5.89	G5	G5	− 25.4	0.5	4	17-23	0.7	

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Ref.
	h m	° ′									
38529	05 41.4	+ 01 09	6.14	G5	G2	+ 30.1	0.2	4	19-22	0.7	
38545	41.5	+ 14 28	5.67	A2	A0n	+ 21.7	1.9	4	3-4	4.0	
38618	42.0	+ 56 53	6.38	A2	A2n	+ 02.9	1.6	4	6-13	1.9	
38645	42.2	+ 68 26	6.40	K0	G7	− 00.1	1.1	4	16-23	0.7	
38765	43.0	+ 51 29	6.40	G5	K0	+ 26.9	0.6	4	16-24	0.7	
39045	05 44.9	+ 32 06	6.41	Ma	M2	+ 104.7	1.1	4	13-23	1.0	
39051	44.9	+ 04 24	6.12	K0	K2	+ 29.6	0.2	4	9-22	1.3	
39225	46.0	+ 33 53	6.38	Ma	M0	+ 101.4	0.8	4	16-22	0.8	
39429	47.5	+ 66 05	6.59	K0	K2	− 21.2	0.3	4	21-23	0.6	
39632	48.7	+ 10 34	6.50	K0	K0	+ 14.3	0.4	4	19-22	0.6	
39685	05 49.0	+ 03 13	6.55	K0	K1	− 03.2	0.5	4	15-23	0.6	
39743	49.4	+ 49 01	6.44	G5	G3	− 01.6	1.6	4	18-23	0.7	*11
39775	49.6	+ 00 57	6.23	K0	K1	+ 22.7	0.6	4	12-24	0.9	
40055	51.4	+ 75 35	6.52	K5	K5	+ 05.2	0.1	4	20-25	0.6	
40083	51.6	+ 54 33	6.26	K0	K1	− 04.6	0.5	4	19-25	0.6	
40084	05 51.6	+ 49 55	6.07	G5	G5	Var.		4	13-21	0.9	11
40282	52.7	+ 01 13	6.49	K2	K5	+ 38.2	0.7	4	7-20	1.0	
40372	53.2	+ 01 49	6.06	A5	A5	Var.		4	16-24	1.3	11
40394	53.4	+ 47 54	5.68	A0	A0	+ 15.4	0.8	4	6-9	1.8	
40486	54.0	+ 48 58	6.24	K0	K0	+ 11.7	0.3	4	21-24	0.6	
40626	05 55.0	+ 49 55	5.98	A0	A0	+ 21.2	0.7	4	3-5	2.6	
40722	55.6	+ 43 22	6.52	K0	K1	− 18.2	0.9	4	20-26	0.6	
40827	56.3	+ 59 24	7.07	K0	G8	+ 32.4	0.4	4	18-25	0.6	
40956	57.1	+ 63 27	6.49	K0	K0	− 14.0	0.6	4	19-25	0.5	
41429	06 00.0	+ 29 31	6.32	Ma	M4	− 34.0	0.7	4	10-20	1.4	
41467	06 00.3	+ 41 52	6.32	K0	K0	+ 06.5	0.5	4	19-23	0.7	
41636	01.3	+ 41 04	6.42	K0	K0	− 86.1	0.2	4	20-23	0.5	
42049	03.5	+ 22 13	6.04	K2	K6	+ 10.3	1.6	4	9-20	1.4	*11
42111	03.8	+ 02 31	5.58	A0	A0	+ 33.2	1.1	4	2-3	1.6	
42351	05.1	+ 18 09	6.44	K0	K1	− 01.9	0.4	4	15-26	0.7	
42466	06 05.8	+ 51 12	6.28	K0	G8	+ 11.8	0.3	4	21-23	0.7	
42471	05.8	+ 32 43	5.96	K2	K5	− 51.4	0.5	4	15-22	1.0	
42807	07.7	+ 10 40	6.46	G5	G4	+ 06.7	0.4	4	20-23	0.7	
43358	10.7	+ 01 12	6.34	F5	F5	+ 02.6	0.9	4	9-14	1.5	
45357	21.8	+ 00 54	6.51	A0	A0n	+ 08.5	2.3	5	3-4	8.2	*

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km sec.	P.E.	Plates	Lines	e	Ref.
	h m	° ′									
45394	06 22.0	+ 20 34	6.11	A0	A0	+ 38.3	0.6	4	10-14	1.8	
45512	22.8	+ 10 23	6.19	K0	K1	− 19.3	0.5	4	17-23	0.7	
45560	23.1	+ 79 40	6.52	A0	A0n	− 07.9	1.4	4	4-5	4.4	
45638	23.5	+ 11 05	6.43	F0	F0	+ 40.6	0.9	4	9-21	1.3	
45724	24.0	+ 02 43	6.39	Ma	M0	+ 10.7	0.6	4	4-19	1.6	
45947	06 25.4	+ 73 46	6.22	F2	F2	+ 05.0	0.7	4	13-21	0.8	
46101	26.3	+ 55 26	6.53	K0	K4	− 18.5	1.8	4	20-24	0.9	*10
46178	26.8	+ 11 45	6.15	K0	K0	− 19.9	0.7	4	18-25	0.8	
46509	28.8	+ 71 50	6.07	G5	K0	− 23.6	0.5	4	17-25	0.7	
46642	29.4	+ 07 39	6.42	A0	A0	+ 36.5	0.6	4	2-9	4.0	
46709	06 29.8	+ 10 04	6.06	K5	K5	+ 38.7	0.4	4	8-20	1.5	
47156	32.1	+ 10 56	6.60	K0	K2	+ 02.5	0.6	4	12-21	0.9	
47220	32.4	+ 02 48	6.42	K0	K0	− 06.6	0.1	4	18-24	0.6	
47358	33.1	+ 22 07	6.28	K0	G8	− 09.7	0.3	4	20-25	0.5	
47415	33.4	+ 24 41	6.48	F5	F8	Var.		4	2-24	1.7	11
47886	06 35.7	+ 11 06	6.43	Ma	M0	+ 17.4	1.1	4	13-22	1.2	
47979	36.1	+ 53 24	6.38	K0	K0	+ 19.8	0.3	4	7-23	1.1	
48073	36.5	+ 37 15	6.24	K0	G6	− 40.2	0.5	4	21-22	0.5	
48348	37.9	+ 03 08	6.44	K0	K2	+ 31.9	0.5	4	17-22	0.9	
48843	40.3	+ 12 49	6.43	F0	A8	+ 08.2	1.2	4	20-25	0.9	
50204	06 47.1	+ 38 38	6.23	A0	A0	+ 25.6	0.6	4	6-8	2.2	
50277	47.4	+ 08 30	5.76	A5	A5n	+ 26.3	1.0	4	4	2.6	
50371	47.8	+ 11 07	6.30	G5	G8	− 33.3	0.2	4	18-24	0.7	
50885	50.0	+ 70 57	5.83	K0	K2	− 15.8	0.6	4	20-21	0.8	
51000	50.5	+ 33 50	6.01	G0	G0	− 10.1	0.7	4	18-22	0.7	
51814	06 53.7	+ 03 45	6.02	K0	K0	+ 17.4	0.2	4	17-23	0.6	
52030	54.6	+ 70 54	6.61	K0	K5	+ 21.1	0.5	4	20-24	0.8	
52100	54.8	+ 32 32	6.46	F0	F0n	− 28.1	0.7	4	4-16	2.5	
52554	56.6	+ 17 53	6.20	Ma	M3	+ 24.2	1.9	4	11-20	1.2	
52556	56.6	+ 15 28	5.89	K0	K0	− 13.1	0.3	5	20-23	0.6	
52609	06 56.8	+ 16 49	6.01	K5	K5	+ 36.9	0.6	4	19-21	1.1	
52913	57.9	+ 09 17	5.93	A2	A2n	Var.		4	6-11	2.8	11
52976	58.2	+ 12 44	6.17	K5	K6	− 14.2	0.5	4	8-23	1.4	
53257	59.3	+ 22 47	5.91	A0	A0n	− 09.1	3.6	4	3-4	5.2	*
53510	07 00.2	+ 09 18	6.02	K0	K5	+ 48.7	0.5	4	15-17	0.9	

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	$\bar{e}$	Ref.
	h m	° ′									
53899	07 01.7	+ 33 58	6.47	K0	K1	− 01.9	0.4	4	21-23	0.7	
53925	01.8	+ 37 36	6.32	K0	K0	+ 10.6	0.9	4	13-23	0.6	
54070	02.4	+ 71 59	6.45	K0	K0	− 66.5	0.5	4	19-23	0.5	
54801	05.2	+ 27 02	5.60	A2	A2n	+ 38.2	2.8	5	2-6	4.3	*
55184	06.8	+ 05 39	6.22	G5	K0	+ 20.6	0.1	4	20-21	0.6	
56031	07 10.3	+ 08 10	5.97	Mb	M4	− 06.6	0.4	4	17-19	0.8	
56941	14.0	+ 42 50	6.57	K0	K0	+ 46.8	0.4	4	15-22	0.7	
56989	14.2	+ 02 54	6.06	G5	G6	+ 23.9	0.5	4	15-22	0.9	
57263	15.4	+ 39 11	6.48	K0	K1	+ 03.9	0.8	4	21-24	0.6	
57646	17.1	+ 52 05	5.91	K2	K5	+ 18.0	0.4	4	18-24	0.8	
57744	07 17.5	+ 23 09	6.02	A0	A0n	+ 17.0	2.4	4	3-5	4.5	
59878	26.9	+ 23 07	6.44	G5	G7	+ 30.8	1.0	4	20-23	0.7	*SR
60111	27.9	+ 03 30	5.66	A5	F0n	+ 00.3	0.6	4	6-13	2.8	
60357	29.0	+ 03 35	5.82	A0	A0n	+ 32.0	1.7	5	3	5.7	
60654	30.5	+ 40 14	6.57	Ma	K8	+ 32.1	1.2	4	19-26	0.9	
61035	07 32.2	+ 24 36	6.32	F0	F0n	+ 06.8	0.8	4	7-18	2.0	
61294	33.5	+ 38 34	5.89	K5	K5	+ 47.1	0.6	4	8-21	1.5	
61603	35.0	+ 23 16	6.18	K5	K5	+ 40.9	0.9	4	13-22	1.2	
61630	35.1	+ 13 59	6.50	K0	K2	+ 06.2	0.7	4	10-24	1.0	
61885	36.3	+ 13 44	6.10	Ma	M1	+ 08.3	0.4	4	16-22	0.9	
62140	07 37.4	+ 63 04	6.35	A5	F0g	+ 01.4	1.5	4	9-15	1.9	
62141	37.4	+ 22 39	6.34	K0	G5	− 02.2	0.7	4	15-24	0.6	
62264	38.0	+ 00 26	6.36	G5	G6	+ 08.7	0.2	4	17-22	0.9	
62407	38.7	+ 13 07	6.50	K0	K3	+ 26.6	0.8	4	18-22	0.9	
62437	38.9	+ 02 39	6.34	F0	F0	+ 14.2	0.8	4	17-24	1.0	
63352	07 43.4	+ 13 38	6.25	K0	K1	− 56.3	0.5	4	13-22	0.9	
63435	43.8	+ 04 34	6.51	G0	G0	− 05.5	0.5	4	19-24	0.6	
63799	45.6	+ 03 32	6.30	G5	K0	− 46.9	0.9	4	10-22	1.0	
63889	46.1	+ 19 35	6.13	K0	K0	+ 40.7	0.3	4	12-23	0.7	
64052	46.9	+ 03 32	6.59	Ma	M4	− 60.0	0.9	4	10-20	1.6	
64938	07 51.2	+ 04 44	6.32	K0	G5	+ 17.5	0.8	4	19-21	0.7	
65066	51.8	+ 08 54	6.12	G5	G6	− 35.1	0.3	4	14-22	0.6	
65299	53.0	+ 84 21	6.39	A0	A0	Var.		4	8-15	1.5	H
65448	53.7	+ 63 21	6.04	F8	F8	+ 18.2	1.9	4	13-16	1.2	*13R
65522	54.0	+ 13 30	6.20	K5	K2	+ 27.8	0.3	4	12-20	1.1	

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	$\bar{e}$	Ref.
	h m	° ′									
65735	07 55.0	+ 20 05	6.28	K0	K0	+ 28.7	0.4	4	22-24	0.7	
65757	55.1	+ 23 53	6.42	K0	K0	+ 26.0	0.8	4	19-24	0.8	
65801	55.4	+ 35 41	6.27	K0	K5	− 14.5	0.8	4	20-22	0.9	
65900	55.9	+ 05 09	5.66	A0	A0	+ 45.1	0.4	4	9-16	1.5	
67224	08 01.9	+ 58 33	6.05	K0	K2	+ 36.2	0.6	4	20-23	0.7	
67827	08 04.7	+ 39 02	6.47	G0	F8	+ 25.7	0.9	4	16-22	0.8	
67934	05.2	+ 82 44	6.17	A0	A0n	− 16.5	5.3	4	3-4	7.2	*
68077	05.8	+ 56 46	5.90	K0	G8	+ 08.3	0.3	4	21-25	0.7	
69149	10.6	+ 54 26	6.40	K5	K5	+ 26.5	0.4	4	20-22	0.8	
69478	12.1	+ 09 11	6.31	K0	G6	+ 29.9	1.4	4	11-27	0.7	
69682	08 12.9	+ 53 53	6.36	F0	F0	+ 10.0	0.7	4	21-27	0.9	
70013	14.6	+ 04 15	6.29	G5	G5	− 45.6	0.6	4	14-22	0.7	
70771	18.7	+ 35 22	6.21	K0	K0	+ 34.1	0.8	4	20-22	0.7	
71095	20.4	+ 02 27	5.91	K0	K5	+ 13.1	0.9	4	12-19	1.1	
71553	23.0	+ 69 39	6.44	K0	K2	− 29.3	0.3	4	20-23	0.8	
72208	08 26.5	+ 10 09	6.58	A0	A0	Var.		5	3-7	5.2	II
72359	27.3	+ 10 26	6.30	A0	A0	Var.		4	8-13	1.9	II
72505	28.2	+ 13 36	6.40	K0	K0	+ 28.8	0.8	4	16-22	0.8	
72561	28.5	+ 05 06	6.13	K0	G5	+ 01.6	0.5	4	12-22	1.0	
72908	30.3	+ 03 05	6.48	K0	K0	− 05.0	0.8	4	13-22	0.6	
73131	08 31.6	+ 53 16	6.54	K0	K1	+ 40.0	0.4	4	22-23	0.8	
73143	31.7	+ 10 00	5.98	A0	A2	+ 15.5	1.6	4	10-22	1.5	
73599	34.1	+ 08 22	6.49	K0	K0	+ 17.7	0.6	4	18-22	0.8	
74591	39.7	+ 06 03	6.00	A2	A3n	− 14.6	0.6	4	5-10	3.7	
74873	41.5	+ 12 28	5.71	A0	A0	+ 21.0	2.0	4	3-4	3.2	
75959	08 48.1	+ 30 57	5.60	K0	G8	− 59.1	0.4	4	20-22	0.5	
76292	50.1	+ 40 35	5.88	F2	F2	+ 25.4	1.0	4	10-26	1.6	
76494	51.4	+ 04 37	6.36	G5	G8	− 11.2	0.4	4	20-23	0.7	
76508	51.5	+ 17 32	6.29	K0	K0	+ 19.9	0.3	4	16-20	0.7	
76629	52.3	+ 09 46	6.32	K0	G8	− 12.6	0.4	4	9-22	0.8	
76944	08 54.2	+ 38 00	6.54	K5	K5	− 15.5	0.3	4	9-22	0.9	
77250	56.3	+ 06 02	6.31	K0	K0	+ 34.3	0.4	4	19-23	0.7	
77309	56.7	+ 54 41	5.68	A2	A2n	− 08.9	2.1	4	4	5.0	*
77445	57.4	+ 07 41	6.07	K0	K0	+ 28.0	0.3	4	17-23	0.7	
78196	09 01.8	+ 01 52	6.41	Ma	M2	+ 04.4	1.2	4	14-20	1.1	

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	$\bar{e}$	Ref.
	h m	° ′									
78234	09 02.0	+ 32 57	6.33	F2	F2	+ 40.9	1.5	4	14-18	2.3	
78633	04.3	+ 72 04	6.46	K0	G8	+ 06.7	0.8	4	20-23	0.8	
78712	04.6	+ 31 23	Var.	Mc	M7	+ 16.3	0.1	4	18-22	1.0	
79248	07.9	+ 21 42	6.09	A0	A0	+ 07.8	0.4	4	7-13	2.0	
79517	09.5	+ 74 26	6.54	G5	K0	+ 56.7	0.7	4	18-24	0.7	
80953	09 17.7	+ 64 23	6.46	K2	K3	+ 08.1	1.5	4	17-24	1.0	*10
81025	18.1	+ 52 01	6.37	G0	G0	Var.		4	21-24	0.8	II
81790	22.7	+ 56 11	6.46	F2	F2	+ 09.6	0.8	4	11-20	0.8	
82189	25.4	+ 72 39	5.82	F5	F5	− 38.9	0.2	4	18-24	0.7	
82670	28.3	+ 23 53	6.43	K5	K5	− 04.7	0.9	4	11-21	1.3	
82685	09 28.4	+ 73 32	6.43	F0	F0n	− 00.5	1.1	4	8-10	3.2	R
82780	29.1	+ 40 24	6.56	F2	F2	Var.		4	8-20	2.4	IIR
83126	31.2	+ 67 43	6.28	K5	K6	+ 20.5	0.3	4	17-22	1.0	
83550	34.2	+ 78 36	6.41	G5	K1	− 26.3	0.6	4	8-22	1.4	
83951	36.7	+ 35 32	6.03	F2	F2	− 08.4	0.9	4	16-22	1.0	
84252	09 38.9	+ 19 20	6.64	K0	K0	+ 00.4	0.6	4	14-22	0.6	
84812	42.6	+ 66 04	6.29	F0	F0n	− 07.2	2.1	4	4-6	4.4	
85505	47.1	+ 00 33	6.29	K0	G5	+ 20.1	1.0	4	15-24	0.5	*9
85583	47.7	+ 61 36	6.42	K0	K0	− 09.7	1.0	4	17-22	0.7	
85709	48.5	+ 06 26	6.27	Ma	M1	− 00.3	0.9	4	10-19	1.0	
86321	09 52.6	+ 84 24	6.48	K0	K6	− 10.5	1.0	4	12-22	1.6	
87500	10 00.3	+ 16 14	6.28	F0	F0n	+ 11.6	4.3	4	8-12	5.0	*
88231	05.3	+ 37 53	6.14	K0	K2	+ 09.7	0.5	5	13-25	0.9	
88651	08.3	+ 60 31	Var.	Ma	M0	− 19.6	0.4	4	16-21	1.2	
89268	12.8	+ 47 17	6.48	K0	K0	− 20.0	0.8	4	18-21	0.8	
89319	10 13.2	+ 48 55	6.15	K0	K0	− 05.2	0.4	4	17-20	1.0	
89344	13.4	+ 25 14	6.60	K0	K2	+ 01.0	0.4	4	8-21	1.5	
89389	13.8	+ 54 18	6.44	F8	F8	− 20.6	0.4	4	14-22	0.9	
90125	19.1	+ 02 52	6.43	K0	K0	− 13.0	0.4	4	11-17	1.5	
90472	21.6	+ 19 52	6.29	K0	K0	+ 32.9	0.5	4	16-21	0.7	
94237	10 47.5	+ 00 21	6.59	K5	K4	+ 09.5	0.6	4	10-21	0.7	
94720	50.9	+ 22 54	6.24	K2	K5	+ 26.7	1.6	4	11-20	0.9	
94747	51.2	+ 26 02	6.40	K0	K0	+ 31.0	0.6	4	19-22	0.8	
95057	53.4	+ 52 26	6.34	K0	K2	− 05.6	0.6	4	16-23	1.0	
95233	54.6	+ 52 02	6.52	G5	G8	+ 01.0	0.9	4	19-22	1.1	

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	$\bar{e}$	Ref.
	h m	° ′									
97501	11 08.1	+ 41 38	6.49	K0	K0	+ 12.7	1.0	4	18-24	0.9	
98499	14.8	+ 67 38	6.31	K0	G8	− 55.2	0.7	4	18-24	0.8	
98960	18.2	+ 00 41	6.26	K0	K3	+ 22.6	0.4	4	17	1.2	
99967	25.0	+ 47 12	6.49	K0	K0	Var.		4	20-22	0.7	II
100030	25.5	+ 48 29	6.38	G5	G5	+ 39.4	1.8	5	18-21	0.5	
100055	11 25.7	+ 49 20	6.42	G5	G6	+ 07.3	0.5	4	18-30	0.9	
100655	29.9	+ 20 59	6.44	K0	K0	− 05.5	1.0	4	16-22	1.1	
101112	33.0	+ 09 26	6.55	K0	K0	+ 12.1	0.4	4	20-22	0.7	
101151	33.3	+ 34 12	6.36	K2	K2	− 04.7	0.5	4	19-22	1.0	
101604	36.4	+ 55 43	6.40	K5	K4	− 05.6	0.4	4	16-23	0.9	
101980	11 39.1	+ 25 47	6.19	K5	K5	− 01.7	1.2	5	11-20	1.5	
103500	50.0	+ 37 20	6.54	Mb	M2	+ 20.7	1.2	4	15-24	1.8	
103736	51.7	+ 62 06	6.28	G5	G5	+ 18.1	0.4	4	12-21	0.4	
103799	52.1	+ 40 55	6.54	F5	F5	+ 26.2	0.6	4	12-23	0.7	
103953	53.2	+ 62 02	6.66	G5	G8	− 24.9	0.5	4	15-22	0.6	
107274	12 14.9	+ 49 32	5.56	K2	K5	+ 11.0	1.0	5	9-20	0.8	
107904	18.9	+ 43 05	5.98	F0	F2n	Var.		4	10-23	2.9	II
108471	22.6	+ 09 10	6.42	K0	G8	− 05.3	0.4	4	16-23	0.9	
108651	23.8	+ 26 27	6.69	A3	A2	Var.		4	17-22	1.0	II
108861	25.4	+ 59 19	6.22	K0	G8	− 15.5	0.9	4	17-24	0.6	
108985	12 26.3	+ 08 10	6.16	K5	K5	− 15.7	0.3	4	13-20	1.2	
109345	28.9	+ 33 57	6.37	K0	K0	− 42.7	0.4	4	18-23	0.6	
109980	33.9	+ 41 25	6.29	A3	A5n	− 16.5	4.1	4	3-5	6.2	*
109996	34.0	+ 23 12	6.47	K0	K0	− 26.2	0.5	4	21-26	0.7	
110462	37.2	+ 63 16	5.92	A0	A0	− 04.6	0.9	4	7-19	1.5	
110678	12 38.7	+ 61 42	6.46	K0	K2	− 04.8	0.9	4	19-22	0.7	
111164	42.2	+ 12 30	6.05	A3	A3n	− 03.5	2.5	4	3-6	6.0	*
111591	45.3	+ 23 24	6.46	K0	K0	+ 07.0	0.7	4	16-23	0.9	
112486	51.9	+ 54 39	5.84	A2	A2	Var.		4	4-23	2.0	II
114357	13 05.0	+ 37 57	6.14	K2	K2	− 18.7	0.4	4	20-25	0.6	
114724	13 07.3	+ 24 48	6.46	K0	G8	− 23.0	1.0	4	17-26	0.7	
114793	07.7	+ 19 17	6.58	G5	G0	− 20.4	0.4	4	18-26	0.8	
114889	08.4	+ 19 15	6.48	K0	K1	− 22.5	0.5	4	19-26	0.5	
115271	11.0	+ 41 23	5.68	A5	A5n	− 18.8	1.2	4	10-17	3.0	
115709	13.8	+ 04 13	6.56	A0	A0	Var.		4	9-14	2.2	II

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Ref.
	h m	° ′									
115723	13 13.9	+ 34 37	5.98	K0	K2	− 19.6	1.0	6	13-26	1.9	S
117200	23.7	+ 65 15	6.66	F0	F2	− 13.9	1.5	4	11-24	1.3	
117201	23.7	+ 65 13	7.01	F0	F5	− 15.1	1.2	4	14-24	0.8	
117261	24.1	+ 41 15	6.54	K0	G3	− 58.3	0.3	4	17-24	0.6	
117281	24.2	+ 51 06	6.77	A3	A5	− 16.3	1.6	4	17-20	1.6	
117404	13 25.0	+ 07 42	6.29	K5	K5	− 01.9	0.4	4	10-21	0.8	
117405	25.0	+ 06 32	6.41	K0	G6	− 18.3	1.0	4	17-19	0.8	
117710	27.0	+ 42 36	6.15	K0	K1	− 19.7	0.2	4	17-21	1.1	
118266	30.6	+ 10 43	6.46	K0	K1	+ 33.7	0.5	4	18-26	0.7	
118295	30.9	+ 44 43	6.63	A5	F0n	− 26.1	1.4	4	7-14	3.3	
118508	13 32.3	+ 25 07	5.90	Ma	M2	− 26.1	1.0	5	9-16	2.1	S
118536	32.5	+ 50 00	6.60	K0	K2	− 08.9	0.2	4	17-26	0.8	
118686	33.4	+ 77 04	6.70	K5	K6	− 13.0	0.3	4	13-22	1.3	
118741	33.7	+ 51 13	6.59	K5	K2	− 46.6	0.2	4	15-23	1.1	R
119081	36.0	+ 28 35	6.36	K0	K2	− 61.8	0.4	4	17-21	1.0	
119445	13 38.2	+ 42 10	6.34	K0	G5	− 31.8	0.4	4	13-21	0.4	
120602	45.4	+ 05 59	6.25	K0	G5	− 23.2	0.7	4	16-21	1.1	
120787	46.5	+ 61 59	6.05	K0	G6	− 11.7	0.4	4	17-23	0.8	
120874	47.1	+ 59 02	6.36	A0	A0	Var.		6	3-16	3.2	H
121146	48.6	+ 68 49	6.44	K0	K0	− 43.5	1.0	4	21-26	0.7	
121607	13 51.4	+ 01 32	5.94	A3	A3n	− 27.9	3.0	5	6-10	5.7	*
122064	54.4	+ 61 59	6.40	K5	K2	− 24.3	0.2	4	19-23	0.9	
122675	58.2	+ 46 15	6.46	K5	K2	− 47.6	0.6	4	16-21	0.9	
122742	58.6	+ 11 16	6.43	G5	G5	− 13.4	1.4	4	17-25	0.7	*H
122744	58.6	+ 08 01	6.35	K0	G5	− 19.1	0.6	4	21-23	0.7	
122866	13 59.3	+ 51 27	6.05	A0	A0	− 08.7	2.3	5	5-6	4.3	*
122909	59.6	+ 69 10	6.42	K5	K3	− 20.5	0.4	4	21-23	0.8	
122910	59.6	+ 02 47	6.35	K0	K0	− 27.5	1.3	4	10-20	1.3	
124186	14 06.9	+ 32 45	6.24	K2	K2	− 20.7	1.5	5	14-23	1.6	S
124681	09.9	+ 03 47	6.62	Ma	M2	− 47.8	1.3	4	8-20	1.4	
125538	14 14.9	+ 39 12	6.48	G5	G8	− 09.0	0.9	6	7-24	2.1	
125632	15.6	+ 55 20	6.55	A3	A2	− 04.2	2.0	4	4-10	4.5	
126271	19.4	+ 08 33	6.22	K2	K1	− 29.0	0.5	4	16-25	1.1	
127043	24.1	+ 28 44	7.45	A0	A0n	− 08.4	4.0	4	2-5	5.3	R
127065	24.2	+ 36 39	6.19	K0	K1	− 16.5	0.3	4	17-26	1.1	

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Ref.
	h m	° ′									
127067	14 24.2	+ 28 44	6.95	A0	A0n	− 10.5	2.8	5	3-4	6.2	
127334	25.7	+ 42 15	6.45	G0	G5	00.0	1.5	4	19-25	0.5	R
127929	29.0	+ 60 40	6.18	F0	F0	− 19.5	0.6	4	13-26	0.9	
128000	29.4	+ 55 50	5.99	K5	K5	+ 04.8	1.6	6	7-23	2.7	S
128402	31.6	+ 23 41	6.48	K0	K0	+ 08.2	0.5	4	19-25	0.9	
129153	14 35.9	+ 13 57	5.98	A5	A8	− 08.4	0.9	5	6-16	2.8	S
129430	37.4	+ 21 33	6.43	G5	G5	− 10.0	0.6	4	8-26	1.7	
130025	40.8	+ 19 18	6.39	K0	G2	− 04.1	0.6		18-22	0.6	
130084	41.1	+ 33 13	6.47	Ma	M0	+ 33.3	1.0	4	10-16	1.4	
130970	45.9	+ 00 09	6.24	K2	K5	— 18.9	1.1	4	10-22	1.5	
131951	14 51.5	+ 14 51	5.77	A0	A0n	− 12.4	3.3	5	3-5	8.0	S
132772	55.8	+ 39 40	5.58	F2	F2	+ 12.6	1.1	6	9-21	2.7	S
132879	56.4	+ 22 27	6.45	K0	K1	− 24.9	0.5	4	13-24	1.1	
133485	59.6	+ 34 56	6.43	K0	K0	− 24.1	0.8	4	14-22	0.8	
134493	15 05.1	+ 50 27	6.27	K0	K0	— 27.7	1.1	4	15-28	0.7	
135530	15 10.5	+ 42 33	6.37	Ma	M1	− 04.8	0.8	4	17-22	1.7	
136643	16.7	+ 25 20	6.44	K0	K2	− 01.2	0.4	4	13-21	0.7	
137390	20.7	+ 45 37	6.24	K2	K2	− 09.1	0.8	4	20-24	0.8	
138383	26.7	+ 37 09	6.52	K0	K0	+ 02.8	0.3	4	20-24	0.8	
138524	27.6	+ 62 27	6.49	K5	K4	− 39.4	0.8	4	19-22	1.0	
138803	15 29.3	+ 17 29	6.45	F0	F0n	− 21.2	1.0	4	15-18	1.8	
138936	30.1	+ 02 00	6.58	A3	A0	− 19.5	2.0	5	7-18	2.0	
139284	32.2	+ 38 42	6.50	K2	K2	+ 03.7	1.2	4	20-27	0.9	
139493	33.4	+ 54 57	5.74	A0	A0n	− 20.3	1.5	5	4-6	8.2	S
139862	35.4	+ 12 23	6.31	G5	G5	— 20.5	0.3	4	18-23	0.6	
140227	15 37.4	+ 69 36	5.86	K0	K0	− 25.2	1.8	4	14-24	1.7	*11S
140232	37.4	+ 18 47	5.80	A3	A0	− 30.5	0.4	4	13-20	1.8	S
140438	38.5	+ 13 59	6.44	G5	G3	− 09.9	1.4	4	18-28	1.0	
141456	44.1	+ 32 02	6.56	K5	K5	− 18.0	0.3	4	13-24	1.1	
141472	44.2	+ 55 47	5.90	K2	K2	− 04.4	1.0	5	13-21	2.5	S
142244	15 48.4	+ 17 43	6.44	K0	K0	− 10.7	0.7	4	13-29	1.2	
142531	50.0	+ 56 07	5.92	K0	K0	− 28.6	1.2	5	16-24	1.7	S
143209	54.0	+ 39 58	6.44	K0	K2	− 13.1	1.0	4	15-26	1.1	
144046	58.8	+ 05 16	6.18	K0	G8	− 42.7	1.1	4	10-21	1.4	
145694	16 07.2	+ 56 06	6.59	K0	K0	− 13.6	0.3	4	19-24	0.6	

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Ref.
	h m	° ′									
145931	16 08.5	+ 42 38	6.01	K5	K6	− 21.2	0.3	4	19-24	1.5	
146537	11.7	+ 27 41	6.30	K2	K3	− 09.9	0.4	4	14-31	1.1	
146603	12.0	+ 67 24	6.28	K0	G8	− 08.5	0.4	4	19-23	0.7	
147662	18.1	+ 68 48	6.47	K0	K2	− 09.6	0.6	4	18-23	0.8	
148228	21.5	+ 11 40	6.21	K0	K0	− 20.3	0.7	4	16-22	0.8	
149009	16 26.9	+ 22 25	5.96	K5	K5	− 22.9	0.8	5	7-27	2.2	S
149084	27.4	+ 35 27	6.47	K5	K8	+ 25.6	1.2	4	9-21	1.3	*10
150429	35.9	+ 63 17	6.44	K5	K5	− 40.6	0.2	4	19-24	0.9	
150580	36.9	+ 25 03	6.22	K2	K3	− 66.6	0.7	4	14-23	1.2	
151623	43.5	+ 79 06	6.38	K0	K0	− 19.8	1.2	4	20-24	0.8	
153226	16 53.0	+ 14 03	6.51	G5	K0	− 29.7	0.5	4	10-22	1.0	
153299	53.5	+ 50 13	6.70	Ma	M0	− 29.6	0.2	4	12-20	0.9	
153312	53.6	+ 24 33	6.36	K0	K0	− 20.8	0.6	4	14-22	1.0	
153697	55.9	+ 65 11	6.44	F0	F0n	− 25.0	0.4	4	8-15	2.1	
154126	58.5	+ 32 02	6.60	K0	K0	− 12.1	0.7	4	18-23	0.8	
154301	16 59.6	+ 19 50	6.57	K5	K5	− 37.8	0.6	4	7-24	1.7	
154319	59.7	+ 69 20	6.52	K0	G0	− 26.8	0.3	4	18-23	0.8	
154391	17 00.1	+ 60 47	6.24	K0	K0	− 15.6	1.0	4	17-23	0.8	
154610	01.4	+ 09 53	6.56	K5	K5	− 04.0	0.3	4	20-23	0.9	
154619	01.5	+ 10 35	6.47	K0	G6	− 22.9	0.4	4	20-24	0.6	
155500	17 06.9	+ 08 01	6.39	K0	K0	− 04.7	1.2	4	11-22	1.2	
155646	07.8	+ 00 29	6.52	F5	F5	+ 58.4	0.7	4	15-21	1.0	
156284	11.6	+ 23 52	6.10	K2	K2	− 39.0	0.8	4	12-23	1.2	
156593	13.4	+ 23 13	6.53	K2	K5	− 13.9	0.6	4	15-21	1.3	
156697	14.0	+ 06 11	6.44	F0	Fon	− 25.2	5.4	4	4-14	8.0	
156891	17 15.0	+ 38 55	5.98	K0	G8	− 36.4	1.2	4	17-28	1.4	S
157257	17.1	+ 16 50	6.59	Ma	M1	+ 40.4	0.6	4	14-21	1.0	
157617	19.2	+ 08 56	5.92	K2	K2	+ 17.9	1.1	5	12-24	2.2	S
157681	19.6	+ 53 31	5.95	K5	K5	− 08.2	0.8	4	9-24	1.7	S
157967	21.4	+ 17 00	6.29	Mb	M4	− 06.5	0.6	4	13-21	1.0	
157978-9	17 21.5	+ 07 41	5.98	A0-G	A0-G	Var.		6	6-20	1.4	IIR
158996	27.2	+ 80 13	5.91	K2	K5	− 05.9	1.3	4	9-21	0.7	
159026	27.3	+ 38 58	6.45	F2	F2n	− 27.7	1.3	4	8-12	6.5	
159222	28.4	+ 34 21	6.54	G5	G2	− 52.1	0.4	4	20-24	0.8	
159354	29.2	+ 14 55	6.66	Mb	M4	+ 31.2	0.7	4	13-21	1.1	

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km. sec.	P.E.	Plates	Lines	$\bar{e}$	Ref.
	h m	° ′									
159925	17 32.2	+ 37 22	6.15	K0	G8	+ 04.5	0.3	4	18-24	0.8	
159926	32.2	+ 28 14	6.48	K5	K5	− 32.6	1.0	4	8-20	1.9	
160677	36.2	+ 31 15	6.30	Ma	M0	− 08.9	0.6	4	16-23	1.0	
160781	36.7	+ 06 22	5.98	K0	K2	− 31.2	1.5	6	7-21	1.0	
160822	36.9	+ 31 22	6.43	K0	K0	− 05.1	1.0	4	17-22	0.8	
160933	17 37.6	+ 69 38	6.48	F8	F8	− 53.3	0.2	4	20-24	0.8	
160950	37.7	+ 43 31	6.67	K0	K2	− 28.2	0.6	4	18-22	0.8	
161162	38.9	+ 57 22	6.84	K0	G5	− 12.8	0.8	4	18-21	0.8	
161178	39.0	+ 72 31	5.96	K0	K0	+ 09.0	0.6	4	18-24	0.6	
161193	39.1	+ 51 52	6.12	K0	K0	− 07.0	0.6	4	17-24	0.7	
161369	17 40.1	+ 44 08	6.57	K2	K4	− 59.3	0.6	4	13-21	0.9	
161815	42.6	+ 38 56	6.51	K0	K0	− 10.5	0.7	4	20-22	1.0	
161832	42.7	+ 39 22	6.56	K0	K3	Var.		4	16-21	1.1	11
162113	44.3	+ 02 00	6.46	K0	K2	− 57.0	0.4	4	14-19	0.9	
162468	46.1	+ 11 59	6.35	K2	K1	− 48.2	0.6	4	19-23	0.8	
162734	17 47.4	+ 15 22	6.54	K0	K0	− 42.0	0.7	5	14-22	0.8	
162774	47.6	+ 01 20	6.15	K5	K5	− 63.6	0.3	4	12-20	1.1	
162826	47.9	+ 40 05	6.52	G0	F8	+ 01.5	0.4	4	21-25	0.7	
163840	53.2	+ 24 01	6.36	G0	G0	Var.		6	16-24	0.7	11
164280	55.3	+ 36 17	5.98	K0	K0	+ 10.5	1.3	5	17-22	1.9	S
164428	17 56.0	+ 78 20	6.38	K5	K5	− 05.3	0.5	4	19-20	0.9	
164780	57.7	+ 75 10	6.44	K0	K0	− 16.8	0.3	4	19-21	0.7	
164824	57.9	+ 33 20	6.27	K5	K5	− 08.9	0.4	4	15-23	1.3	
166207	18 04.5	+ 50 49	6.35	K0	K0	− 56.1	1.7	4	20-22	0.9	*12
166411	05.4	+ 30 26	6.64	K2	K1	− 78.6	0.3	4	21-24	0.8	
167304	18 09.5	+ 41 08	6.36	K0	K0	− 47.2	0.6	4	22-24	0.8	
167654	11.1	+ 02 22	6.31	Mb	M3	+ 23.0	0.8	4	13-22	1.1	
168009	12.7	+ 45 10	6.30	G0	G0	− 64.4	0.4	4	16-24	0.7	
168323	14.0	+ 23 15	6.72	K5	K6	+ 04.8	0.4	4	15-19	1.2	
168694	16.0	+ 29 37	6.14	K0	K2	− 34.8	0.9	4	21-24	0.9	
169221	18 18.6	+ 49 40	6.51	K0	K0	− 16.0	0.8	4	15-22	0.7	
169646	20.6	+ 38 42	6.45	K2	K2	− 39.2	1.2	4	18-24	1.0	
170137	22.8	+ 03 41	6.14	K2	K2	− 17.7	1.1	5	9-18	2.2	
170829	26.4	+ 20 46	6.59	G5	G8	Var.		4	16-27	0.8	11
171994	32.6	+ 16 07	6.38	K0	K0	− 45.0	1.1	4	15-20	0.8	

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	$\bar{e}$	Ref.
	h m	° ′									
172424	18 35.0	+ 07 16	6.36	K0	G8	− 40.0	0.4	4	13-22	0.7	
172569	35.9	+ 65 24	6.00	A3	A3	Var.		4	9-18	2.1	II
172631	36.2	+ 30 46	6.48	K0	G5	− 48.9	0.2	4	19-23	0.6	
172958	37.9	+ 31 31	6.47	A0	B9n	− 17.3	1.0	4	3-5	5.7	
173383	39.9	+ 39 13	6.55	K5	K5	Var.		4	16-24	1.4	II
173398	18 40.0	+ 62 39	6.01	K0	K0	− 25.7	0.4	4	16-25	0.6	
173416	40.1	+ 36 28	6.25	K0	G8	− 59.9	0.4	4	11-23	0.8	
173833	42.3	+ 18 36	6.27	K5	K6	− 11.4	0.7	4	7-18	1.6	
173920	42.9	+ 54 47	6.26	G5	G0	+ 07.1	0.1	4	20-26	0.7	
174205	44.3	+ 70 41	6.56	K2	K2	− 04.4	0.6	4	22-25	0.7	
174369	18 45.1	+ 24 56	6.56	A0	A2n	Var.		5	5-9	4.0	II
174481	45.6	+ 48 39	6.02	A3	A5n	− 32.0	2.1	4	8-10	4.4	
174569	46.0	+ 10 52	6.63	K2	K5	− 22.2	0.5	5	12-21	1.2	R
175679	51.4	+ 02 21	6.28	K0	G8	− 14.4	0.5	4	17-22	0.7	
175743	51.7	+ 17 59	5.72	K2	K2	Var.		5	9-23	1.6	II
176541	18 55.7	+ 22 40	6.41	Ma	M3	− 52.5	0.6	4	16-17	1.2	
176707	56.5	+ 50 41	6.37	G5	G8	− 19.6	0.5	4	16-26	0.8	
176776	56.8	+ 19 10	6.51	K0	K0	− 27.9	0.4	4	19-22	0.9	
176844	57.1	+ 40 32	6.77	Ma	M2	− 03.0	0.7	4	20-23	1.1	
176939	57.5	+ 24 53	6.92	K2	K3	− 20.2	0.6	4	17-25	1.0	
176981	18 57.6	+ 08 14	6.62	K2	K2	− 07.7	1.4	4	19-25	0.9	*11
177199	58.6	+ 19 31	6.25	K0	K2	− 06.0	0.4	4	19-26	0.9	
179094	19 06.1	+ 52 16	5.93	K0	G8	Var.		4	21-24	0.6	II
179933	09.4	+ 65 49	6.19	A2	A2n	− 23.0	1.9	4	3-5	2.6	
181122	14.1	+ 09 27	6.38	K0	K0	− 10.7	0.5	4	16-26	0.8	
181597	19 16.0	+ 49 23	6.26	K0	K0	− 13.0	0.4	4	17-24	0.9	
181655	16.2	+ 37 09	6.36	G5	G5	+ 02.5	0.5	4	8-24	0.9	
182272	18.8	+ 33 19	6.30	K0	K0	− 14.8	0.4	4	19-25	0.5	
182488	19.8	+ 33 01	6.50	K0	K1	− 19.5	0.9	4	20-22	0.7	
182635	20.5	+ 36 15	6.45	K0	K0	− 31.9	0.3	4	15-23	0.7	
183387	19 24.2	+ 00 02	6.52	K2	K2	− 58.9	0.9	4	19-21	1.0	
183589	25.2	+ 02 41	6.38	K5	K5	− 05.7	1.3	4	13-21	1.1	
183611	25.3	+ 62 21	6.46	K5	K4	− 38.9	0.9	4	19-21	0.8	
184102	27.8	+ 79 24	6.00	A2	A2n	− 04.1	1.8	4	4-6	5.3	
184786	31.0	+ 49 02	6.19	Mb	M4	− 07.8	0.8	5	12-24	1.1	

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	ē	Ref.
	h m	° ′									
184884	19 31.4	+ 10 55	6.53	A2	A2n	− 06.1	3.1	4	3-5	5.7	*
184936	31.6	+ 59 57	6.43	K5	K5	− 17.7	0.4	4	20-23	1.0	
184944	31.7	+ 14 10	6.47	K0	K0	− 41.0	0.5	4	18-22	0.7	
184958	31.8	+ 70 47	6.25	K2	K4	− 41.9	0.4	4	12-22	0.9	
184977	31.9	+ 47 57	6.70	A5	A5	− 01.0	0.7	4	13-23	1.4	
185264	19 33.2	+ 50 01	6.63	G5	G8	+ 09.3	0.4	5	16-23	0.8	
185436	34.0	+ 20 34	6.50	K0	K0	+ 06.0	0.6	4	13-26	1.1	
185622	34.9	+ 16 21	6.58	K5	K6	− 00.4	1.4	5	9-25	1.6	
186021	36.9	+ 22 13	6.44	K2	K1	− 22.0	0.4	4	17-21	1.0	
186121	37.5	+ 42 50	6.39	Ma	M2	− 04.2	1.1	4	17-22	1.0	
186532	19 39.9	+ 55 13	6.52	Mb	M6	− 25.7	0.9	4	19-21	1.0	
186702	40.9	+ 34 10	6.77	Ma	M2	+ 10.1	0.4	4	19-21	1.0	
186776	41.4	+ 40 28	6.44	Ma	M2	− 98.1	0.3	4	16-21	1.0	
186815	41.6	+ 56 47	6.39	G5	G5	− 24.6	0.7	4	14-19	1.1	
186998	42.5	+ 24 53	6.60	F0	F0n	+ 15.1	2.9	4	4-5	5.1	
187038	19 42.7	+ 32 38	6.18	K2	K2	− 45.4	0.3	5	18-28	0.9	
187764	46.6	+ 68 11	6.35	F0	F0n	− 12.6	2.9	4	10-16	2.6	*
187880	47.2	+ 37 35	6.31	Ma	M2	− 14.2	0.8	4	15-22	1.0	
188149	48.7	+ 36 11	6.33	K0	K3	− 19.8	0.3	4	14-24	1.0	
188350	49.6	+ 00 01	5.57	A0	A0n	− 42.6	2.9	4	4-8	3.9	*
189127	19 53.4	+ 57 59	6.19	K0	G8	− 15.5	0.2	4	18-24	0.7	
189322	54.3	+ 01 07	6.35	G5	G6	+ 07.0	1.1	4	13-22	1.0	*10
189695	56.2	+ 08 17	6.08	K2	K5	− 36.8	0.6	4	9-25	1.3	
189942	57.5	+ 36 49	6.39	K0	K0	− 15.0	0.9	4	18-23	0.7	
190252	59.0	+ 70 05	6.46	G5	G3	− 10.3	0.7	4	20-26	0.6	
190658	20 00.9	+ 15 13	6.56	Ma	M1	Var.		4	16-20	1.0	11
190771	01.5	+ 38 12	6.56	G5	G0	− 24.2	0.2	4	18-27	0.7	
190964	02.4	+ 51 33	6.28	Ma	M0	− 54.2	0.5	4	12-24	1.1	
191096	03.1	+ 56 03	6.18	F0	F2	− 12.2	0.6	4	13-24	0.9	
191178	03.5	+ 16 24	6.67	Ma	M3	+ 13.4	0.6	4	13-20	1.2	
191329	20 04.3	+ 49 57	6.52	A2	A2n	+ 02.2	2.6	4	3-4	5.0	*
191372	04.5	+ 67 45	6.56	Ma	M1	− 40.6	0.7	4	15-23	0.8	
191814	06.7	+ 20 51	6.26	K0	G5	− 06.0	0.8	4	16-21	0.6	
192535	10.3	+ 43 04	6.25	K2	K5	− 22.1	0.1	4	15-23	1.0	
193094	13.4	+ 28 50	6.38	K0	G8	− 19.0	0.3	6	15-21	0.6	

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	$\bar{e}$	Ref.
	h m	° ′									
193217	20 14.0	+ 42 24	6.45	K2	K3	− 16.4	0.4	4	12-21	1.0	
193373	14.8	+ 12 56	6.50	Ma	M0	+ 25.9	0.6	4	19-20	0.9	
193944	17.9	+ 53 16	6.38	K5	K5	− 02.1	0.3	4	15-21	1.4	
194220	19.4	+ 42 40	6.33	K0	K0	− 19.1	0.4	5	20-24	0.7	
194244	19.5	+ 00 45	6.11	A0	A0n	+ 02.7	3.3	4	3-4	10.	*
194298	20 19.8	+ 63 41	5.92	K5	K6	+ 31.9	0.8	4	19-23	1.0	
194526	21.0	+ 09 45	6.46	K5	K5	− 75.3	0.6	4	11-21	1.3	
194616	21.5	+ 19 31	6.44	K0	K0	− 29.1	0.4	4	17-21	0.9	
194937	23.2	+ 08 07	6.26	K0	K0	− 10.0	0.4	6	11-24	1.1	
194953	23.3	+ 02 36	6.35	K0	G5	− 20.5	0.3	4	18-25	0.8	
195820	20 28.5	+ 51 58	6.27	K0	K0	− 08.9	0.6	4	22-25	0.7	
196134	30.3	+ 41 25	6.43	K0	K0	+ 02.0	0.6	4	19-23	0.8	
196379	31.9	+ 51 31	6.26	F0	F0	− 13.2	1.0	4	20-25	1.0	
196610	33.4	+ 17 55	6.27	Mc	M7	− 63.3	0.2	4	17-23	1.3	
196642	33.6	+ 37 58	6.32	K0	K0	− 35.5	0.9	4	18-22	0.8	
196787	20 34.5	+ 81 05	5.62	K0	G8	− 03.9	0.2	4	19-24	0.6	
197101	36.4	+ 55 39	6.50	F0	F0n	− 01.0	1.5	4	4-8	4.8	
197249	37.4	+ 17 11	6.27	K0	G6	− 01.4	1.0	4	10-23	1.1	
197508	39.1	+ 83 17	6.16	A2	A2	Var.		4	16-22	0.7	H
197812	40.9	+ 17 44	Var.	Mb	M6	− 19.6	1.2	4	15-19	1.1	R
197939	20 41.8	+ 56 08	6.24	Ma	M2	− 27.3	0.4	5	13-24	1.2	
198181	43.5	+ 52 38	6.43	K0	K0	− 27.6	0.5	4	19-22	0.7	
198236	43.9	+ 69 23	6.52	K0	G8	− 07.5	0.4	5	18-24	0.7	
198404	45.0	+ 05 11	6.30	K0	K0	− 20.7	0.3	4	17-22	0.8	
199095	49.8	+ 82 10	5.69	A0	A0	Var.		4	4-7	1.6	H
199442	20 52.1	+ 00 05	6.26	K2	K2	− 24.6	0.6	5	20-22	0.9	
199611	53.3	+ 50 20	5.80	F0	F0n	− 19.6	2.0	5	8-11	3.7	*
199941	55.2	+ 16 26	6.53	F2	F2	+ 01.7	0.7	4	15-22	1.3	
200430	58.3	+ 14 20	6.38	Ma	M1	− 37.0	0.8	5	12-22	1.2	
200527	58.9	+ 44 25	6.38	Mb	M3	+ 02.1	0.5	4	17-24	1.0	
200661	20 59.7	+ 02 33	6.55	K0	K0	− 09.4	0.6	6	6-20	1.1	
200663	59.7	+ 01 54	6.42	G5	G5	− 10.7	1.0	4	11-20	0.9	
200740	21 00.2	+ 49 57	6.45	K0	K0	− 21.1	0.5	4	21-28	0.6	
201298	03.5	+ 06 36	6.38	K5	K6	+ 21.5	0.7	4	12-21	1.1	
202582	11.7	+ 63 59	6.41	G0	G0	+ 29.6	0.4	4	18-24	0.6	

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	$\bar{e}$	Ref.
	h m	° ′									
202720	21 12.7	+ 41 50	6.53	K2	K2	+ 09.2	0.4	4	17-21	0.9	
202951	14.1	+ 10 47	6.32	K5	K6	− 35.5	1.3	4	18-25	1.0	*9
203358	16.6	+ 32 02	6.44	G5	G5	− 27.5	0.5	4	22-23	0.5	R
203630	18.4	+ 29 53	6.28	K0	K1	− 23.9	0.4	4	20-24	0.7	
203857	19.7	+ 36 55	6.59	K5	K5	− 01.4	0.6	4	20-23	0.9	
203886	21 19.9	+ 24 06	6.42	K0	K0	− 22.8	0.3	4	18-23	0.5	
204445	23.5	+ 07 46	6.66	Ma	M2	− 04.1	0.5	4	13-20	0.9	
204560	24.3	+ 17 29	6.36	K5	K3	− 11.1	0.9	4	17-22	1.1	
204585	24.5	+ 21 45	6.18	Mb	M3	− 20.5	0.6	4	18-22	0.9	
204599	24.6	+ 59 19	6.44	Ma	M2	− 14.4	0.2	4	18-21	0.9	
205314	21 29.4	+ 49 30	5.76	A0	A0n	Var.		5	2-4	2.9	H
205349	29.6	+ 45 25	6.56	K2	K2	− 04.2	0.6	4	15-25	0.9	
205688	31.9	+ 29 37	6.47	K0	G8	− 18.7	0.7	4	20-23	0.7	
205924	33.5	+ 05 19	5.80	F0	F0n	− 21.0	2.8	5	2-7	6.5	*
206040	34.3	+ 53 36	6.20	G5	G8	+ 02.5	0.7	4	15-26	0.8	
206509	21 37.4	+ 54 25	6.16	K0	K0	+ 05.1	0.3	4	19-24	0.8	
206632	38.3	+ 45 18	6.47	Mb	M4	+ 10.3	0.4	4	14-23	1.1	
206731	39.0	+ 49 08	6.12	K0	G5	− 03.5	1.3	4	21-23	0.7	*10
207088	41.5	+ 35 24	6.60	K0	G6	− 04.0	0.7	4	18-22	0.8	
207223	42.3	+ 16 44	6.24	F0	F2	− 19.7	0.8	4	16-28	1.1	
207446	21 43.9	+ 36 06	6.60	K5	K5	− 29.5	0.6	4	16-24	0.9	
207636	45.3	+ 69 41	6.42	A0	A0n	− 03.2	2.3	4	3-4	5.5	*
208110	48.9	+ 06 23	6.58	G0	G0	− 09.8	0.1	4	16-21	0.8	
208527	51.7	+ 20 48	6.62	K5	K5	+ 03.5	1.7	5	7-22	2.0	
208606	52.3	+ 61 04	6.22	K5	K0g	Var.		5	19-26	0.7	H
209112	21 55.9	+ 62 13	6.16	Mb	M2	− 14.5	0.6	4	16-23	0.9	
209258	56.9	+ 74 31	6.64	K5	K5	− 15.1	1.5	4	20-24	0.9	*10
210502	22 05.7	+ 11 08	5.92	K5	K5	+ 21.7	1.3	5	11-21	2.1	S
210905	08.5	+ 58 34	6.52	K0	K0	− 27.3	0.8	4	19-26	0.6	
211029	09.3	+ 62 48	6.06	Ma	M3	− 12.3	1.1	4	12-23	1.0	
212047	22 16.4	+ 26 26	6.50	Ma	M3	− 04.8	1.4	4	13-20	1.2	
212150	17.1	+ 76 00	6.56	A0	A0n	− 18.7	2.1	4	3-4	2.5	
212988	23.2	+ 31 20	6.26	K2	K3	+ 01.9	1.0	5	9-22	1.1	
213242	25.0	+ 63 34	6.38	K0	K1	− 25.9	0.4	4	22-24	0.7	
213272	25.2	+ 35 13	6.53	A0	A0n	− 03.1	2.8	4	4-5	3.3	*

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	$\bar{e}$	Ref.
	h m	° ′									
213389	22 25.9	+ 48 51	6.52	K0	K1	Var.		5	17-22	1.0	II
213644	27.9	+ 15 20	6.36	K0	K2	− 26.8	0.6	4	20-24	0.8	
213720	28.4	+ 53 31	6.47	K0	K0	− 13.4	0.7	4	12-22	0.7	
214298	32.1	+ 12 04	6.53	K5	K3	− 18.1	1.5	5	8-20	2.2	
214313	32.2	+ 35 08	6.50	K5	K3	+ 11.0	0.5	4	19-24	0.7	
214710	22 35.0	+ 74 51	6.06	K5	K5	− 05.3	0.8	4	17-25	0.9	
214714	35.0	+ 37 04	6.14	G5	G0g	− 06.5	0.8	4	15-22	0.7	
214878	36.2	+ 53 20	6.10	K0	G8	− 05.7	0.2	4	15-21	0.6	
214979	36.9	+ 30 26	6.48	K5	K5	− 33.0	0.5	4	17-22	0.8	
215030	37.2	+ 41 03	6.07	K0	K0	− 13.0	0.4	4	16-21	0.7	
215159	22 38.2	+ 53 23	6.26	K2	K3	+ 09.6	0.8	4	18-24	0.7	
215518	40.7	+ 51 59	6.66	K2	K5	+ 05.8	0.6	4	20-24	0.9	
215907	43.5	+ 57 57	6.29	A0	A0	− 00.6	1.6	4	4-5	2.5	
215943	43.7	+ 36 52	6.00	K0	G8	− 23.2	1.0	4	17-22	0.7	
216102	45.0	+ 62 24	6.16	K0	K0	− 25.6	0.6	4	19-23	0.5	
216201	22 45.8	+ 18 36	6.50	K0	K0	− 37.6	0.6	4	17-22	0.6	
216756	50.4	+ 36 33	6.00	F2	F3	− 28.0	1.0	5	10-20	0.7	
217019	52.5	+ 03 15	6.43	K2	K0	+ 11.7	0.3	4	19-21	0.7	
217314	54.8	+ 52 06	6.41	K2	K2	+ 28.5	0.4	4	8-20	1.1	
217459	55.7	+ 02 29	5.96	K0	K2	+ 21.4	0.6	4	15-21	0.9	
217673	22 57.3	+ 56 34	6.50	K2	K2	− 04.5	0.5	4	20-21	0.9	
217944	59.2	+ 58 01	6.50	G5	G5	+ 15.8	0.4	4	20-24	0.6	
218103	23 00.2	+ 00 46	6.38	K0	G8	− 11.4	0.4	4	21-23	0.6	
218261	01.5	+ 19 22	6.42	F8	G0	− 01.2	0.9	4	15-24	0.7	
218416	02.8	+ 52 17	6.26	K0	K0	+ 05.7	0.8	4	20-22	0.6	
218560	23 03.9	+ 63 41	6.41	K0	G8	− 27.0	0.8	4	17-20	0.7	
219139	08.5	+ 10 31	5.94	K0	K0	+ 18.0	0.8	4	14-17	1.5	S
219310	09.7	+ 23 34	6.49	K0	K1	− 25.8	0.1	4	19-22	0.9	
219485	11.0	+ 73 41	5.74	A0	A0	− 03.8	0.9	4	6-10	1.5	
220074	15.8	+ 61 26	6.62	K5	K6	− 33.8	0.4	4	19-23	0.8	
220130	23 16.2	+ 61 40	6.43	K5	K2	− 22.4	0.9	4	13-23	0.8	
220242	17.1	+ 26 05	6.64	F2	F2	+ 09.0	0.4	4	18-24	0.7	
221113	24.1	+ 22 31	6.45	K0	K0	+ 20.6	0.4	4	19-21	0.6	
221246	25.3	+ 48 36	6.38	K2	K4	+ 07.0	0.5	4	18-20	0.8	
221293	25.8	+ 38 06	6.21	K0	G8	− 08.8	0.6	4	16-21	0.8	

TABLE I—*Continued*

Star H.D.	α (1900)	δ (1900)	Vis. Mag.	Type H.D.	Type D.D.O.	Velocity Km./sec.	P.E.	Plates	Lines	$\bar{e}$	Ref.
	h m	° ′									
221491	23 27.5	+ 34 25	6.55	A0	A0n	+ 10.8	2.7	4	3-4	4.6	*
221661	28.9	+ 44 31	6.28	G5	G6	+ 08.1	0.3	4	12-22	0.7	
221662	28.9	+ 20 18	6.29	Ma	M1	+ 06.7	0.3	4	17-23	1.0	
221776	29.9	+ 37 29	6.34	K5	K5	− 10.9	0.8	4	8-20	1.4	
221861	30.6	+ 71 05	6.13	K0	K0g	− 02.4	0.5	4	19-26	0.7	
221905	23 30.9	+ 24 01	6.60	Ma	M1	− 10.6	0.8	5	14-19	1.1	
222618	37.1	+ 56 43	6.33	G5	G8	− 08.1	0.2	4	22-25	0.7	
222670	37.6	+ 63 58	6.85	Ma	M2	− 01.7	0.9	4	9-22	0.9	
222682	37.7	+ 61 07	6.54	K2	K2	− 14.5	0.4	4	21-23	0.6	
224128	50.3	+ 25 24	6.67	K5	K5	− 13.3	0.6	4	15-23	1.0	
224303	23 51.6	+ 22 05	6.30	Ma	M0	+ 01.8	0.6	4	10-22	1.2	
224309	51.7	+ 82 38	6.42	A0	A2n	− 13.9	1.0	4	4-5	5.5	
224784	55.5	+ 59 01	6.37	K0	G6	− 32.2	0.5	4	18-24	0.6	
224870	56.3	+ 49 25	6.36	K0	G5	− 19.1	0.2	4	16-23	0.7	
225136	23 58.7	+ 66 09	6.62	Ma	M3	+ 17.6	0.6	4	11-19	1.0	
225276	59.8	+ 26 06	6.52	K2	K2	− 03.6	0.8	4	19-23	0.7	

Notes to Table I

H.D.	
6480 -	This star with H.D. 6479 forms a wide double. The brighter companion has a velocity of -9 km. The two stars have a common proper motion.
8949 -	There is a faint companion, separation 70″, B.D.S. 770.
11037 -	All the plates but one are taken with the 12½-inch camera.
15253 -	Brighter component of double star A.D.S. 1878, separation 2″.6.
16458 -	λ4554, Ba +, is very strong in this star—stronger than in an ordinary star of type M7, and almost as strong as in 19 Piscium, type N. The absolute magnitude line-ratios have not yet been determined for plates taken with our spectrograph but using the curves determined for the one-prism at Victoria, which is nearly the same dispersion, the absolute magnitude is $-3.5\pm$. In all the plates obtained of K-type stars here no other star of this type has λ4554 nearly so strong.
17378 -	Harvard gives the spectrum as composite A-F. There does not seem to be any evidence of composite spectrum on our plates. The α Cygni lines are very strong.
26923 -	Brighter star of a wide double A.D.S. 3085, separation 65″.
28736 -	This star belongs to the Taurus cluster.
32039 -	This and the next star form a wide double, the components of which have a common proper motion. H.D. 32040 may be variable but the range is too small considering the character of the lines to make this definite. The mean velocity of the 8 plates for the two stars is $+36$ km. $\pm$.
34533 -	This is the brighter component of a wide double A.D.S. 3903, separation 23″. The spectrum is composite.
35295 -	The brighter component of a wide double A.D.S. 4000, separation 31″.
36041 -	The brighter component of a wide double B.D.S. 2757, separation 75″.
59878 -	Brighter component of double star A.D.S. 6160, separation 11″.
65448 -	Brighter component of wide double B.D.S. 4359, separation 47″.
82685 -	Brighter component of double star A.D.S. 7446, separation 5″.
82780 -	Brightest star of three forming a wide triple A.D.S. 7438.
118741 -	This star is double, A.D.S. 8976, separation 1″.9, magnitudes 6.4-7.9; not always resolved on the slit.
127043 -	This star forms with H.D. 127067 a wide double. The velocities of the two stars seem to be equal.
127334 -	All plates but one taken with 12½-inch camera.
157978-9	The spectrum is composite, types about A0-G; two stars not seen on slit.
174569 -	Brighter component of A.D.S. 11750, separation 4″.
197812 -	Variable, mag. 6.4-7.5.
203358 -	Double star A.D.S. 14889, separation 1″.8; not always resolved on slit.

TABLE II

Star H.D.	J.D.242.... or 243....	Vel. Km./sec.	P.E.	Lines	M	Remarks
15138	0575.886	− 59.3	2.6	7	N	The components are
$02^h\ 21^m.2$		+ 56.0	3.2	7		about equal.
+ 50° 07′	0672.565	− 02.0	1.8	15	N	Velocity of system
6.27 F2	1008.791	+ 41.1	1.2	6	Y	− 4 km. ±
		− 49.1	3.4	6		
	1093.560	− 09.2	1.5	5	Y	
21018	0707.661	− 03.0	0.7	21	No	
$03^h\ 18^m.4$	1004.810	− 04.9	0.7	23	Y	
+ 04° 31′	1106.563	+ 11.4	1.1	17	F	
6.47 F8		+ 12.6	0.9	21	No	
	1329.892	− 00.5	0.7	20	N	
	1357.807	+ 07.3	0.8	22	F	
23626	0615.857	+ 05.3	0.9	17	F	
$03^h\ 41^m.5$	0701.620	+ 00.8	0.6	18	Y	
+ 31° 54′	1076.625	− 17.5	0.7	12	Y	
6.23 F6		− 17.1	1.2	18	Ma	
	1127.517	− 06.1	0.8	21	N	
29104	0640.762	− 33.8	1.4	11	Y	The components are
$04^h\ 29^m.8$		+ 75.8	2.2	7		very unequal which
+ 19° 41′	1072.665	− 23.4	1.5	4	Y	may account for the
6.56 F8	1092.650	− 26.2	0.9	19	Y	discordant velocities
	1367.769	+ 15.2	1.0	6	N	obtained when the
		− 73.6	1.4	6		lines are single.
	1391.713	+ 14.5	0.7	18	N	
	1395.695	+ 01.1	0.8	15	N	
	1396.735	+ 17.7	1.5	11	N	
	1397.788	+ 07.3	1.5	13	N	
33541	0758.615	− 02.4	1.9	7	Y	Few sharp lines. On
$05^h\ 05^m.9$	1006.910	+ 03.8	4.4	4	F	the last plate K and
+ 73° 09′	1356.876	− 00.3	3.1	6	Y	Hδ are double giving
5.76 A0	1402.744	− 04.4	1.7	5	Y	velocities − 45.8 km.
						and + 28.8 km.
34053	1076.694	− 22.8	3.4	4	Y	Fair hydrogen and
$05^h\ 09^m.5$	1094.680	+ 01.2	5.3	6	F	calcium K.
+ 22° 10′	1357.933	+ 14.4	1.9	4	Y	Some other faint lines.
6.16 A2	1418.783	− 27.1	2.3	5	F	

TABLE II—*Continued*

Star H.D.	J.D.242.... or 243....	Vel. Km./sec.	P.E.	Lines	M	Remarks
40084	1023.896	− 03.7	0.8	21	Y	On the last plate the
05^h $51^m.6$	1160.552	− 05.4	1.0	20	N	lines are double but
+ 49° 55′	1386.824	− 02.0	0.7	21	Y	resolved in the violet
6.07 G5	1419.753	− 27.7	2.3	3	N	only.
		+ 47.3	3.3	3		
40372	0726.697	+ 18.7	1.4	24	No	
05^h $53^m.2$	1113.641	− 04.8	1.0	16	Y	
+ 01° 49′	1377.861	+ 101.3	1.0	22	Y	
6.06 A5	1427.787	+ 62.5	1.6	18	N	
47415	0685.792	+ 20.0	1.1	24	No	The lines are double on
06^h $33^m.4$	1029.902	+ 65.0	1.1	7	Y	the last three plates.
+ 24° 41′		− 28.3	2.3	6		In each case the first
6.48 F8	1385.853	− 10.3	0.6	8	Y	velocity refers to the
		+ 86.5	2.0	5		stronger component.
	1446.703	+ 54.0	3.3	3	Y	The last plate is weak.
		− 42.6	1.2	2		
52913	1029.942	− 19.8	2.8	6	Y	Numerous lines of fair
06^h $57^m.9$	1106.715	− 02.8	3.5	8	F	quality only.
+ 09° 17′	1396.873	− 25.8	1.5	11	Y	
5.93 A2	1452.769	+ 02.5	3.2	9	N	
65299	1114.700	− 24.6	1.8	8	Y	Good lines.
07^h $53^m.0$	1302.707	− 05.7	1.5	12	No	
+ 84° 21′	1339.591	+ 11.3	1.5	15	F	
6.39 A0	1363.532	+ 08.6	1.2	15	N	
72208	0731.806	− 00.2	7.2	3	Y	
08^h $26^m.5$	0837.549	+ 08.4	9.8	4	F	
+ 10° 09′	1168.640	− 41.0	4.1	5	N	
6.58 A0	1427.906	+ 36.3	2.0	7	Y	
	1527.626	+ 34.7	2.9	5	N	
72359	0731.840	+ 20.9	2.6	8	Y	Good lines.
08^h $27^m.3$		+ 24.3	3.5	8	Y	
+ 10° 26′	1087.810	− 04.8	1.9	11	N	
6.30 A0	1396.959	+ 07.2	1.3	12	Y	
	1518.659	− 09.6	1.3	13	F	

TABLE II—*Continued*

Star H.D.	J.D.242.... or 243....	Vel. Km./sec.	P.E.	Lines	M	Remarks
81025	0463.585	− 02.0	1.2	22	F	
09ʰ 18ᵐ.1	0805.662	− 15.8	0.7	24	No	
+ 52° 01′	1155.694	− 38.4	0.7	21	Y	
6.37 G0	1198.641	− 06.2	0.7	21	N	
82780	0474.559	− 23.0	2.2	8	Y	The second plate is weak.
09ʰ 29ᵐ.1	0796.704	+ 11.5	3.8	9	F	
+ 40° 24′		+ 24.3	2.9	12	No	
6.56 F2	0849.567	− 35.7	1.4	20	No	
	1199.610	− 132.7	1.7	15	N	
99967	0797.752	+ 51.1	0.8	20	Y	An orbit is being computed for this star.
11ʰ 25ᵐ.0	0832.691	+ 13.8	0.6	22	N	
+ 47° 12′	0849.611	+ 00.6	0.7	24	N	
6.49 K0	0859.583	+ 24.2	0.8	22	N	
107904	0444.733	− 24.7	4.3	10	N	
12ʰ 18ᵐ.9	0473.658	− 11.4	2.9	23	No	
+ 43° 05′	0797.794	− 05.0	2.3	17	Y	
5.98 F2n	1171.744	+ 04.2	3.5	13	F	
108651	0461.683	− 05.2	1.1	22	N	Good lines.
12ʰ 23ᵐ.8	0473.681	− 16.4	0.9	22	F	
+ 26° 27′	0478.653	− 14.6	1.3	17	Y	
6.69 A2	1191.692	+ 09.3	0.7	21	Y	
112486	0451.731	− 01.8	1.9	11	Y	Components about equal in intensity.
12ʰ 51ᵐ.9	0753.910	− 01.7	0.9	23	No	
+ 54° 39′	0858.646	− 36.0	3.1	8	N	
5.84 A2		+ 45.1	2.5	8		
	1210.683	− 37.7	2.1	6	N	
		+ 35.2	0.7	6		
115709	0787.849	+ 25.1	2.3	14	N	
13ʰ 13ᵐ.8	0809.787	− 06.5	2.6	9	Y	
+ 04° 13′	0846.656	+ 20.1	1.9	14	No	
6.56 A0	1200.703	− 13.2	2.2	14	Y	

TABLE II—*Continued*

Star H.D.	J.D.242.... or 243....	Vel. Km./sec.	P.E.	Lines	M	Remarks
120874	0135.682	− 58.3	2.2	11	F	The lines are poor but
$13^h\ 47^m.1$		− 47.5	4.3	16	N	the last plate seems to
+ 59° 02′	0141.624	− 33.9	2.1	13	No	establish the varia-
6.36 A0	0878.650	− 60.2	2.9	8	F	bility.
	1235.664	− 43.8	6.2	3	Y	
	1252.583	− 03.9	2.4	6	F	
		− 09.9	2.1	8	No	
157978-9	9780.705	− 17.2	7.9	6	B	The spectrum is com-
$17^h\ 21^m.5$	9790.709	+ 05.0	2.7	20	B	posite. The measures
+ 07° 41′		+ 04.6	2.8	15	No	refer to the G type
5.98 A0-G	9803.643	+ 00.7	3.2	10	Y	lines. Only K shows
	0066.944	− 15.0	4.5	8	B	the A type definitely.
	0083.927	− 04.5	3.5	9	Y	
	1314.574	− 03.5	1.4	16	N	
161832	0597.546	− 39.9	1.0	20	No	
$17^h\ 42^m.7$		− 38.3	1.2	21	No	
+ 39° 22′	0873.794	− 20.5	1.2	20	N	
6.56 K3		− 21.3	1.5	17	F	
	0980.530	− 29.6	0.7	19	Y	
	1286.676	− 36.0	1.0	16	No	
163840	0603.568	− 26.5	0.8	23	F	
$17^h\ 53^m.2$		− 25.8	0.6	21	No	
+ 24° 01′	0885.812	− 34.1	0.8	21	F	
6.36 G0	0963.542	− 43.9	0.6	22	No	
		− 43.5	0.5	24	N	
	1282.642	− 32.4	0.4	22	No	
	1305.569	− 36.4	0.8	21	No	
	1309.778	− 33.3	1.0	16	No	
170829	0574.662	− 65.0	0.7	27	N	
$18^h\ 26^m.4$	0624.534	− 73.0	0.7	26	No	
+ 20° 46′	0951.593	− 48.8	0.6	20	N	
6.59 G8	0996.508	− 63.5	1.5	16	F	

TABLE II—*Continued*

Star H.D.	J.D.242.... or 243....	Vel. Km./sec.	P.E.	Lines	M	Remarks
172569	9757.811	− 06.3	2.4	16	N	
18ʰ 35ᵐ.9	9828.646	− 14.5	1.8	18	B	
+ 65° 24′	0075.941	− 26.6	3.4	14	B	
6.00 A3		− 32.1	5.3	9	F	
		− 32.2	2.5	14	No	
	1264.777	− 18.8	2.1	12	No	
173383	0576.656	− 24.1	1.3	22	No	
18ʰ 39ᵐ.9	0902.807	− 42.2	2.5	16	F	
+ 39° 13′	0955.628	− 33.1	0.8	24	N	
6.55 K5	0998.500	− 30.9	1.1	18	Y	
174369	0602.594	− 04.5	5.6	7	N	The lines are poor.
18ʰ 45ᵐ.1	0616.748	+ 23.6	4.1	5	Y	
+ 24° 56′	0809.928	+ 10.0	5.4	9	No	
6.56 A2n	1003.986	− 45.4	3.3	7	F	
		− 54.1	3.0	5	F	
	1314.619	− 26.6	2.8	7	F	
175743	9408.854	+ 51.4	1.0	22	T	
18ʰ 51ᵐ.7	9419.787	+ 54.3	0.9	23	T	
+ 17° 59′	9466.713	+ 26.8	3.6	9	No	
5.72 K2		+ 27.1	3.9	6	K	
	9540.497	+ 45.2	1.8	21	B	
	1314.637	+ 46.7	0.9	19	N	
179094	0987.585	+ 15.6	0.6	21	No	An orbit has been completed for this star. H and K show as emission lines.
19ʰ 06ᵐ.1	1008.496	− 33.0	0.6	23	Y	
+ 52° 16′	1027.469	+ 15.5	0.5	24	Y	
5.93 G8	1040.451	− 17.3	0.7	24	Y	
190658	0607.638	− 114.8	1.1	16	Y	The velocity is very large, but shows about 17 km. range.
20ʰ 00ᵐ.9	0931.759	− 106.3	1.1	20	No	
+ 15° 13′	1012.528	− 118.6	0.9	16	K	
6.56 M1	1317.674	− 101.8	1.2	18	N	
197508	0643.548	+ 04.4	0.5	22	Y	Very good lines.
20ʰ 39ᵐ.1	0959.684	+ 15.6	0.9	22	N	
+ 83° 17′	1019.533	+ 08.1	0.5	21	F	
6.16 A2	1322.590	+ 18.0	0.8	16	Y	

TABLE II—*Continued*

Star H.D.	J.D.242.... or 243....	Vel. Km./sec.	P.E.	Lines	M	Remarks
199095	0564.797	− 26.6	1.7	4	Y	
$20^h\ 49^m.8$	0643.566	− 53.4	1.8	6	Y	
+ 82° 10′	1019.542	+ 01.4	1.8	4	F	
5.69 A0	1019.546	− 01.2	1.0	7	Y	
205314	0579.768	− 03.1	1.2	2	Y	Very poor lines, poorer than the P.E. indicates and the variability is not well established.
$21^h\ 29^m.4$	0958.699	− 43.9	4.5	4	Y	
+ 49° 30′	0996.617	− 74.8	2.7	2	N	
5.76 A0n	1010.574	− 21.4	4.4	3	F	
	1315.769	− 21.3	1.6	3	Y	
208606	0608.708	− 28.2	0.4	19	No	
$21^h\ 52.^m3$	0937.830	− 37.1	0.7	23	N	
+ 61° 04′	0962.730	− 24.0	0.9	20	Y	
6.22 K0g	1040.514	− 27.9	0.9	24	F	
	1001.633	− 40.4	0.8	26	K	
213389	0576.784	− 34.5	0.9	17	F	
$22^h\ 25^m.9$	0914.844	− 30.8	1.0	22	A	
+ 48° 51′	0973.762	+ 19.3	1.4	17	Y	
6.52 K1	0989.655	− 05.2	1.2	18	Y	
	1010.635	+ 31.2	0.6	22	F	

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LIGHT CURVES OF THE VARIABLE STARS IN THE GLOBULAR CLUSTER NGC 5466

BY

HELEN B. SAWYER

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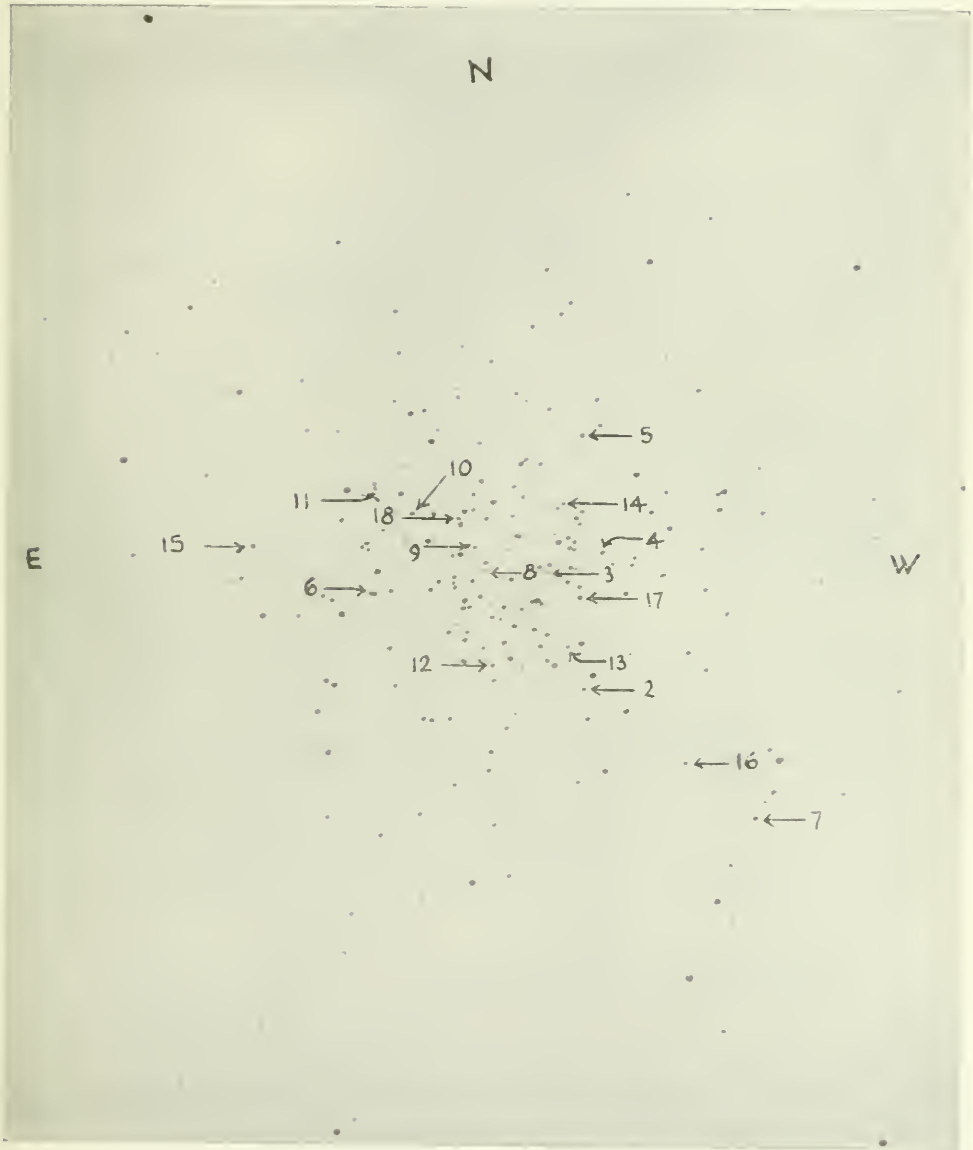
PLATE XXXI



The cluster NGC 5466, with variables marked. Enlarged from D.D.O. plate 7857, 1942, June 8, exp. 20^{m}. Scale, 1 mm = $6''.6$.

LIGHT CURVES OF THE VARIABLE STARS IN THE GLOBULAR CLUSTER NGC 5466

By Helen B. Sawyer

(with Plate xxxi)

THE globular cluster NGC 5466 is a loose cluster of low absolute magnitude lying in very high galactic latitude. It closely resembles the cluster NGC 5053 which is relatively close to it in the sky. It is well situated for observation from the northern hemisphere, since its R.A. is $14^h\ 03^m.2$ and Dec. $+ 28° 56'$ (1950). It has a galactic longitude of 8°, and latitude of $+ 72°$.

In 1926 Baade[1] announced the discovery of fourteen variable stars in this cluster. From the similarity of their magnitudes and the general trend of the light changes, he concluded they were all cluster type variables. On the basis of a median magnitude of 16.17 for these variables, he derived the distance of the cluster as 19,000 parsecs. This distance was reduced in 1929[2] to 17,000 parsecs by the zero point correction for absolute magnitude of Cepheid variables.

The distance of 17,000 parsecs is still accepted in the recent revision by Shapley[3] of the distances of clusters in high galactic latitudes. From the survey of nebulae in the field it appears that this cluster lies in a region rich in galaxies, and Shapley has therefore applied no correction for absorption. The colour class determined by Stebbins and Whitford is f8, with a colour excess of $+ 0.05$. Because of its high galactic latitude, therefore, this cluster is actually at the very great distance of 16,000 parsecs above the galactic plane, and is one of the few objects which indicates the enormous extent of our galaxy in this direction. It is a cluster of low apparent and absolute magnitude. Its apparent photographic magnitude as determined by Christie[5] with the schraffier kassette is 10.39, giving it an absolute magnitude of only -5.8.

The cluster was put on the observing list of this observatory in 1940, in order that enough plates might be acquired to permit the determination of the periods of Baade's variables. A total of 58 plates has been taken by the writer, who is indebted for instrumental

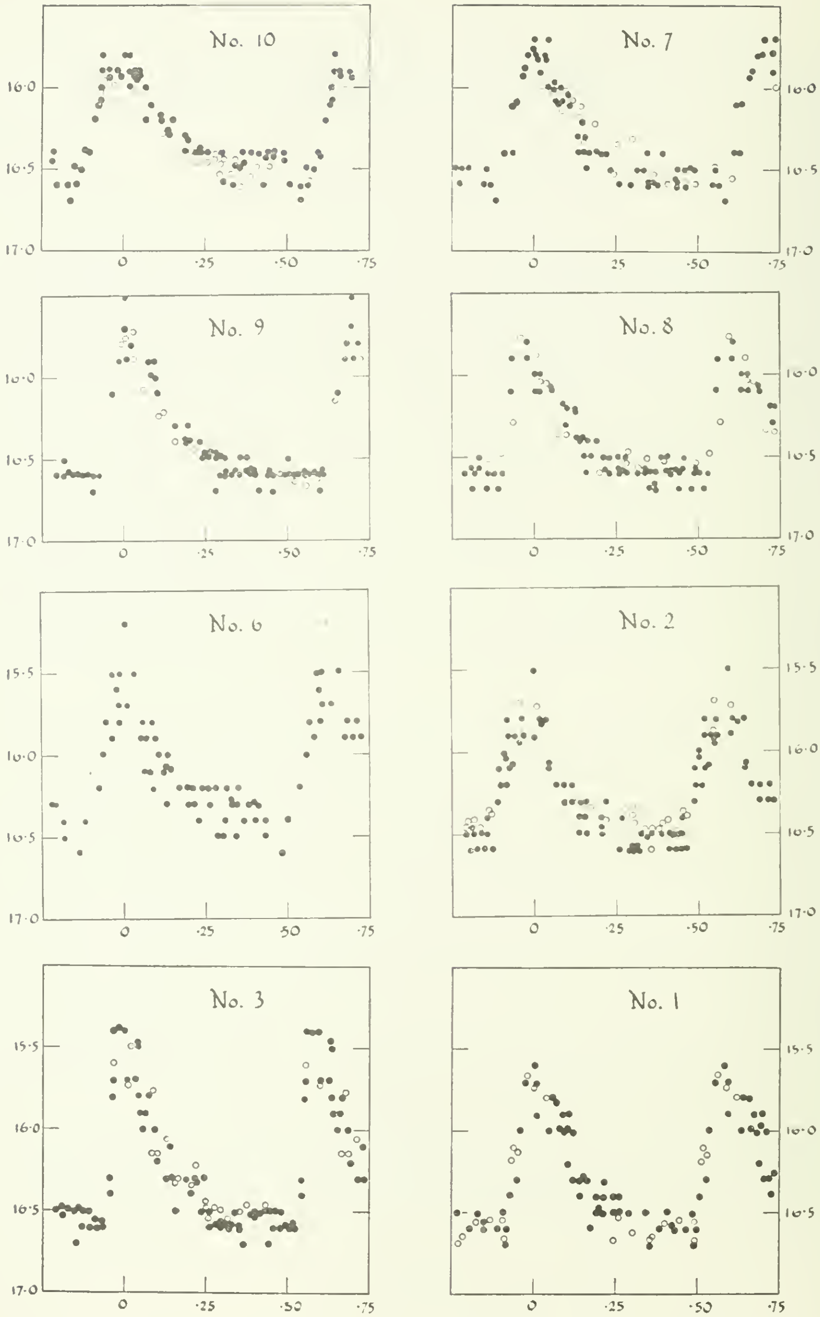


Fig. 1. Light curves of variables with periods between 0.7 day and 0.57 day.

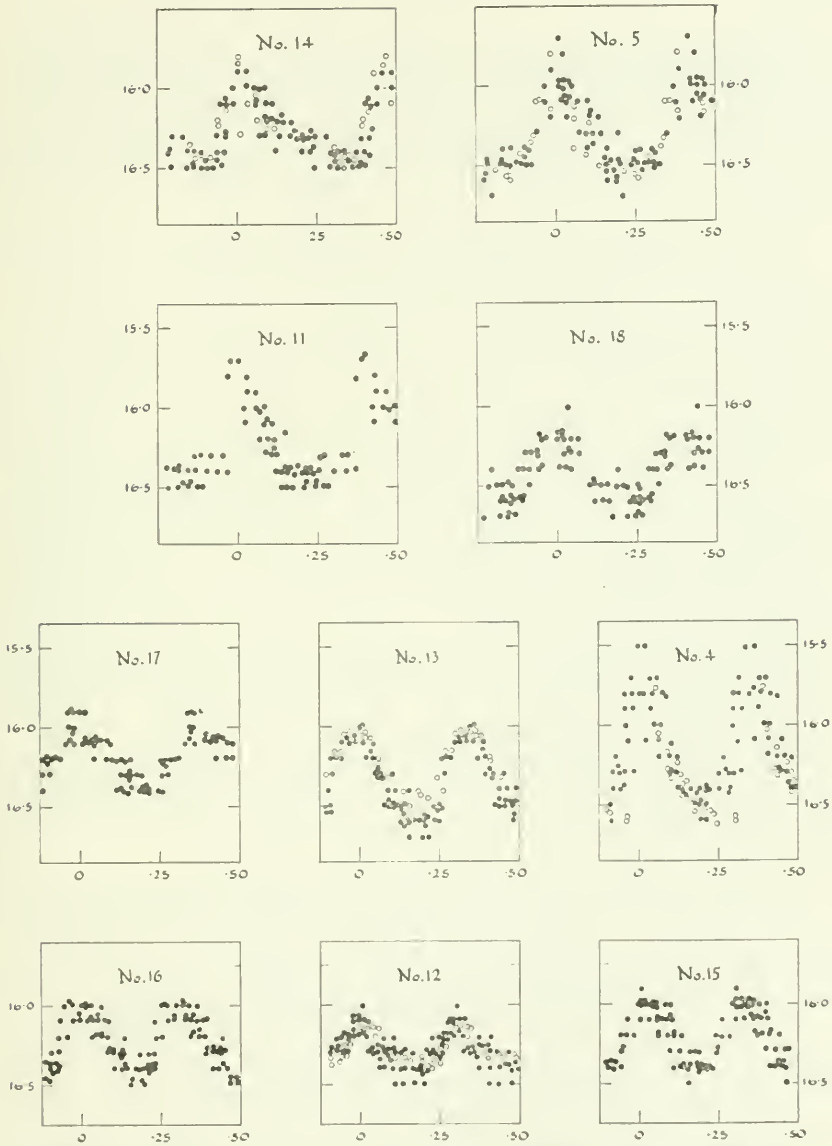


Fig. 2. Light curves of variables with periods between 0.44 and 0.28 day. Baade's observations are represented by open circles, Sawyer's, by dots.

assistance especially to Dr. F. S. Hogg, and to Mr. G. Longworth, Miss Ruth Northcott, Mr. D. K. Norris and Mr. W. S. Armstrong.

About a dozen pairs of these plates have been systematically examined with the blink microscope and four new variables discovered. These all have small ranges of only half a magnitude. The positions of the new variables on the same co-ordinate basis as those found by Baade are given in the remarks to Table I.

Baade published a drawing of the cluster for identification of his variables. Plate XXXI shows a print of this cluster from a David Dunlap plate, on which Sawyer's four new variables are marked, and all of Baade's except No. 1 which is too far from the cluster centre to show. All of the variables except No. 1 are included in the catalogue of 241 stars of this cluster published by Hopmann,[6] which he later[7] compared with the Hamburg positions.

All of the variables were estimated on the David Dunlap plates with the use of the magnitude sequence as determined by Baade. Because of the relative sparseness of stars, magnitude estimates in this cluster possess a greater degree of reliability than in the more compact clusters.

The 58 plates from this observatory, along with the 21 observations published by Baade for most of his variables, have permitted the determination of periods for all of the 18 variables. For six variables there are no observations by Baade available. Four of these are the new variables found by the writer. The other two are close double stars, on which Baade could make no reliable estimates from the Hamburg plates. These periods are therefore not so well determined as for most of the other twelve variables.

Table I gives the elements of the variables, including the number in Hopmann's catalogue, the maximum and minimum magnitudes, the mean, an epoch of a well observed maximum, and the period. Remarks on a few individual stars follow the table.

Table II gives the observations of these eighteen variables from the David Dunlap plates, with the phase expressed in thousandths of a day as computed on the basis of the assigned period.

The light curves for all of these stars are shown in Figures 1 and 2, where the stars are arranged in order of decreasing period length. The light curves are of an ordinary type. The interval between Baade's plates and the writer's is only twenty years, but there is not much suggestion of period change. For one or two variables the two series of observations might be best represented by slightly different periods, but in general the periods appear very constant. No long-period Cepheids have been found in this cluster. The mean magni-

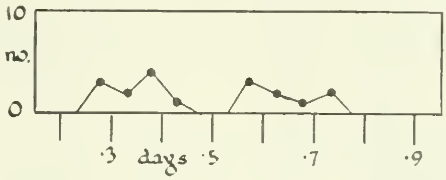


Fig. 3. Frequency of periods in NGC 5466.

tude of the eighteen variables is 16·17, the same as determined by Baade for eleven variables nineteen years ago.

On the basis of period frequency, NGC 5466 belongs to the double maximum type of cluster to which the writer[8] has recently called attention. Figure 3 gives a diagram of the period frequency in this cluster. The periods are collected in groups of 0.05 day; the ordinate represents the number of variables having periods in the interval indicated by the abscissa. There appear to be no periods close to half a day in this cluster; the periods fall around two-thirds of a day and one-third of a day. In NGC 5466, the gap in which no periods have been found amounts to 0.13 day. It will be important to discover the reason behind such a frequency distribution of period lengths.

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(4) Stebbins and Whitford, *Mt. W. Cont.*, no. 547, 1936.
(5) Christie, *Mt. W. Cont.*, no. 620, 1939.
(6) Hopmann, *A.N.*, v. 217, p. 333, 1922.
(7) Hopmann, *A.N.*, v. 229, p. 209, 1927.
(8) Sawyer, *J.R.A.S.C.*, v. 37, pp. 295-302 (*Comm. D.D.O.* no. 11), 1944.

Richmond Hill, Ontario,
April 25, 1945.

TABLE I

ELEMENTS OF THE VARIABLE STARS IN NGC 5466

Var. No.	Hopmann	Magnitudes Max.	Min.	Mean	Epoch Julian Day	Period
1	—	15.6	16.7	16.15	30553.674	0.577415
2	64	15.5	16.6	16.05	30554.720	0.588523
3	95	15.4	16.7	16.05	30550.623	0.578065
4	56	15.5	16.6	16.05	30556.602	0.337968
5	61	15.7	16.7	16.20	20519.697	0.380519
6	202	15.2	16.6	15.90	39786.653	0.62096
7	20	15.7	16.7	16.20	30519.697	0.703423
8	141	15.8	16.7	16.25	30520.617	0.629120
9	148	15.5	16.7	16.10	30170.656	0.685027
10	186	15.8	16.7	16.25	30519.697	0.709273
11	198	15.7	16.7	16.20	30884.625	0.37799
12	134	16.0	16.5	16.25	30880.665	0.2942387
13	83	16.0	16.7	16.35	30556.702	0.341557
14	84	15.8	16.5	16.15	30880.599	0.440041
15	227	15.9	16.5	16.20	30519.618	0.28672
16	37	16.0	16.5	16.25	30553.612	0.29667
17	68	15.9	16.4	16.15	30519.713	0.370117
18	166	16.0	16.7	16.35	30519.697	0.37406

REMARKS TO TABLE I

1. This star is very near the edge of the plates, and measures have considerable uncertainty.

4. The large range and steepness of the curve strongly suggest that the period of this star might lie close to half a day. But the writer has not been able to satisfy the existing observations with a related period around 0.51 day.

5. Baade's observations from plates 3475 and 3476 are not plotted as they seem inconsistent with the others.

6. The variable is one component of a close double and no measures are published by Baade.

11. This star is also one component of a double, and Baade could not derive reliable measures from his plates. The related period of 0.60668 day satisfies the observations nearly as well as the period published, but with slightly larger scatter.

12. Baade's observation from plate 3476 is inconsistent and not plotted.

13. Baade's observation from plate 3476 is omitted from plot.

15. x″, + 223; y″, + 20.

16. x″, − 149; y″, − 175.

17. x″, − 60; y″, − 30.

18. x″, + 44; y″, + 41.

TABLE II—Observations of Variable Stars

Plate	Julian Day	No. 1		No. 2		No. 3		No. 4		No. 5		No. 6	
		Mag.	Phase	Mag.	Phase	Mag.	Phase	Mag.	Phase	Mag.	Phase	Mag.	Phase
5697	29785.670	16.0	535	16.2	150	16.5	405	16.4	311	16.0	373	16.2	259
5709	86.653	16.7	364	15.9	544	16.3	232	16.3	280	16.7	214	15.2	000
5806	813.632	16.5	204	16.5	451	15.5	042	16.4	222	16.5	176	16.2	278
5818	14.631	16.0	048	16.4	273	16.6	463	16.6	207	16.2	034	15.5	035
5833	15.628	16.6	468	16.3	093	16.6	304	16.6	190	16.5	270	16.3	411
6845	30170.656	—	386	16.3	212	16.5	400	16.4	013	—	275	—	250
6856	71.630	16.5	205	16.1	038	16.3	218	15.8	312	16.4	107	15.6	603
6873	72.700	16.3	120	16.1	520	16.3	132	16.1	030	16.1	036	16.5	431
7853	519.618	15.7	011	16.5	209	16.4	211	16.4	192	16.5	302	16.4	232
7857	.697	15.9	090	16.6	288	16.6	290	16.2	271	15.7	000	16.4	311
7858	.713	15.9	106	16.6	304	16.6	306	16.0	287	15.8	016	16.3	327
7859	.728	16.0	121	16.6	319	16.6	321	15.8	302	16.0	031	16.5	342
7868	20.617	16.6	433	15.8	031	16.0	053	16.5	178	16.5	159	15.7	610
7872	.710	16.3	526	16.3	124	16.3	146	16.3	271	16.5	252	15.8	082
7936	50.623	16.5	413	16.1	023	15.4	000	16.3	104	16.3	104	16.2	189
7953	53.612	16.4	515	16.2	069	16.2	099	16.0	052	16.1	049	16.1	073
7958	.674	15.6	000	16.5	131	16.5	161	16.3	104	16.2	111	16.3	135
7973	54.640	—	389	15.9	509	16.4	549	16.2	066	16.5	316	16.6	480
7978	.720	—	469	15.5	000	15.9	051	16.4	146	16.2	396	16.0	560
7987	55.608	—	202	16.6	299	16.6	360	15.8	020	16.3	142	—	207
7991	.652	—	246	16.5	343	16.5	404	16.0	064	16.3	186	16.2	251
7995	.720	—	314	16.5	411	16.5	472	16.4	132	16.4	254	16.2	319
8006	56.602	—	041	16.3	116	16.3	198	15.5	000	15.9	375	15.9	580
8009	.626	—	065	16.3	140	16.3	222	15.5	024	16.0	019	15.8	604
8011	.645	—	084	16.3	159	16.5	241	15.8	043	16.0	038	15.7	002
8016	.702	—	141	16.5	216	16.6	298	16.2	100	16.1	095	15.8	059
8017	.710	—	149	16.4	224	16.6	306	16.3	108	16.2	103	15.9	067
8802	880.599	16.2	108	16.6	426	16.6	479	16.5	224	16.6	171	16.4	435
8805	.627	16.3	136	16.4	451	16.6	507	16.3	252	16.6	199	—	463
8808	.665	16.6	174	16.1	492	16.3	545	15.9	290	16.5	237	16.4	501

TABLE II—*Continued*—OBSERVATIONS OF VARIABLE STARS

Plate	Julian Day	No. 1		No. 2		No. 3		No. 4		No. 5		No. 6	
		Mag.	Phase	Mag.	Phase	Mag.	Phase	Mag.	Phase	Mag.	Phase	Mag.	Phase
8811	30880.694	16.5	203	15.8	521	15.4	574	15.7	319	16.5	266	16.2	530
8814	.732	16.4	241	15.8	559	15.5	044	16.1	019	16.4	304	—	568
8828	83.599	16.3	221	16.2	483	15.7	011	16.5	182	16.2	127	16.3	331
8831	.635	16.4	257	15.9	519	15.8	047	16.4	218	16.4	163	16.4	367
8834	.672	16.5	294	15.9	556	15.8	084	16.4	255	16.5	200	16.4	404
8837	84.625	16.0	092	16.5	332	16.5	458	16.5	194	16.0	011	16.0	115
8840	.653	16.0	120	16.5	360	16.5	486	16.5	222	16.2	039	16.0	143
8843	.685	16.3	152	16.5	392	16.6	518	16.5	254	16.3	071	16.2	175
8847	.726	16.4	193	16.5	433	15.9	558	16.4	295	16.3	112	16.3	216
8852	.775	16.5	242	16.3	482	15.7	030	15.8	006	16.5	161	16.3	265
8854	.800	16.5	267	16.0	507	15.9	055	15.9	031	16.6	186	16.5	290
8888	99.610	15.8	064	15.8	016	16.5	414	16.1	308	16.5	156	16.2	197
8890	.630	16.0	084	15.8	036	16.5	434	15.9	328	16.5	176	16.2	217
8899	.715	16.3	169	16.2	121	16.6	519	15.8	075	16.4	261	16.5	302
8903	.762	16.4	216	16.5	168	15.7	566	16.2	122	16.5	308	16.3	349
8913	900.608	16.5	485	16.6	425	16.5	256	16.4	293	16.1	012	15.8	574
8915	.624	16.6	501	16.6	441	16.6	272	16.3	309	16.0	028	15.5	590
8923	.710	15.9	010	16.1	527	16.6	358	15.7	057	16.4	114	15.9	055
8937	01.656	—	378	16.6	296	16.1	148	16.3	327	16.4	299	16.3	380
9026	33.642	—	029	16.0	502	16.5	340	16.5	206	16.5	322	16.1	076
9031	.694	—	081	15.9	554	16.5	392	16.6	258	16.1	374	16.1	128
10101	1257.690	16.4	147	16.6	274	16.0	094	16.4	142	16.5	169	15.5	604
10110	58.678	15.7	558	16.2	081	16.6	503	16.1	116	16.0	015	16.2	350
10115	.732	15.8	034	16.4	138	15.8	557	16.4	170	16.1	069	16.3	404
10123	59.619	16.5	344	16.5	437	16.6	288	15.7	044	16.4	195	15.9	049
10128	.656	16.6	381	16.6	474	16.6	325	15.8	081	16.5	232	16.1	086
10132	.702	16.6	427	16.2	520	16.7	371	16.2	127	16.5	278	16.1	132
10137	.772	16.7	497	15.9	001	16.7	441	16.4	197	16.3	348	16.3	202

TABLE II—*Continued*—OBSERVATIONS OF VARIABLE STARS

Plate	Julian Day	No. 7		No. 8		No. 9		No. 10		No. 11		No. 12	
		Mag.	Phase	Mag.	Phase	Mag.	Phase	Mag.	Phase	Mag.	Phase	Mag.	Phase
5697	29785.670	16.4	347	16.6	494	15.8	684	16.2	071	16.7	240	16.3	161
5709	86.653	16.4	626	16.5	219	16.5	297	16.6	344	16.1	089	16.3	262
5806	813.632	16.4	172	16.4	146	16.6	560	16.4	371	16.4	231	16.5	171
5818	14.631	16.6	467	16.7	516	16.4	189	15.9	661	16.3	096	16.1	287
5833	15.628	16.0	057	16.6	255	16.5	501	16.4	239	16.3	337	16.3	107
6845	30170.656	16.4	560	16.5	459	15.7	000	16.1	631	16.0	054	16.1	283
6856	71.630	16.4	127	16.5	175	16.6	289	16.3	186	16.7	272	16.3	080
6873	72.700	16.5	494	15.8	615	15.9	674	16.6	547	16.5	208	16.2	268
7853	0519.618	16.1	624	16.6	259	16.5	284	16.0	630	16.5	131	16.1	278
7857	.697	15.7	000	16.6	338	16.5	363	15.8	000	16.5	210	16.3	063
7858	.713	15.9	016	16.7	354	16.6	379	15.9	016	16.4	226	16.4	079
7859	.728	15.8	031	16.6	369	16.6	393	15.9	031	16.5	241	16.3	094
7868	20.617	16.5	217	16.0	000	16.7	597	16.4	211	15.8	374	16.5	100
7872	.710	16.5	310	16.2	093	15.5	005	16.4	304	16.2	089	16.4	193
7936	50.623	15.8	679	16.7	437	16.7	462	16.6	427	16.5	141	16.3	094
7953	53.612	16.3	151	16.6	281	15.8	026	16.5	579	16.2	106	16.4	140
7958	.674	16.4	213	16.6	343	16.0	088	15.9	641	16.4	168	16.5	202
7973	54.640	16.5	475	16.1	051	16.5	369	16.3	189	15.7	000	16.2	286
7978	.720	16.6	555	16.4	131	16.6	449	16.4	269	16.0	080	16.2	071
7987	55.608	15.7	036	16.5	389	16.1	652	16.5	447	—	212	16.3	077
7991	.652	16.0	080	16.6	433	15.9	011	16.4	491	16.3	256	16.3	121
7995	.720	16.4	148	16.6	501	15.9	079	16.6	559	16.3	324	16.4	189
8006	56.602	16.5	325	16.2	125	16.5	276	15.8	023	16.2	072	16.4	188
8009	.626	16.6	351	16.4	149	16.5	300	15.9	047	16.3	096	16.3	212
8011	.645	16.6	370	16.4	168	16.6	319	16.0	066	16.3	115	16.3	231
8016	.702	16.6	427	16.6	225	16.6	376	16.2	123	16.5	172	16.1	288
8017	.710	16.6	435	16.5	233	16.6	384	16.3	131	16.4	180	16.1	002
8802	880.599	16.0	046	16.2	125	16.5	255	16.4	591	16.4	132	16.2	228
8805	.627	16.1	074	16.5	153	16.7	283	16.2	619	16.4	160	16.2	256
8808	.665	16.1	112	16.4	191	16.6	321	15.9	657	16.5	198	16.0	000

TABLE II—*Continued*—OBSERVATIONS OF VARIABLE STARS

Plate	Julian Day	No. 7 Mag.	No. 7 Phase	No. 8 Mag.	No. 8 Phase	No. 9 Mag.	No. 9 Phase	No. 10 Mag.	No. 10 Phase	No. 11 Mag.	No. 11 Phase	No. 12 Mag.	No. 12 Phase
8811	30880.694	16.2	141	16.6	220	16.6	350	15.9	686	—	227	16.3	029
8814	.732	16.4	179	16.5	258	16.6	388	16.0	015	16.3	265	16.3	067
8828	83.599	16.5	232	15.9	609	16.6	515	15.9	045	16.3	108	16.2	286
8831	.635	16.6	268	16.0	016	16.6	551	16.1	081	16.4	144	16.3	028
8834	.672	16.6	305	16.1	053	16.6	588	16.2	118	16.4	181	16.4	065
8837	84.625	16.6	555	16.6	377	16.3	171	16.5	362	15.7	000	16.5	135
8840	.653	16.7	583	16.5	405	16.3	199	16.4	390	15.8	028	16.4	163
8843	.685	16.4	615	16.6	437	16.4	231	16.4	422	15.9	060	16.4	195
8847	.726	15.9	656	16.7	478	16.5	272	16.4	463	16.1	101	16.3	236
8852	.775	15.8	705	16.6	527	16.6	321	16.6	512	16.2	150	16.2	285
8854	.800	15.8	026	16.1	552	16.6	346	16.7	537	16.4	175	16.2	016
8888	99.610	16.0	065	16.6	263	16.0	085	16.4	452	16.5	243	16.2	114
8890	.630	16.1	085	16.5	283	16.1	105	16.4	472	16.5	263	16.3	134
8899	.715	16.3	170	16.7	368	16.4	190	16.5	557	16.4	348	16.3	219
8903	.762	16.4	217	16.6	415	16.5	237	16.4	604	16.1	017	16.2	266
8913	900.608	16.6	359	16.1	003	16.6	398	15.9	031	16.3	107	16.3	229
8915	.624	16.6	375	16.1	019	16.7	414	15.9	047	16.4	123	16.2	245
8923	.710	16.5	461	16.3	105	16.6	500	16.3	133	16.4	209	16.3	037
8937	01.656	15.8	000	16.6	421	15.9	076	16.5	370	16.0	021	16.3	100
9026	33.642	16.5	332	16.6	322	16.6	551	16.4	439	16.4	256	16.2	014
9031	.694	16.6	384	16.7	374	16.6	603	16.4	491	16.4	308	16.3	066
10101	1257.690	16.1	102	16.6	373	16.6	581	16.5	349	16.4	367	16.4	105
10110	58.678	16.4	387	16.2	103	16.4	199	16.1	628	16.4	221	16.4	211
10115	.732	16.5	441	16.6	157	16.5	253	15.8	682	16.5	275	16.2	265
10123	59.619	16.1	624	16.6	415	16.6	455	16.2	150	15.9	028	16.2	269
10128	.656	15.9	661	16.6	452	16.6	492	16.4	187	16.0	065	16.1	012
10132	.702	15.8	004	16.6	498	16.6	528	16.4	233	16.1	111	16.3	058
10137	.772	16.1	074	15.9	568	16.6	608	16.6	303	16.4	181	16.4	128

TABLE II—*Continued*—OBSERVATIONS OF VARIABLE STARS

Plate	Julian Day	No. 13 Mag.	No. 13 Phase	No. 14 Mag.	No. 14 Phase	No. 15 Mag.	No. 15 Phase	No. 16 Mag.	No. 16 Phase	No. 17 Mag.	No. 17 Phase	No. 18 Mag.	No. 18 Phase
5697	29785.670	16.7	204	16.4	333	16.2	055	16.4	137	16.2	269	—	253
5709	86.653	16.6	162	16.1	436	16.4	178	16.4	230	16.3	142	16.5	114
5806	813.632	16.4	158	16.3	132	16.4	205	16.4	212	16.2	102	16.6	160
5818	14.631	16.6	132	16.4	251.	16.1	057	16.1	024	16.0	361	16.4	037
5833	15.628	16.3	105	16.4	368	16.4	194	16.3	131	16.2	247	16.6	286
6845	30170.656	16.5	255	16.3	283	—	263	16.1	045	16.1	333	—	331
6856	71.630	16.6	204	16.3	377	16.3	090	16.3	129	16.4	197	16.4	183
6873	72.700	16.6	250	16.2	127	16.1	300	16.0	013	16.3	157	16.5	131
7853	519.618	16.6	146	16.5	293	16.0	000	16.4	123	16.3	275	16.4	295
7857	.697	16.6	225	16.5	372	16.0	079	16.5	202	16.0	354	16.2	000
7858	.713	16.5	241	16.5	388	16.2	095	16.4	218	15.9	000	16.2	016
7859	.728	16.5	256	16.4	403	16.2	110	16.4	233	16.1	015	16.3	031
7868	20.617	16.5	120	16.1	412	16.4	139	16.2	232	16.3	164	16.7	172
7872	.710	16.6	213	16.0	065	16.4	232	16.1	028	16.4	257	16.6	265
7936	50.623	16.3	069	16.1	055	16.0	039	16.1	274	16.3	190	16.7	253
7953	53.612	16.1	326	16.1	404	16.5	161	16.0	000	16.4	218	16.5	250
7958	.674	16.2	046	15.9	025	16.4	223	16.2	062	16.2	280	16.4	312
7973	54.640	16.3	329	16.2	111	16.0	042	16.4	138	16.2	136	16.5	155
7978	.720	16.3	067	16.3	191	16.3	122	16.4	218	16.4	216	16.6	235
7987	55.608	16.2	272	16.4	199	16.4	150	16.3	216	16.1	364	16.4	001
7991	.652	16.1	316	16.5	243	16.4	194	16.0	260	16.1	038	16.4	045
7995	.720	16.1	043	16.5	311	16.2	262	16.2	031	16.2	106	16.5	113
8006	56.602	16.4	242	16.5	313	16.2	284	16.0	023	16.4	247	16.7	247
8009	.626	16.3	266	16.5	337	16.0	021	16.1	047	16.2	271	16.7	271
8011	.645	16.2	285	16.5	356	16.0	040	16.0	066	16.2	290	16.6	290
8016	.702	16.0	000	16.4	413	16.1	097	16.3	123	16.0	347	16.4	347
8017	.710	16.1	008	16.3	421	16.0	105	16.2	131	15.9	355	16.4	355
8802	880.599	16.4	101	15.9	000	16.0	001	16.2	057	16.1	022	16.3	308
8805	.627	16.5	129	16.0	028	16.1	029	16.3	085	16.1	050	16.3	336
8808	.665	16.6	167	16.0	066	16.0	067	16.3	123	16.1	098	16.2	000

TABLE II—*Continued*—OBSERVATIONS OF VARIABLE STARS

Plate	Julian Day	No. 13 Mag.	No. 13 Phase	No. 14 Mag.	No. 14 Phase	No. 15 Mag.	No. 15 Phase	No. 16 Mag.	No. 16 Phase	No. 17 Mag.	No. 17 Phase	No. 18 Mag.	No. 18 Phase
8811	30880.694	16.7	196	16.1	095	16.1	096	16.5	152	16.4	117	16.0	029
8814	.732	16.5	234	16.2	133	16.2	134	16.5	190	16.4	155	16.2	067
8828	83.599	16.2	027	16.5	360	16.4	133	16.3	090	16.1	061	16.5	316
8831	.635	16.3	063	16.1	396	16.3	169	16.3	126	16.1	097	16.2	352
8834	.672	16.5	100	16.0	433	16.4	206	16.5	163	16.4	134	16.2	015
8837	84.625	16.2	028	16.1	066	15.9	012	16.1	226	16.1	347	16.7	219
8840	.653	16.3	056	16.2	094	16.0	040	16.0	254	15.9	005	16.6	247
8843	.685	16.5	088	16.2	126	16.1	072	16.0	286	16.1	037	16.4	279
8847	.726	16.5	129	16.3	167	16.2	113	16.1	030	16.1	078	16.3	320
8852	.775	16.6	178	16.3	216	16.4	162	16.1	079	16.2	127	16.2	369
8854	.800	16.6	203	16.4	241	16.4	187	16.3	104	16.3	152	16.3	020
8888	99.610	16.1	326	16.2	089	16.1	088	16.3	081	16.4	157	16.6	242
8890	.630	16.0	005	16.2	109	16.4	108	16.4	101	16.3	177	16.5	262
8899	.715	16.4	090	16.3	194	16.3	193	16.4	186	16.3	262	16.2	347
8903	.762	16.6	137	16.3	241	16.3	240	16.4	233	16.2	309	16.2	020
8913	0900.608	16.1	300	16.3	207	16.4	226	16.3	189	16.1	045	16.6	118
8915	.624	16.1	316	16.3	223	16 2	242	16.4	205	16.1	061	16.6	134
8923	. .710	16.4	060	16.4	309	16.0	041	16.1	291	16.2	157	16.5	220
8937	01.656	16.2	023	16.5	375	16.4	127	16.1	050	15.9	352	16.2	044
9026	33.642	16.6	203	16.4	238	15.9	000	16.1	292	16.3	138	16.6	235
9031	.694	16.2	255	16.4	290	16.2	052	16.2	048	16.4	190	16.6	287
10101	1257.690	16.5	113	16.3	416	16.0	055	16.1	080	15.9	334	16.3	347
10110	58.678	16.5	076	16.0	084	16.3	183	16.4	178	16.4	211	16.5	212
10115	.732	16.6	130	16.2	138	16.4	237	16.4	232	16.2	265	16.6	266
10123	59.619	16.2	335	16.2	175	16.1	263	16.3	229	16.2	042	16.3	031
10128	.656	16.3	030	16.3	182	16.0	014	16.2	266	16.2	079	16.3	068
10132	.702	16.4	076	16.3	228	16.1	060	16.0	015	16.4	125	16.5	114
10137	.772	16.7	146	16.4	298	16.3	130	16.2	085	16.4	195	16.5	184

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PERIODS OF VARIABLE STARS IN THE GLOBULAR CLUSTER NGC 5053

BY

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PERIODS OF VARIABLE STARS IN THE GLOBULAR CLUSTER NGC 5053

By Helen B. Sawyer

THE globular cluster NGC 5053 is a loose globular cluster in high galactic latitude, with very low intrinsic luminosity. With an absolute magnitude of only −5.3,[1] this cluster ranks near the bottom of the luminosity scale of globular clusters, the only cluster of lower luminosity being NGC 7492, of absolute magnitude −4.7. Its concentration class is XI,[2] its galactic latitude and longitude are +78° and 310°. At R.A. $13^h\ 39^m.0$, Dec. + 17° 57′ (1950) it is well placed for observation in the northern hemisphere.

A. Variable Stars.

In 1927 Baade[3] announced the discovery of nine variable stars in this object, and published estimates of their magnitudes on 37 plates, taken mostly with the 1-metre Hamburg reflector. A plate of the cluster identifying the variables and sequence stars is given in his paper. From the behaviour of the variables on these plates, he assumed that they were all cluster type variables, with a mean median magnitude of 16.19, but he determined no periods.

An accumulation of 64 plates taken by the writer with the 74-inch David Dunlap reflector over the past nine years provides material for intensive investigation of the variables in this cluster. For telescopic assistance in taking these plates, I am indebted to Dr. F. S. Hogg, Mr. Gerald Longworth, and Miss Ruth Northcott.

Numerous pairs of plates were searched systematically with the blink microscope, but only one new variable was detected, No. 10, at $x = +94''$, $y = +56''$, on Baade's co-ordinate system.

The magnitude sequence as determined by Baade was used, and the variables estimated twice on each plate. Periods have now been determined for all ten variables, all of which were found to be of the cluster type. For most of the variables, the same period satisfies both the series of observations by Baade (which are not republished in this paper) and those of Sawyer. There is a separation of about ten years between these two series. For two variables, there is real evidence for a period change in this interval. And for one other variable, five isolated, early, scattered observations by Baade are

TABLE I.

OBSERVATIONS OF VARIABLE STARS IN NGC 5053

Plate	Julian Day	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
3285	29076.610	16.1	16.35	16.2	15.9	16.35	16.35	16.1	16.45	16.1	16.2
3298	77.620	16.5	16.15	16.0	16.2	16.0	16.35	16.05	16.05	16.45	16.15
3312	78.618	16.2	16.35	16.4	15.95	16.35	16.25	16.3	16.2	16.4	16.4
3327	79.631	..	16.45	16.3	16.3	16.1	16.35	16.5	16.45	16.35	16.4
5696	785.639	16.6	16.45	15.95	15.75	16.25	16.3	16.4	16.25	16.2	16.5
5707	86.625	16.3	16.05	16.5	16.3	16.15	16.15	16.4	16.05	16.3	16.2
5710	.672	16.35	16.1	16.4	16.55	15.9	16.35	16.3	16.35	16.5	16.05
5721	87.621	16.45	16.45	16.45	15.65	16.4	16.6	16.2	16.05	16.4	16.2
6833	30169.622	16.0	16.35	16.5	16.4	16.5	16.0	16.2	16.5	16.4	16.4
6814	70.631	16.4	16.2	16.3	15.85	15.95	16.25	16.3	..	16.2	16.1
7854	519.640	15.9	16.35	15.8	16.45	16.2	16.3	16.25	16.4	16.4	16.2
7856	.677	15.95	16.4	16.0	16.45	16.3	16.15	16.3	16.5	16.4	16.2
7869	20.642	16.35	16.0	16.5	16.3	16.5	16.35	16.1	16.1	16.0	16.2
7871	.678	16.45	16.15	16.45	15.95	16.5	16.35	16.2	16.15	16.05	16.35
7988	55.617	16.5	16.3	16.5	16.1	16.45	16.0	16.35	16.45	16.15	16.2
7990	.640	16.55	16.45	16.5	16.2	16.35	16.1	16.25	16.65	16.25	16.3
8007	56.611	16.05	15.95	16.45	16.45	15.95	16.55	16.2	16.2	16.45	16.35
8010	.635	16.05	15.9	16.45	16.55	15.95	16.45	16.25	16.25	16.45	16.4
8803	880.610	16.5	16.05	16.4	16.5	16.15	16.3	15.9	16.05	16.3	16.2
8806	.638	16.45	15.95	16.3	16.3	16.1	16.3	16.1	16.1	16.3	16.0
8809	.676	16.25	16.1	16.0	16.45	16.35	16.3	16.1	16.3	16.35	16.1
8812	.706	15.8	16.25	15.95	16.3	16.4	16.45	16.3	16.5	16.35	16.2
8815	.745	15.8	16.35	16.0	16.4	16.45	16.4	16.4	16.55	16.35	16.4
8829	83.612	16.35	16.05	16.15	15.8	16.3	16.4	16.25	16.4	16.35	16.1
8832	.647	16.45	15.95	15.9	15.9	16.4	16.5	16.3	16.5	16.4	16.0

TABLE I *Continued*

Observations of Variable Stars in NGC 5053

Plate	Julian Day	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
8838	30884.637	15.8	16.5	16.45	16.55	16.25	16.15	16.3	16.25	16.55	16.2
8841	.665	15.9	16.4	16.4	16.5	16.1	16.2	16.35	16.35	16.5	16.3
8844	.697	15.95	16.35	16.5	16.55	16.0	16.3	16.4	16.35	16.55	16.4
8848	.738	16.05	16.05	16.5	16.5	16.05	16.45	16.35	16.5	16.4	16.4
8889	99.620	16.1	16.1	16.15	15.7	16.5	16.15	15.95	16.4	16.05	16.4
8898	.705	16.2	16.3	16.0	15.9	15.95	16.45	16.25	16.45	16.1	16.3
8914	30900.617	16.5	16.35	16.5	16.45	16.3	16.4	16.05	16.35	16.4	16.2
8924	.720	16.4	15.9	16.55	16.5	16.4	16.05	16.0	16.55	16.4	16.25
10100	1257.665	16.45	16.0	16.55	16.45	16.5	16.5	16.3	16.35	16.35	16.2
10106	58.633	16.25	16.5	16.2	16.0	16.05	16.1	16.05	16.05	15.9	16.5
10109	.667	15.7	16.5	16.35	16.15	16.15	16.05	16.2	16.1	15.95	16.45
10114	.722	15.8	16.5	16.45	16.3	16.2	16.3	16.35	16.35	16.2	16.45
10122	59.608	16.35	16.15	15.85	16.45	16.4	16.25	15.95	16.5	16.25	16.35
10127	646	16.55	16.2	15.9	16.5	16.4	16.45	15.9	16.3	16.45	16.4
10131	.692	16.55	16.3	16.0	16.55	16.5	16.5	16.15	16.0	16.45	16.45
12034	969.630	16.5	16.55	16.5	15.8	16.45	16.3	16.5	16.45	16.45	16.4
12035	.638	16.4	16.35	16.4	15.85	16.4	16.15	16.3	16.4	16.45	16.4
12037	.680	16.5	16.1	16.5	15.8	16.4	16.25	16.25	16.5	16.45	16.3
12038	.688	16.45	15.95	16.4	15.95	16.3	16.3	16.15	16.4	16.4	16.15
12040	.708	16.45	16.0	16.45	16.0	16.4	16.4	16.2	16.4	16.5	16.2

TABLE I *Continued*

OBSERVATIONS OF VARIABLE STARS IN NGC 5053

Plate	Julian Day	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
12041	31969.715	16.4	15.9	16.45	16.1	16.5	16.3	16.15	16.3	16.5	16.15
12056	70.610	15.75	16.3	15.9	16.45	15.8	16.55	16.15	16.15	16.6	16.1
12057	.619	15.75	16.3	16.0	16.5	15.9	16.6	16.3	16.15	16.45	16.2
12060	.660	15.8	16.45	16.0	16.35	15.9	16.35	16.3	16.25	16.35	16.0
12061	.669	15.8	16.3	16.15	16.35	15.95	16.4	16.3	16.25	16.3	16.15
12064	.710	16.0	16.45	16.3	16.2	15.95	16.05	16.5	16.55	16.15	16.2
12066	.725	16.0	.	16.15	.	..	16.05	.	..	..	16.2
12105	76.607	16.2	16.15	16.1	16.3	16.35	16.1	16.2	16.3	16.2	16.3
12108	.629	16.25	16.2	16.2	16.35	16.4	16.2	16.3	16.3	16.15	16.2
12112	.667	16.4	16.25	16.3	16.4	16.35	16.35	16.4	16.05	16.0	16.2
12114	.695	16.35	16.3	16.4	16.45	16.4	16.4	16.4	16.1	16.15	16.25
12131	77.603	16.55	16.3	16.4	15.7	16.4	16.5	16.2	16.5	16.3	16.15
12134	.643	16.4	16.05	16.0	15.9	16.4	16.4	16.3	16.4	16.4	16.1
12139	.692	16.3	16.05	15.85	16.1	16.05	16.3	16.25	16.45	16.45	16.2
12322	2001.612	16.4	16.1	16.45	16.4	16.4	16.05	16.0	15.95	16.45	16.1
12324	.656	16.4	16.05	16.5	16.5	16.4	16.1	16.0	16.0	16.5	16.1
12341	05.657	15.95	16.2	16.1	15.85	15.85	16.4	15.95	16.25	16.2	16.3
12342	.665	16.05	16.2	16.1	15.95	15.95	16.45	15.95	16.2	16.3	16.3
12360	06.624	16.4	16.4	16.5	16.45	16.3	16.35	16.35	16.5	16.5	16.3
12363	.656	16.5	16.35	16.4	16.5	16.3	16.0	16.1	16.5	16.55	16.4

not well represented by a period which suits all the other observations.

Table I contains the observations of the variables on the David Dunlap plates. Table II gives the elements of the variables as derived from these observations in conjunction with those of Baade. The light curves are represented by the individual observations in figures 1 and 2. Baade's observations have been represented in separate curves.

For this cluster, the longest cluster type period is 0.74 day, and the shortest is 0.29 day. The average range of these ten variables

TABLE II

ELEMENTS OF VARIABLE STARS IN NGC 5053

Var.	Max.	Magnitude Min.	Mean	Epoch of Maximum	Period d
1	15.8	16.6	16.2	30519.640	0.647178
2	15.9	16.5	16.2	30556.611	0.378953
3	15.8	16.6	16.2	30519.640	0.592946
4	15.7	16.6	16.15	29787.621	0.400585
5	15.8	16.6	16.2	29786.672	0.416868
6	16.0	16.6	16.3	30555.617	0.292198
7	15.9	16.5	16.2	30880.610	0.351581
8	15.8	16.6	16.2	30520.642	0.362842
9	15.9	16.6	16.25	30520.642	0.74173
10	16.0	16.5	16.25	29077.620	0.30354

REMARKS TO TABLE II

Var. 4. A double star; Baade did not publish his observations and the period depends solely on those of Sawyer.

Var. 5. The early isolated observations by Baade are omitted from the light curve as they do not harmonize with the rest.

Var. 6. The shortest period derived in this cluster.

Var. 7. The one Mt. Wilson observation is omitted from the light curve.

Var. 8. Definitely a changing period. Baade's observations are plotted with the same epoch, but with a period of 0.362852. β for this star is -12×10^{10}. The early observations by Baade are omitted from the curve.

Var. 9. The longest period in the cluster, and apparently increasing in length. Baade's observations are represented by the elements Maximum = 24976.456 + 0.74169 E. The value of β here is 48×10^{10}. Martin found large positive values of β around this length of period. The five early observations of Baade are omitted. A great deal of work was done in an attempt to find a shorter, related period for this star, but the value around 0.74 best represents the observations.

Var. 10. No observations by Baade, so the period is determined solely from Sawyer's observations.

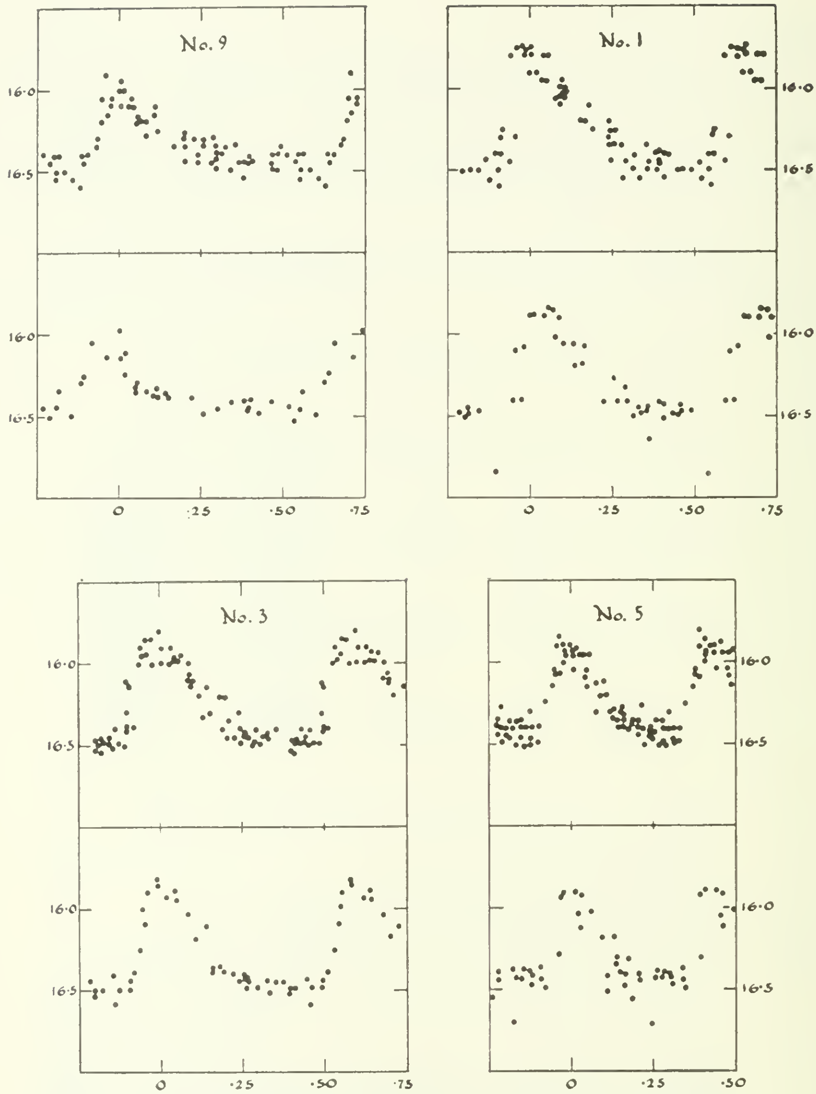

Fig. 1. Light curves of the longer period cluster type variables in NGC 5053, with periods from 0.74 day to 0.41 day. The upper curve for each variable represents observations by Sawyer, the lower, a series made a dozen years earlier by Baade.

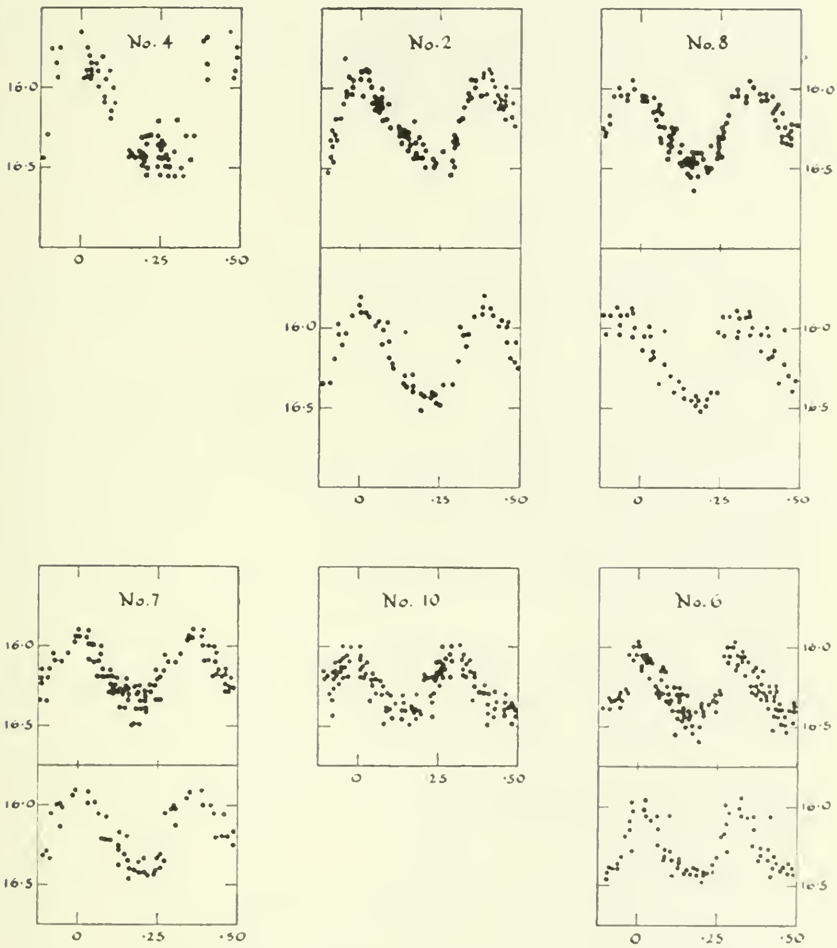

Fig. 2. Light curves of the shorter period variables in NGC 5053, with periods from 0.40 day to 0.29 day. For variables Nos. 4 and 10, no observations by Baade were available.

is rather small, being only 0.7 magnitude. In regard to period frequency, this cluster is another of the double maximum type discussed by the writer,[4] with an avoidance of periods close to half a day. In this case, however, as shown in figure 3, the majority of periods lie in the one-third of a day region.

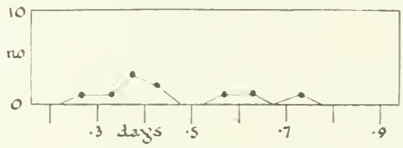

Fig. 3. The frequency distribution of periods in NGC 5053, intervals of 0.05 day.

B. Variable Stars in Relation to Colour-Magnitude Diagram

This cluster is important as a testing-ground for the relation between variable and non-variable stars, since Cuffey[5] has determined the colour-magnitude diagram for it. Schwarzschild,[6] Cuffey, and Baade,[7] have pointed out that the cluster type variables in globular clusters lie in a definite region of the colour-magnitude diagram, and that most of the stars in this region tend to be variable.

With the 36-inch Link reflector, Cuffey made a photometric survey of this cluster, and obtained magnitudes and red colour indices for 155 stars in it. The colour-magnitude diagram was found to be characteristic for a globular cluster, although unusual in that one of the fainter branches extends toward red stars, though he points out that this trend might be changed by observational evidence a magnitude or two fainter.

Cuffey found the nine variable stars to be closely grouped together at the beginning of the faint blue branch, near apparent red photographic magnitude 15.6, and red colour-index 0.7. In and around this same colour magnitude region were fourteen stars not known to be variable. Cuffey lacked sufficient plates to confirm or deny the variability of these.

The writer has estimated these stars on all of her plates, from an identification chart kindly provided by Dr. Cuffey. The stars lying in this critical region of the colour-magnitude diagram are, according to numbers in Cuffey's unpublished catalogue: 68, 15, 81, 90, 101, 118, 148, 156, and 158. No. 68 proved to be the same as

Variable No. 10 which had been independently found by the writer with the blink microscope. Other stars close to the region, which Cuffey suggested as possible variables are: 21, 25, 33, 131, and 146.

Accordingly the magnitudes of these 14 stars were estimated once by the writer on each of 62 plates; the extreme points for the stars were then estimated a second time. The result was somewhat surprising. Not a single one of these stars (apart from the known Var. No. 10) proved to be variable in the sense of having a range large enough to conclude variability. For eleven of these stars, the estimates on 62 plates have a maximum spread of only 0.2 magnitude per star. For one of them, there is one point which gives a spread of 0.3 magnitude. And for the remaining one, No. 158, the estimates have a spread of 0.4 magnitude, with three points over the 0.2 magnitude interval. A star of comparable magnitude, presumed non-variable, was estimated along with the possible variables. The estimates on this star gave a spread of 0.3 magnitude, just one point being over the 0.2 magnitude interval. On the other hand, the estimates of the variable of smallest range, No. 10, have a spread of 0.5 magnitude, with 16 points outside a 0.2 magnitude interval. The distribution of the estimates for these stars is given in Table III.

TABLE III

Frequency of Recorded Magnitudes for Cuffey's Possible Variables on 62 Plates

Star	16.1	16.2	16.3	16.4	16.5	Star	16.0	16.1	16.2	16.3	16.4	16.5
15	1	27	34			21		13	34	15		
81		13	38	11		25		6	44	12		
90			14	37	11	33			3	39	20	
101			22	38	2	131			16	36	10	
118		1	37	24		146			6	28	28	
148		8	24	30		68	4	6	19	12	14	7
156	1	12	38	11		non-var.			4	11	40	7
158	2	15	33	10	2							

It would appear then that a star in a globular cluster can have the same colour and magnitude as the cluster type variables and not vary its light by an appreciable amount. This is contrary to the findings of Schwarzschild in Messier 3 where he concluded "In the color-magnitude diagram of Messier 3 the region occupied by the variables does not seem to contain non-variables, which indicates that stars which can pulsate do pulsate."

Of course a variation whose total range is not more than 0.2 magnitude cannot be ruled out for these stars from the existing observations.

C. Distance of Cluster.

Since Baade's magnitude sequence was employed, the modulus of the cluster as determined from the median magnitudes of the variables should be expected to agree closely with Baade's value. Such proves to be the case. The median magnitude of the ten cluster type variables as determined by the writer is 16.23, with an average deviation of only 0.04 magnitude. The median magnitude of seven variables as determined by Baade was 16.19. Shapley[1] used a modulus of 16.2 in his most recent determination of the distances of high latitude clusters. This gives a distance of the cluster of about 17 kiloparsecs, in excellent agreement with Cuffey's distance of 16 ± 2 kiloparsecs as determined from the colour magnitude diagram. Any absorption correction may be neglected for this cluster, since there is an absence of colour excess as well as an excess in the numbers of extragalactic nebulae in nearby fields.

This cluster is noteworthy for its very large distance of about 55,000 light years above the galactic plane, as well as for its very low luminosity. Its luminosity and appearance are in marked contrast to the adjacent cluster NGC 5024, which is a close neighbour in space, but of much higher intrinsic luminosity.

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THE ORBITS OF THE SPECTROSCOPIC BINARIES H.D. 99967, H.D. 181144, H.D. 209813 and H.D. 213389

BY

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THE ORBITS OF THE SPECTROSCOPIC BINARIES H.D. 99967, H.D. 181144, H.D. 209813 and H.D. 213389.

By Ruth J. Northcott

THESE four stars were found to have variable velocities in the course of radial-velocity programmes at this Observatory. The positions, visual magnitudes, spectral classes, together with the reference announcing the variable character of the stars are given in Table I.

TABLE I

Star	1900 α	1900 δ	Vis. Mag.	D.D.O. Type	Reference in Pub. D.D.O.
H.D. 99967	$11^h\ 25^m.0$	47°12′	6.49	K0	v.1, no. 16, 1945
H.D. 181144	19 14.2	16 19	6.92	F7	v.1, no. 3, 1939
H.D. 209813	22 01.0	46 45	6.52	K0	v.1, no. 3, 1939
H.D. 213389	22 25.9	48 51	6.52	K1	v.1, no. 16, 1945

The spectra of each of the stars were examined in order to determine the absolute magnitudes and spectroscopic parallaxes. The lines used were those used by R. K. Young and W. E. Harper.[1] The values are given in the tables of binary elements.

H.D. 99967

The first four plates taken of this star in 1942 and 1943 showed the velocity to vary over 50 km./sec., and it was put on the spectroscopic binary programme. Due to the poor observing weather during the winter and the binary's long and somewhat uncertain period of 75 days, observation of this star was not completed until 1946, with a total of 55 plates. All the plates but the first were taken with the 25-inch camera and one-prism spectrograph, giving a dispersion of about 33 A./mm. at Hγ. The information obtained from these plates is given in Table II. The observations were grouped according to phase into 33 observational equations; in no case did the observations to be grouped differ in time by more than one revolution. Weights (1, 2, 3) were assigned according to the number of plates.

[1]Pub. D. A. O., v. 3, p. 1, 1924.

The preliminary elements were derived using R. K. Young's[2] graphical method. It was found that a circular orbit fitted the observations fairly well. Final elements were derived using T. E.

TABLE II

Radial-Velocity Observations of H.D. 99967

J.D. 243	Vo km./sec.	Phase from final T	Vo km./sec.	Vo − Vc km./sec.
0442.687	+43.6	39.837	+45.8	−2.2
0797.752	+51.1	20.599	+48.9	+2.2
0832.691	+13.8	55.538	+11.8	+2.0
0849.611	+00.6	72.458	+01.4	−0.8
0859.583	+24.2	7.569	+20.8	+3.4
0867.594	+40.5	15.580	+40.2	+0.3
0873.594	+50.8	21.580	+51.0	−0.2
0878.601	+53.2	26.587	+55.5	−2.3
0885.609	+57.0	33.595	+54.0	+3.0
0894.578	+44.0	42.573	+40.7	+3.3
1187.665	+52.7	36.208	+51.3	+1.4
1191.660	+43.4	40.203	+45.2	−1.8
1194.662	+38.9	43.205	+39.4	−0.5
1197.635	+33.0	46.178	+32.7	+0.3
1199.639	+26.9	48.182	+28.8	−1.9
1200.650	+23.6	49.193	+25.9	−2.3
1202.633	+21.6	51.176	+21.3	+0.3
1207.618	+09.5	56.161	+10.4	−0.9
1208.624	+07.1	57.167	+08.6	−1.5
1209.611	+07.5	58.154	+06.8	+0.7
1210.621	+03.4	59.164	+05.2	−1.8
1213.619	+03.2	62.162	+01.2	+2.0
1218.612	−07.4	67.155	−01.4	−6.0
1221.609	−01.0	70.152	−00.6	−0.4
1224.604	+03.2	73.147	+02.3	+0.9
1226.567	+06.6	0.249	+05.2	+1.4
1227.574	+05.3	1.256	+06.9	−1.6
1231.578	+15.7	5.260	+15.3	+0.4
1235.617	+24.4	9.299	+25.1	−0.7
1528.702	+12.0	2.942	+10.2	+1.8
1537.646	+33.6	11.886	+31.6	+2.0
1538.689	+34.0	12.929	+34.1	−0.1
1539.653	+33.8	13.893	+36.4	−2.6
1542.637	+41.6	16.877	+43.0	−1.4

[2]J. R. A. S. C., v. 11, p. 130, 1917.

TABLE II—*Continued*

RADIAL-VELOCITY OBSERVATIONS OF H.D. 99967

J.D. 243	Vo km./sec.	Phase from final T	Vc km./sec.	Vo−Vc km./sec.
1543.643	+45.4	17.883	+44.9	+0.5
1551.586	+53.1	25.826	+55.1	−2.0
1552.592	+56.4	26.832	+55.6	+0.8
1553.570	+56.6	27.810	+55.9	+0.7
1554.578	+56.0	28.818	+56.0	0.0
1555.599	+54.2	29.839	+55.9	−1.7
1578.587	+19.0	52.827	+17.6	+1.4
1589.585	−01.4	63.825	−00.3	−1.1
1882.726	+06.3	57.523	+08.0	−1.7
1883.703	+08.2	58.499	+06.3	+1.9
1905.681	+14.0	5.617	+16.1	−2.1
1907.737	+22.5	7.673	+21.1	+1.4
1908.681	+23.0	8.617	+22.9	+0.1
1921.660	+51.1	21.596	+51.0	+0.1
1922.684	+51.3	22.620	+52.3	−1.0
1923.626	+53.7	23.562	+53.4	+0.3
1929.597	+59.2	29.533	+56.0	+3.2
1942.615	+40.0	42.551	+40.7	−0.7
1943.606	+36.7	43.542	+38.7	−2.0
1962.705	+00.8	62.641	+00.7	+0.1
1985.621	+30.0	10.696	+28.6	+1.4

Sterne's[3] form of least-squares solution for very small eccentricity. Corrections were computed for all six elements. Reduction of

TABLE III

ORBITAL ELEMENTS OF H.D. 99967

		Preliminary	Final	
Period	P	74.87 days	74.861 days	± 0.0148
Eccentricity	e	0	0.0290	± 0.0066
Angle of periastron	ω		218°.70	± 12°.9
Periastron passage	T		J.D.2430852.014	± 0.137
Velocity of system	γ	+27.85 km./sec.	+27.863	± 0.107
Semi-amplitude	K	29.0 km./sec.	28.771	± 0.192
a sin i			2.961×10^7 km.	
$\frac{m_1^3 \sin^3 i}{(m_1 + m_2)^2}$			0.185☉	
Absolute magnitude	M	(spectroscopic)	+0.3	
Spectroscopic parallax			0″.006	

[3]Proc. Nat. Acad. of Sc., v. 27, p. 179, 1941.

Σpv^2 was from 136 to 108. Table III gives the preliminary and final elements obtained.

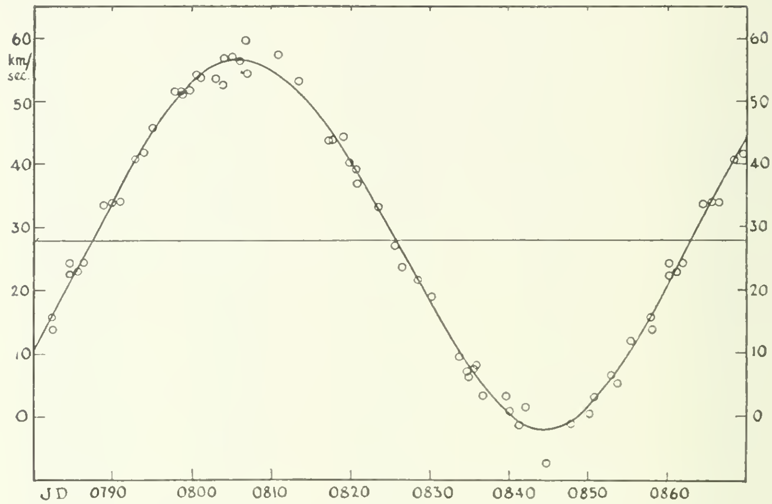

FIGURE 1—Velocity Curve of the Spectroscopic Binary H.D. 99967

The individual observations are plotted on the graph in figure 1. The probable error of a single plate is 1.9 km./sec.

H.D. 181144

Four plates of this star, taken in 1938, showed variation in radial velocity of over 50 km./sec. It was put on the spectroscopic binary programme in 1945 and 25 plates were obtained; a few plates were taken in 1946 to complete the observation. The early plates were taken with the one-prism spectrograph and the 12½-inch camera giving a dispersion of 66 A./mm. at Hγ; the rest of the plates were taken with the 25-inch camera and 33 A./mm. at Hγ. The data from the individual plates are given in Table IV. The early observations enabled the period to be well determined and the others were grouped according to phase into 20 observational equations, weighted (1, 2, 3) according to number of plates.

The preliminary orbit, derived graphically, was essentially circular. T. E. Sterne's method of least-squares solution for very small eccentricities was used to determine the corrections for the five elements. Reduction of Σpv^2 was from 117 to 101. Table V gives the preliminary and final elements obtained.

TABLE IV

RADIAL-VELOCITY OBSERVATIONS OF H.D. 181144

J.D. 242-243	Vo km./sec.	Phase from final T	Vc km./sec.	Vo−Vc km./sec.
9082.758	+23.8	5.262	+33.2	−9.4
9170.583	−15.2	1.622	−09.9	−5.3
9172.540	−33.8	3.579	−30.0	−3.8
9184.543	+18.2	4.821	+21.3	−3.1
1630.812	−39.3	3.055	−41.0	+1.7
1631.779	−09.1	4.022	−13.1	+4.0
1647.751	−21.3	3.853	−20.2	−1.1
1653.731	+07.5	4.452	+06.0	+1.5
1656.663	−24.4	2.004	−25.3	+0.9
1661.713	−10.0	1.673	−12.1	+2.1
1666.713	+06.7	1.293	+04.6	+2.1
1669.695	−00.5	4.275	−01.9	+1.4
1670.707	+34.4	5.287	+32.6	+1.8
1672.686	−23.0	1.886	−20.8	−2.2
1678.701	−39.7	2.521	−39.3	−0.4
1684.680	−37.3	3.120	−40.3	+3.0
1686.626	+26.0	5.066	+28.2	−2.2
1691.601	+15.7	4.660	+14.7	+1.0
1694.674	−36.4	2.353	−35.8	−0.6
1695.579	−38.1	3.258	−38.2	+0.1
1704.533	−04.1	1.451	−02.4	−1.7
1706.672	−32.7	3.590	−29.7	−3.0
1708.656	+33.9	0.194	+34.4	−0.5
1710.584	−29.9	2.122	−29.3	−0.6
1711.649	−37.2	3.187	−39.3	+2.1
1714.583	+20.0	0.741	+25.5	−5.5
1746.488	+32.1	0.364	+33.3	−1.2
1757.496	+33.9	0.611	+29.0	+4.9
1763.467	+09.6	1.202	+08.5	+1.1
1975.850	−26.8	3.759	−23.8	−3.0
1981.831	−01.8	4.354	+01.6	−3.4
1985.856	−43.2	2.999	−41.5	−1.7
1990.761	−39.9	2.523	−39.4	−0.5
2010.760	+17.1	1.001	+16.7	+0.4

TABLE V

ORBITAL ELEMENTS OF H.D. 181144

		Preliminary	Final	
Period	P	5.3803 days	5.3803	± 0.0004 estimated
Eccentricity	e	0	0.0183	± 0.0091
Angle of periastron	ω		348°.74	± 29°.2
Periastron passage	T		J.D.2431638.518	± 0.008
Velocity of system	γ	−04.6 km./sec.	−04.440	± 0.253
Semi-amplitude	K	38.5 km./sec.	38.176	± 0.364
a sin i			2.824×10^6 km.	
$\dfrac{m_1^3 \sin^3 i}{(m_1 + m_2)^2}$			0.0311☉	
Absolute magnitude	M (spectroscopic)		+4.2	
Spectroscopic parallax			0″.029	

The individual observations are plotted on the graph in figure 2. The probable error of a single plate is 1.5 km./sec.

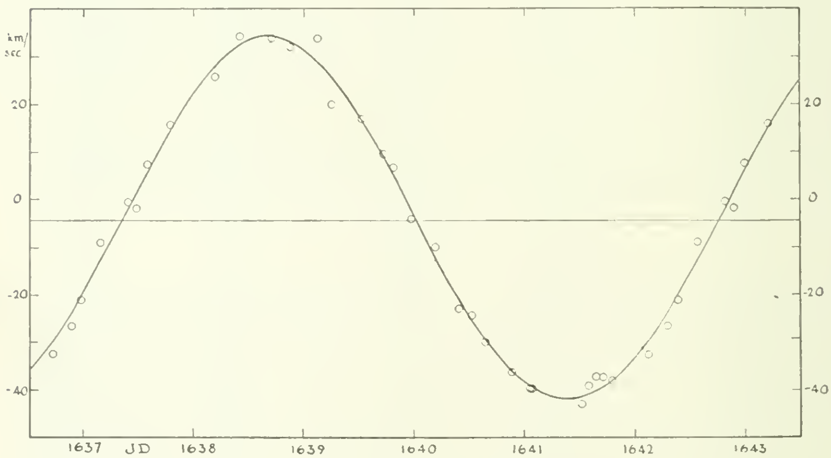

FIGURE 2—Velocity Curve of the Spectroscopic Binary H. D. 181144

H.D. 209813

Four early plates, taken 1935-1937 showed this star to vary in radial velocity by about 55 km./sec. In 1945 observations to

TABLE VI

RADIAL-VELOCITY OBSERVATIONS OF H.D. 209813

J.D. 242-243	Vo km./sec.	Phase from final T	Vc km./sec.	Vo−Vc km./sec.
8131.491	−32.6	13.167	−31.1	−1.5
8432.631	+16.0	21.135	+11.0	+5.0
8769.750	−08.0	16.220	−06.8	−1.2
8798.644	+04.2	20.683	+11.4	−7.2
1647.847	−46.1	11.459	−43.1	−3.0
1653.825	+02.2	17.437	+01.4	+0.8
1666.803	−51.2	5.984	−51.0	−0.2
1669.794	−49.7	8.975	—53.8	+4.1
1672.779	−38.6	11.960	−39.9	+1.3
1678.772	+01.1	18.043	+04.8	−3.7
1683.772	+03.1	22.953	+04.6	−1.5
1685.772	−07.3	0.522	−09.6	+2.3
1686.762	−16.4	1.512	−17.3	+0.9
1691.674	−52.5	6.424	−52.5	0.0
1694.728	−51.8	9.478	−52.4	+0.6
1701.719	−02.7	16.469	−05.0	+2.3
1702.712	+02.5	17.462	+01.5	+1.0
1703.714	+08.5	18.464	+06.8	+1.7
1704.706	+13.6	19.456	+10.1	+3.5
1705.722	+09.9	20.472	+11.4	−1.5
1706.697	+09.2	21.447	+10.4	−1.2
1708.698	−01.0	23.448	+01.6	−2.6
1710.644	−15.5	0.963	−13.4	−2.1
1714.718	−48.9	5.037	−46.3	−2.6
1715.782	−52.9	6.101	−51.4	−0.5
1728.686	+08.9	19.005	+08.8	+0.1
1746.545	−36.8	12.433	−36.6	−0.2
1747.633	−28.2	13.521	−28.3	+0.1
1748.694	−25.5	14.582	−19.7	−5.8
1757.590	+02.6	23.478	+01.4	+1.2
1765.549	−54.3	7.006	−54.0	−0.3
1770.644	−35.6	12.101	−38.9	+3.3
1790.476	−57.3	7.502	−54.7	−2.6
1791.489	−54.8	8.515	−54.5	−0.3
1813.454	−51.5	6.049	−51.2	−0.3
2017.831	−16.1	14.978	−16.5	+0.4
2025.815	+02.1	22.962	+04.5	−2.4
2028.865	−18.6	1.581	−18.9	+0.3
2037.783	−49.3	10.499	−48.4	−0.9
2056.744	−44.4	5.029	−46.2	+1.8
2078.652	−25.0	2.506	−27.1	+2.1
2079.807	−37.3	3.661	−36.8	−0.5
2098.630	+10.4	22.484	+06.9	+3.5

determine its orbit were started; 39 plates were obtained in 1945 and 1946. Three early plates were taken with the 12½-inch camera and one-prism spectrograph; the rest were with the 25-inch camera giving a dispersion of about 33 A./mm. at Hγ. Table VI gives the information from these plates. Using the early plates, the period was well determined; the other plates were grouped according to phase into 25 observational equations. Weights (1, 2) were assigned according to the number of plates.

TABLE VII

J. D. 242-243	$V_{H \text{ and } K}$ km./sec.	V_c km./sec.	O−C km./sec.
8798.644	+11.4	+11.4	0.0
1672.779	−48.8	−39.9	−8.9
1678.772	+00.4	+04.8	−3.4
1790.476	−54.3	−54.7	+0.4
2028.865	−32.7*	−18.9	−13.8
2037.783	−54.7*	−48.4	−6.3

The spectrum of the star is K0. Emission H and K lines of calcium were observed on six plates of strong exposure. The velocities given by the H and K lines are shown in Table VII. The asterisk means the velocity of the H line only is given.

TABLE VIII

Orbital Elements of H.D. 209813

		Preliminary	Final	
Period	P	24.431 days	24.431	± 0.002 (estim'd)
Eccentricity	e	0	0.0271	± 0.0079
Angle of periastron	ω		60°.38	± 17°.8
Periastron passage	T		J.D.2431660.819	± 0.026
Velocity of system	γ	−22.0 km./sec.	−22.208	± 0.147
Semi-amplitude	K	34.5 km./sec.	33.135	± 0.240
a sin i			1.113×10^7 km.	
$\frac{m_1^3 \sin^3 i}{(m_1 + m_2)^2}$			0.0922☉	
Absolute magnitude	M	(spectroscopic)	+3.3	
Spectroscopic parallax			0″.023	

The preliminary orbit was circular and was found graphically. The five final elements were found using T. E. Sterne's method of least-squares solution for small eccentricities. Reduction of Σpv^2 was from 167 to 105. Table VIII gives the preliminary and final elements obtained.

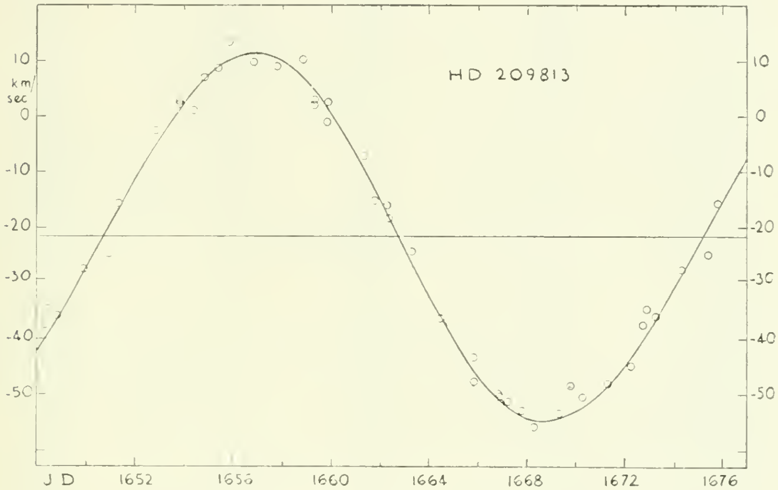

FIGURE 3—Velocity Curve of the Spectroscopic Binary H. D. 209813

The individual observations are plotted on the graph in figure 3. The probable error of a single plate is 1.4 km./sec.

H.D. 213389

During 1942 and 1943 five plates of this star were taken, showing it to vary by about 66 km./sec. In 1945 observations were commenced to determine its orbit; 36 plates were obtained during 1945 and 1946. All the plates were taken with the one-prism spectrograph and the 25-inch camera giving a dispersion of about 33 A./mm. at Hγ. Table IX gives the information from these plates. The period was determined with considerable accuracy from the early plates. The other plates were grouped according to phase into 24 observational equations and weighted (1, 2) according to the number of plates.

TABLE IX

RADIAL-VELOCITY OBSERVATIONS OF H.D. 213389

J.D. 243	Vo km./sec.	Phase from final T	Vc km./sec.	Vo−Vc km./sec.
0576.784	−33.4	2.886	−33.5	+0.1
0914.844	−32.0	3.601	−35.0	+3.0
0973.762	+18.6	9.254	+18.0	+0.6
0989.655	−05.1	7.392	−05.6	+0.5
1010.635	+32.8	10.617	+34.6	−1.8
1656.726	+03.1	17.528	−00.8	+3.9
1666.772	+28.5	9.819	+26.2	+2.3
1672.807	+27.0	15.854	+23.3	+3.7
1678.799	−33.9	4.092	−34.5	+0.6
1684.738	+33.2	10.030	+28.6	+5.6
1686.784	+45.1	12.076	+44.1	+1.0
1694.756	−30.1	2.293	−30.2	+0.1
1701.745	+15.4	9.282	+19.7	−4.3
1702.747	+31.2	10.284	+31.3	−0.1
1704.755	+39.3	12.292	+44.7	−5.4
1705.756	+43.4	13.293	+44.7	−1.3
1706.758	+41.8	14.295	+39.7	+2.1
1708.725	+17.6	16.262	+18.0	−0.4
1710.692	−11.4	0.474	−10.8	−0.6
1715.729	−27.2	5.511	−26.7	−0.5
1733.649	−25.1	5.676	−25.3	+0.2
1746.579	−15.0	0.851	−15.8	+0.8
1747.533	−29.1	1.805	−26.2	−2.9
1764.594	−21.4	1.111	−19.0	−2.4
1770.699	−09.4	7.216	−07.8	−1.6
1778.567	+30.2	15.084	+32.5	−2.3
1780.534	+06.0	17.051	+06.3	−0.3
1791.532	+31.6	10.294	+31.4	+0.2
1794.490	+46.6	13.252	+44.9	+1.7
1797.467	+15.8	16.229	+18.2	−2.4
1813.497	+37.1	14.504	+38.0	−0.9
2018.728	−15.2	6.675	−14.6	−0.6
2019.847	+00.8	7.794	−00.2	+1.0
2020.831	+09.8	8.778	+10.5	−0.7
2053.784	−17.9	6.221	−19.8	+1.9
2059.822	+47.2	12.259	+43.5	+3.7
2066.716	−19.6	1.398	−22.2	+2.6
2076.603	+40.8	11.285	+40.0	+0.8
2090.750	−01.8	7.677	−01.8	0.0
2121.603	−34.2	3.020	−34.0	−0.2
2157.554	−35.3	3.461	−34.9	−0.4

The preliminary orbit was found by graphical means to be circular and T. E. Sterne's method of least-squares solution for orbits of small eccentricity was used to determine the five final elements. Reduction of Σpv^2 was from 178 to 111. Table X gives the preliminary and final elements obtained.

TABLE X

ORBITAL ELEMENTS OF H.D. 213389

		Preliminary	Final	
Period	P	17.755 days	17.755	± 0.002 (estim'd)
Eccentricity	e	0	0.0226	± 0.0073
Angle of periastron	ω		103°.34	± 19°.8
Periastron passage	T		J.D.2431656.953	± 0.021
Velocity of system	γ	+05.0 km./sec.	+05.356	± 0.215
Semi-amplitude	K	40.0 km./sec.	40.172	± 0.305
a sin i			9.806×10^6 km.	
$\frac{m_1^3 \sin^3 i}{(m_1 + m_2)^2}$			0.119⊙	
Absolute magnitude	M (spectroscopic)		+2.2	
Spectroscopic parallax			0″.014	

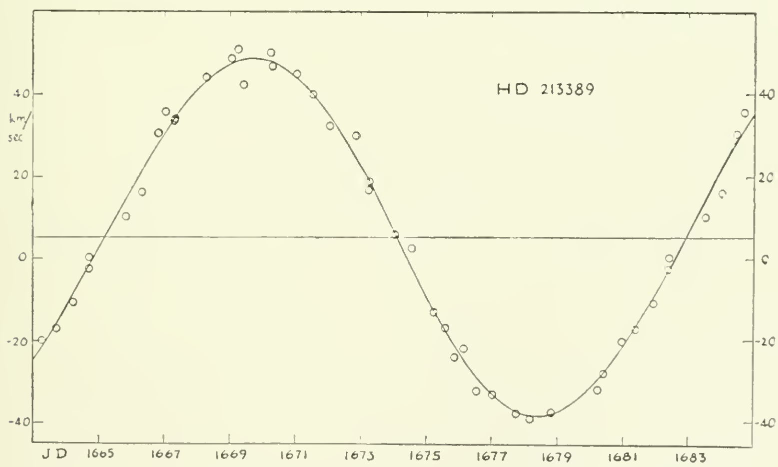

FIGURE 4—Velocity Curve of the Spectroscopic Binary H. D. 213389

The individual observations are plotted on the graph in figure 4. The probable error of a single plate is 1.5 km./sec.

Richmond Hill, Ontario
March 1, 1947.

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A BIBLIOGRAPHY
OF
INDIVIDUAL GLOBULAR CLUSTERS

BY

HELEN B. SAWYER

1947
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TORONTO, CANADA

PLATE XXXII

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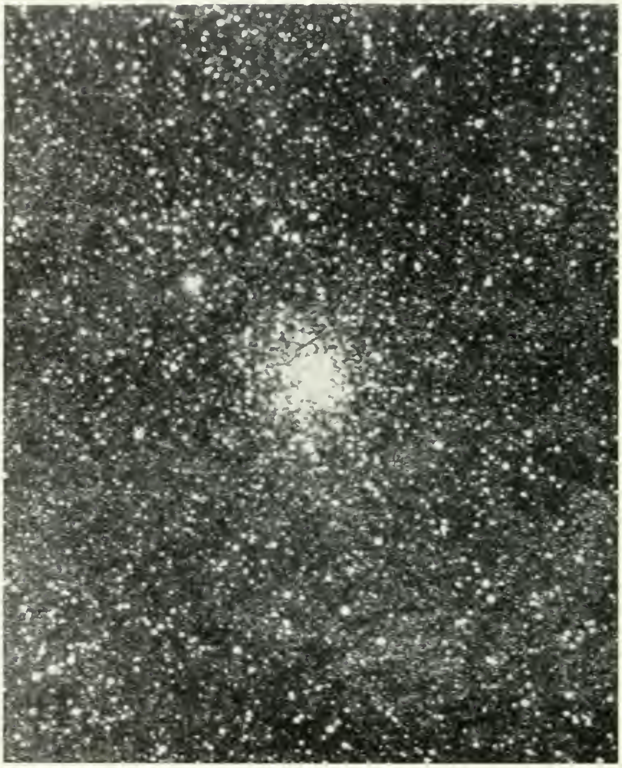

W

The cluster NGC 6868, Messier 71, long thought to be a galactic cluster, but now considered in the globular category. The photograph is from a plate with one hour exposure by D.K. Norris with the 74-inch David Dunlap reflector, June 21, 1947. Scale, 1 mm $= 14'.7$.

A BIBLIOGRAPHY OF INDIVIDUAL GLOBULAR CLUSTERS

By Helen B. Sawyer

(With Plate XXXII)

Advertisement.—Whoever attempts the enlargement of the bounds of knowledge in any particular branch of science, in justice to himself, the public, and previous laborers in the same field, should make himself familiar with all that has been previously published on the subject. But information of this kind is so widely dispersed through the journals and transactions of learned societies of all parts of the civilized world, that index catalogues or references to authorities are of the utmost importance to the investigator.—*Joseph Henry, Secretary, Smithsonian Institute,* Washington, 1877.

I. Purpose and Development of Work

In this bibliography an attempt is made to list under the cluster concerned, all research papers containing information on individual globular clusters. The purpose is to enable any astronomer to find out what work has been done on a specific cluster, thus saving time and avoiding duplication of research. Globular clusters, with a large range in linear diameter, absolute magnitude, and numbers of variable stars are being treated more and more as individual systems.

Only clusters thought to belong directly to our own galaxy are included, and only clusters considered globular at present. A few minutes of studying the bibliography will show the type of information available on the cluster. A few hours of reading the original sources indicated in this work will give the reader all the published facts about the object. For only a few clusters, notably Messier 13 in Hercules and Messier 3 in Canes Venatici, is the literature voluminous and unwieldy.

For over twenty years I have maintained a card catalogue of references to globular cluster literature. This catalogue is a necessary complement to the 2000 globular cluster photographs which have now been accumulated at the David Dunlap Observatory on about one-half of the known globular clusters. One result of this catalogue was the publication by the writer in 1939 of *A Catalogue of 1116 Variable Stars in Globular Clusters* (Dunlap Publication, no. 4). This paper gives a list of references to variable stars in these clusters. (A second edition of this catalogue is in preparation at present). But at the time this work was published it was felt that a complete bibliography of individual clusters would be of great use to an astronomer concerned with globular clusters. It is good for an astronomer working on variables in a cluster, or radial velocities, or space reddening, to be able to find out speedily what other data about the cluster are known.

In the globular cluster literature of the present century little attention is paid to the earlier references, that is, those up until the later nineteenth century. References to globular clusters of a century ago are buried beneath an enormous amount of literature on all kinds of nebulous objects, and in nebular catalogues. There is a confusion of numbering too, before the New General Catalogue, so that each cluster may be referred to by any one of several numbers.

As far as possible, the writer has read over this entire mass of literature, back to the time of Hevelius and Halley, and segregated all pertinent material from it. Over 800 individual references in about 125 different serial publications have been listed and surveyed. The bibliography is essentially complete up to the disruption of communications in Canada at the beginning of the last war. Most literature published up to the end of 1938 was safely received and has been included, together with as much as possible of the literature of the past eight years. Disruption of foreign communications occurred in Canada in 1939; some material was received through the United States during the ensuing two years.

The substance of earlier bibliographies has been incorporated in the present work, as well as many references not in any existing bibliography. Of course the Astronomischer Jahresbericht has been used for many years as a basis for references. For earlier bibliographies some use has been made of the list of papers on nebulae by Knobel, Monthly Notices, vol. 36, p. 377, 1876. This list does not give much clue to the character of many of the references, but the subject was rediscussed by Holden, who published a very comprehensive reference work, with comments, in Smithsonian Miscellaneous Collections, no. 311, 1877 (from which our foreword is taken). A more recent bibliography was published by Bigourdan in 1917, in Paris Annales, Observations 1907. A comprehensive bibliography was published by Shapley in *Star Clusters*, 1930, and supplemented in 1935 by Miss Mohr with later references in Harvard Circular, no. 402.

Reference should here be made to several of the longer works on clusters which cannot be adequately dealt with in this bibliography because of the extensive material they contain, and which any serious worker in the field of globular clusters should consult. Readers are certainly familiar with the volume *Star Clusters* by Shapley, 1930, and his article *Stellar Clusters* in the Handbuch der Astrophysik, vol. V, 2, 1933, where most of the important information on clusters is gathered into a concise form. In ten Bruggencate's monograph *Sternhaufen*, 1927, emphasis is placed particularly on the theoretical side of clusters. In the final volume of the extensive series *Observations de nébuleuses et d'amas stellaires* by Bigourdan, in Paris Annales, Observations, several hundred pages are devoted to the development of the study of nebulae and clusters. For the objects in Messier's catalogue readers should consult the long series by Flammarion in the Bulletin de la Société Astronomique de France, 1917-21, where a complete historical account of each cluster is given. Messier's original descriptions are reprinted, along with Flammarion's drawings and photographs of the objects. Early twentieth century catalogues of globular clusters are those of Bailey, 1908 and 1918, Hinks 1911, Shapley 1918 and 1919, Charlier 1918, and Lundmark 1920.

For convenience and the avoidance of repetition of references, the bibliography has been divided into two sections. All papers referring to individual globular clusters are listed in the first section. The important papers dealing principally with one cluster are listed by date, author and title directly under that cluster. These comprise the main body of the work in Section A. But many papers, such as the catalogues mentioned above, list attributes of several or many clusters. Reference to these works is made in Section A by date and author under each cluster concerned. Section B is a complete list of these references in their entirety, arranged chronologically.

Of the more than 800 references studied for this bibliography, about 700 were available in the scientific libraries around Toronto, which include those of the David Dunlap Observatory and Royal Astronomical Society of Canada, the University of Toronto, the

Royal Canadian Institute, and the Meteorological Service of Canada. About fifty more papers were obtained from other Canadian libraries, those of the Dominion Observatory, Ottawa, McGill University, and the University of Alberta. Fifty others were borrowed from United States libraries, chiefly from the Harvard Observatory and the University of Michigan. I am indebted to librarians Miss Slater and Miss Wales of the University of Toronto, Miss Hanley of the Harvard Observatory, and Mr. Gauthier of the Dominion Observatory for aid in obtaining some of the references.

I am especially indebted to Miss Edna Fuller, Miss Ruth Northcott and my husband, Dr. F. S. Hogg, all of the David Dunlap Observatory, for assistance at various stages of the work; to Mrs. R. E. Williamson for preparation of the final manuscript for the printer; and above all to Dr. Harlow Shapley for his inspiration for my two decades of work on star clusters.

I began this work with the realization that it was beyond the limits of human frailty to make it one hundred per cent complete and correct. I have striven to make the bibliography as correct and complete as circumstances would permit, and will welcome any corrections or additions of important papers which may be included in later lists.

II. A Catalogue of Globular Star Clusters

For the convenience of the reader, certain of the material indicated in the bibliography has been assimilated into a table of information on globular clusters. Table I lists all clusters at present on the globular list for our own galaxy. The clusters are arranged by NGC number, which does not always correspond to right ascension for 1950. Successive columns give the NGC number, the right ascension and declination for 1950, and the constellation in which the cluster is located as determined from the I.A.U. Atlas. The galactic longitude and latitude have been computed for 1900 on the basis of the Harvard Pole $12^h 40^m$, $+28°$, with the help of Ohlsson's tables, Lund Annals, no. 3, 1932. The concentration class for most clusters is that assigned by Shapley and Sawyer in 1927. The angular diameters are partly by Mowbray, 1946, and partly by Shapley and Sayer, 1935. The integrated photographic magnitude is, when possible, by Christie, 1940; or by Sawyer and Shapley, 1927, reduced to the same system. The spectral type and radial velocity in kilometres a second are by Mayall, 1946; the number of variables according to Sawyer, 1939, with some more recent adjustments. The magnitudes of bright stars and variables are from the most recent reliable published observations to be found under each cluster. The color excess is by Stebbins and Whitford, 1936. The modulus from variables in the next to the last column of the table is uncorrected for absorption, and the reader may apply the correction which seems to him best to fit the case. Many of the blanks in the table will be filled during the coming months from studies of the David Dunlap plates.

(*a*) It is interesting to note from this catalogue the distribution of globular clusters by constellation. The 99 globular clusters are found in only 37 of the constellations. Somewhat surprisingly, the largest number of globular clusters is found in the constellation of Ophiuchus, which has 20. The second largest total, 17, is as one would expect, in Sagittarius; Scorpio is third with 8. No other constellation has more than 3. Six constellations have 3 each, 7 have 2, and 22 have one. The distribution by constellation is as follows:

Ophiuchus 20, Sagittarius 17, Scorpio 8, 3 each in Coma Berenices, Lupus, Hercules, Ara, Pavo, and Aquarius; 2 each in Toucan, Musca, Hydra, Centaurus, Apus, Serpens, Delphinus; one cluster each in Sculptor, Horologium, Mensa, Columba, Lepus, Puppis, Lynx, Carina, Vela, Canes Venatici, Bootes, Virgo, Libra, Norma, Corona Austrina, Telescopium, Scutum, Aquila, Lyra, Sagitta, Pegasus, Capricornus.

The heaviest concentration of known globular clusters is definitely in the region of Ophiuchus-Sagittarius, rather than in the more commonly mentioned one of Sagittarius-Scorpio.

(*b*) A feature of the main section of the bibliography is that for each cluster I have tried to indicate the date of the first recorded observation. This is the first observation of the object in the sky; I have not attempted to indicate when the object was first correctly assigned to the globular category. Even at the present day the proper classification of some objects is still doubtful.

It is interesting then to note the astronomers who first observed these objects in the sky. The man who leads all others in the discovery of globular clusters is Sir William Herschel, who found exactly one-third of the clusters accepted as globular today.

TABLE I. CATALOGUE OF 99 GLOBULAR CLUSTERS

NGC	R.A. 1950	Dec.	Const.	l 1900	b	Conc.	Diam.	Mag.	Sp.	R.V.	Vars.	25 B.S.	Mod. Var.	Col.E.
	h m	° ′		°	°		′							
104	00 21.9	−72 21	Tucn	272	−45	III	56	4.5	—	—	8	13.44	—	—
288	00 50.2	−26 52	Scul	154	−88	X	12.4	8.96	—	—	2	14.80	—	0.00
362	01 00.6	−71 07	Tucn	268	−47	III	17.7	8.0	—	—	11	11.12	15.5	—
1261	03 10.9	−55 25	Horo	236	−52	II	4.0	9.5	—	—	—	—	—	—
1841	04 52.5	−84 05	Mens	264	−30	—	2.4	12.2	—	—	—	—	—	—
1851	05 12.4	−40 05	Colm	211	−34	II	11.5	7.72	dF5	+291	3	—	—	—
1904	05 22.2	−24 34	Leps	195	−28	V	7.8	8.39	dF3	+231	5	15.29	—	—
2298	06 47.2	−35 57	Pupp	213	−15	VI	4.2	10.48	F8	+ 64	6	—	—	—
2419	07 34.8	+39 00	Lync	148	+27	II	6.2	11.51	F5	+ 14	36	17.84	19.21	−.15
2808	09 10.9	−64 39	Cari	250	−11	I	18.8	7.8	—	—	4	14.9	—	—
3201	10 15.5	−46 09	Velr	215	+09	X	29.3	8.8	—	—	76	—	15.08	—
4147	12 07.6	+18 49	Coma	224	+78	VI:	4.1	11.01	A5	+191	4	16.58	16.52	+.02
4372	12 23.0	−72 24	Musc	268	−10	XII	19.8	9.1	—	—	8	—	—	—
4590	12 36.8	−26 29	Hyda	268	+37	X	9.8	9.12	A6	−116	28	14.80	15.90	—
4833	12 56.0	−70 36	Musc	271	−08	VIII	12.7	8.5	—	—	11	—	15.65	—
5024	13 10.5	+18 26	Coma	306	+79	V	14.4	8.68	A8n	−112	42	15.07	16.45	.00
5053	13 13.9	+17 57	Coma	308	+78	XI	8.9	10.9	—	—	10	15.6	16.2	—
5139	13 23.8	−47 03	Cent	277	+15	VIII	65.4	5.1	—	—	168	—	14.65	—
5272	13 39.9	+28 38	C Ven	07	+77	VI	18.6	7.21	dF2	−150	186	14.23	15.43	+.05
5286	13 43.0	−51 07	Cent	280	+10	V	13.6	9.5	—	—	0	—	—	—
5466	14 03.2	+28 46	Boot	08	+72	XII	9.2	10.39	—	—	18	15.72	16.16	+.05
5634	14 27.0	−05 45	Virg	311	+48	IV	3.7	10.8	F4	− 63	7	16.32	16.91	+.02
5694	14 36.7	−26 19	Hyda	299	+29	VII	2.2	10.87	A9	−187	0	16.79	—	+.02
4499	14 52.7	−82 02	Apus	275	−21	XI	6.2	11.6	—	—	—	—	—	—
5824	15 00.9	−32 53	Lupi	300	+21	I	3.7	10.08	dF5	− 58	—	—	—	+.05

REMARKS—This table does not include the globular clusters now considered to be associated with the Magellanic Clouds, Fornax Cluster, or other external galaxies.

NGC 6235 and 6535 are dropped from this catalogue, though information on them is included in Section A.

ADDED IN PROOF—R. J. Trumpler considers NGC 2682 [M 67] to be a globular cluster.

TABLE I—*Continued*

NGC	R.A. 1950	Dec.	Const.	l 1900	b	Conc.	Diam.	Mag.	Sp.	R.V.	Vars.	25 B.S.	Mod. Var.	Col. E.
	h m	° ′		°	°		′							
5897	15 14.5	−20 50	Libr	311	+29	XI	8.7	9.61	—	—	—	15.15	—	+.05
5904	15 16.0	+02 16	Serp	332	+46	V	19.9	7.04	dF7	+ 45	97	13.97	15.03	+.05
5927	15 24.4	−50 29	Lupi	294	+04	VIII	12.0	9.7	—	—	—	—	—	—
5946	15 31.8	−50 30	Norm	295	+03	IX	2.6	11.0	—	—	—	—	—	—
5986	15 42.8	−37 37	Lupi	305	+13	VII	6.0	8.72	G0	+ 2	1	—	—	+.10
6093	16 14.1	−22 52	Scor	321	+18	II	5.1	8.39	dF4	+ 18	7	14.88	16.05	+.10
6101	16 20.0	−72 06	Apus	285	−17	X	14.6	10.2	—	—	—	—	—	—
6121	16 20.6	−26 24	Scor	319	+15	IX	22.8	7.41	—	—	43	13.11	13.97	+.22
6139	16 24.3	−38 44	Scor	310	+06	II	2.6	10.4	—	—	—	—	—	+.39
6144	16 24.2	−25 56	Scor	320	+14	XI	6.2	10.85	—	—	—	15.76	—	+.15
6171	16 29.7	−12 57	Ophi	331	+22	X	7.8	10.10	G2	−147	24	15.5	16.01	+.44
6205	16 39.9	+36 33	Herc	26	+40	V	23.2	6.78	dF2	−228	15	13.75	14.8	+.08
6218	16 44.6	−01 52	Ophi	343	+25	IX	12.2	7.95	F7	+ 36	1	13.97	15.0	+.13
6229	16 45.6	+47 37	Herc	40	+39	IV:	3.8	10.26	dF6	−150	21	16.18	17.53	+.07
6254	16 54.5	−04 02	Ophi	343	+22	VII	12.2	7.64	G0	+ 73	2	14.06	15.0	+.19
6266	16 58.1	−30 03	Ophi	321	+06	IV	6.3	8.16	dF6	− 81	26	15.87	16.40	+.27
6273	16 59.5	−26 11	Ophi	325	+08	VIII	5.3	8.29	dF2	+102	4	14.80	—	+.20
6284	17 01.5	−24 41	Ophi	326	+09	IX:	2.7	10.61	G1	+ 22	6	16.06	—	+.13
6287	17 02.1	−22 38	Ophi	328	+10	VII	2.7	11.24	—	—	3	16.08	—	+.34
6293	17 07.1	−26 30	Ophi	325	+07	IV	3.5	9.38	A9	− 73	5	15.39	—	+.12
6304	17 11.4	−29 24	Ophi	324	+04	VI	3.8	9.82	G3	− 98	—	—	—	+.44
6316	17 13.4	−28 05	Ophi	325	+04	III	2.4	10.10	—	—	—	—	—	+.39
6325	17 15.0	−23 42	Ophi	329	+07	IV:	1.6	12.66	—	—	—	—	—	+.40
6333	17 16.2	−18 28	Ophi	333	+09	VIII	5.5	8.92	F1	+224	1	15.61	—	+.24
6341	17 15.6	+43 12	Herc	35	+34	IV	12.2	7.30	A5n	−118	16	—	—	−.02

TABLE I—*Continued*

NGC	R.A. 1950	Dec.	Const.	l 1900	b	Conc.	Diam.	Mag.	Sp.	R.V.	Vars.	25 B.S.	Mod. Var.	Col. E.
	h m	° ′		°	°		′							
6342	17 18.2	−19 32	Ophi	333	+08	IV	1.3	11.35	—	—	—	—	—	+.44
6352	17 21.6	−48 26	Arae	309	−08	XI:	8.9	9.1	—	—	—	—	—	—
6355	17 20.9	−26 19	Ophi	327	+04	—	1:	9.6	—	—	—	—	—	—
6356	17 20.7	−17 46	Ophi	334	+09	II	3.5	9.68	gG2	+ 31	—	17.16	—	+.32
6362	17 26.6	−67 01	Arae	293	−18	X	8.5	8.3	—	—	17	—	—	—
6366	17 25.1	−05 02	Ophi	346	+15	XI	5.8	12.1	—	—	2	15.78	16.2	+.55
6388	17 32.6	−44 43	Scor	313	−08	III	6.8	8.7	—	—	—	—	—	—
6397	17 36.8	−53 39	Arae	306	−13	IX	19:	7.3	—	—	2	12.61	—	—
6401	17 35.6	−23 53	Ophi	331	+03	—	1	—	—	—	—	—	—	—
6402	17 35.0	−03 13	Ophi	349	+13	VIII	6.7	9.44	G0	−131	72	15.44	16.85	+.32
6426	17 42.4	+03 12	Ophi	356	+15	IX	2.2	12.33	—	—	10	—	—	+.20
—	17 45.7	−60 45	Pavo	300	−17	—	0.5	15.1	—	—	—	—	—	—
6440	17 45.9	−20 21	Sgtr	335	+02	V	1.7	12.05	G3	−133	—	—	—	+.76
6441	17 46.8	−37 02	Scor	321	−06	III	3.0	8.93	G4	− 70	—	—	—	+.37
6453	17 48.0	−34 37	Scor	323	−05	IV	3.6:	11.4	—	—	—	—	—	+.30
6496	17 55.5	−44 15	Scor	316	−11	XII	12.7	10.3	—	—	—	—	—	—
6517	17 59.1	−08 57	Ophi	347	+05	IV	1.0	12.90	—	—	—	—	—	+.64
6522	18 00.4	−30 02	Sgtr	329	−05	VI	1.5	10.40	—	—	—	—	—	+.37
6528	18 01.6	−30 04	Sgtr	328	−06	V	1.2	11.04	—	—	—	—	—	+.50
6539	18 02.1	−07 35	Serp	349	+05	X	3.5	12.39	—	—	1	—	—	+.82
6541	18 04.4	−43 44	Cor A	317	−12	III	23.2	7.9	—	—	1	13.35	—	—
6544	18 04.3	−25 01	Sgtr	334	−04	—	1:	—	G1	− 12	—	—	—	—
6553	18 06.3	−25 56	Sgtr	333	−04	XI	3.2	10.20	—	—	0	—	—	+.74
6569	18 10.4	−31 50	Sgtr	328	−08	VIII	2.2	10.63	—	—	—	—	—	+.39
6584	18 14.6	−52 14	Tele	310	−18	VIII	9.7	9.4	—	—	0	—	—	—

TABLE I—*Continued*

NGC	R.A. 1950	Dec.	Const.	l 1900	b	Conc.	Diam.	Mag.	Sp.	R.V.	Vars.	25 B.S.	Mod. Var.	Col. E.
	h m	° '		°	°		'							
6624	18 20.5	−30 23	Sgtr	330	−09	VI	2.7	9.53	G4	+ 69	—	—	—	+.25
6626	18 21.5	−24 54	Sgtr	335	−07	IV	15.0	8.48	G0	+ 1	9	14.87	—	+.29
6637	18 28.1	−32 23	Sgtr	329	−12	V	3.8	8.94	G5	+ 95	—	—	—	+.34
6638	18 27.9	−25 32	Sgtr	336	−09	VI	2.2	10.24	G3	− 14	—	16.22	—	+.24
6652	18 32.5	−33 02	Sgtr	329	−13	VI:	2.3	9.86	G3	−124	—	—	—	+.22
6656	18 33.3	−23 58	Sgtr	337	−09	VII	17.0	6.48	F6	−148	25	12.93	14.17	+.19
6681	18 40.0	−32 21	Sgtr	330	−14	V	4.1	8.95	G2	+198	—	—	—	+.07
6684	18 44.1	−65 14	Pavo	297	−25	—	—	—	—	—	—	—	—	—
6712	18 50.3	−08 47	Scut	353	−06	IX:	4.2	9.98	G4	−131	4	16.10	—	+.32
6715	18 52.0	−30 32	Sgtr	333	−16	III	5.5	8.74	F7	+107	—	—	—	+.15
6723	18 56.2	−36 42	Sgtr	328	−19	VII	7.5	7.75	G3	− 3	19	14.20	15.33	+.03
6752	19 06.4	−60 04	Pavo	304	−27	VI	41.9	7.2	—	—	1	13.26	—	—
6760	19 08.6	+00 57	Aqil	04	−05	IX:	2.4	11.25	—	—	2	—	—	+.64
6779	19 14.6	+30 05	Lyra	30	+08	X	5.0	9.55	F5	−154	11	15.31	16.3	+.07
6809	19 36.9	−31 03	Sgtr	337	−25	XI	14.8	7.08	—	—	2	13.58	—	−.02
6838	19 51.5	+18 39	Sgte	24	−06	—	6.1	—	gG5	− 80	—	—	—	—
6864	20 03.2	−22 04	Sgtr	348	−27	I	4.6	9.50	G1	−222	11	17.06	—	+.15
6934	20 31.7	+07 14	Dlph	20	−20	VIII	6.2	10.01	F9	−360	51	15.78	16.67	+.07
6981	20 50.7	−12 44	Aqar	03	−34	IX	5.1	10.24	G2	−255	31	15.86	16.80	+.07
7006	20 59.1	+16 00	Dlph	32	−20	I	2.2	11.45	F1	−348	20	17.1	18.6	+.02
7078	21 27.6	+11 57	Pegs	33	−28	IV	12.3	7.33	dF0	−114	66	14.31	15.63	+.00
7089	21 30.9	−01 03	Aqar	22	−37	II	11.7	7.30	dF0	− 3	17	14.61	15.7	+.03
7099	21 37.5	−23 25	Capr	355	−48	V	8.9	8.58	A7n	−164	3	14.63	—	−.05
7492	23 05.7	−15 54	Aqar	22	−65	XII	4.3	12.33	—	—	9	16.82	—	−.20

He found 33, while his nearest competitor, James Dunlop, who worked in the southern hemisphere, found 21. Messier found 14, Méchain and John Herschel 5 each, Lacaille 4, and no other observer found more than two. Table II lists the globular clusters by NGC number according to their discoverer.

TABLE II

DISCOVERERS OF GLOBULAR CLUSTERS

WILLIAM HERSCHEL: 288, 2419, 4147, 5053, 5466, 5634, 5694, 5897, 6144, 6229, 6284, 6287, 6293, 6304, 6316, 6342, 6355, 6356, 6401, 6426, 6440, 6517, 6522, 6528, 6544, 6553, 6569, 6624, 6638, 6712, 6934, 7006, 7492.

JAMES DUNLOP: 362, 1261, 1851, 2298, 2808, 3201, 4372, 5286, 5927, 5986, 6101, 6139, 6352, 6362, 6388, 6441, 6496, 6584, 6652, 6723, 6752.

CHARLES MESSIER: 4590, 5272, 6218, 6254, 6266, 6273, 6333, 6402, 6626, 6637, 6681, 6715, 6779, 7099.

PIERRE MÉCHAIN: 1904, 6093, 6171, 6864, 6981.

JOHN HERSCHEL: 1841, 5946, 6325, 6453, 6684.

ABBÉ DE LACAILLE: 104, 4833, 6397, 6809.

HALLEY, 5139, 6205; HEVELIUS or IHLE, 6656; KIRCH, 5904; MARALDI, 7078, 7089; DE CHÉSEAUX, 6121; KÖHLER, 6838; BODE, 5024, 6341; CACCIATORE, 6541; BRORSON, 6539; HIND, 6760; WINNECKE, 6366; BARNARD, 5824; STEWART, IC 4499; SHAPLEY, one unnumbered.

I have made every effort to assign the discovery to the correct observer, but will be pleased to receive any corrections. A paper by the writer discussing the development of nebular catalogues in the eighteenth century, with special reference to Messier and Méchain, and the publication of a long overlooked letter by the latter, is to be found in Dunlap Comm., no. 14, 1947.

(*c*) It is interesting to compare the totals of variables as listed in this catalogue of globular clusters with those in the catalogue of variables in David Dunlap Publication no. 4, 1939. The total of 1116 variables known at that time has grown to 1294 now, an increase of 178 variables. But whereas in 1939, 60 globulars had been searched for variables, the number now has increased to only 62. Actually three more clusters have been examined, but one on the earlier list, NGC 6535, has now been dropped from the globular category. Since the globular clusters now being searched for variables are increasingly difficult objects, further progress will be slow. The writer has in her possession data on other clusters which will be published when completed.

III. Instructions for Use of Bibliography

All references to individual globular clusters are listed in Section A where the clusters are arranged by NGC number, with Messier's number indicated in parenthesis. The Right Ascension and Declination are for 1950; the galactic coordinates are for 1900.

Under each cluster are listed by date, author and title all principal papers on that cluster. Many important references to individual clusters are lost in works on another cluster or subject; every attempt has been made to include these stray bits of information. Numerous papers intercompare clusters, and these are listed under each cluster so compared.

Papers which involve several or more clusters are usually listed under each cluster concerned by date and author only. The complete reference list for these items will be found in Section B. There was no iron-clad rule as to whether papers mentioning a few clusters should be listed by title under each cluster, but in general Section B is a list of catalogues and works providing observational data on many clusters. Since the New General Catalogue number by Dreyer, 1888, is used for each cluster, there is no additional reference to this catalogue by individual cluster.

The first date and name reference under NGC 104, 47 Tucanae, is 1755 Lacaille. If the reader will turn to Section B, he can read the title of the paper as well as the printed source. For some of the early catalogues, notably those of Lacaille, the Herschels and Dunlop, the catalogue number of the object follows the name of the author. When photographs or drawings accompany the paper this is usually, but not always, indicated. Certain clusters, such as Messier 13, have had too many photographs published for all to be included, but I have attempted to indicate sources where photographs of the less well-known clusters can be found.

Many of the longer and more important references in Section B have been indexed with lettered sub-divisions. Early in the work it appeared that to list a cluster as being included in a given reference was not always enough. For example, a reference may contain one list of clusters which the writer of the paper considered globular, and another list considered as non-globular. Simply to index both lists in the same way would be quite misleading. For these papers, then, I have made as many lettered subdivisions as seemed necessary to serve as an information guide to the material contained therein. For some of the longer works this has been a rather difficult procedure. For Shapley's *Star Clusters* and his article *Stellar Clusters* in the Handbuch der Astrophysik, which provide such a comprehensive summary of information, only material not previously published by the same author has been indexed.

In cases where the same author has published more than one paper in a given year, these are differentiated by an italicized Roman numeral following the year. A long series of papers forming an obvious whole, such as that of Bigourdan, has been indexed under the first year of the series with a dash following the date, i.e., 1891—Bigourdan. Certain volumes which appeared in several editions such as Webb, *Celestial Objects for Common Telescopes*, have been indexed under the date of the edition which I used, with a cross reference to the date of the first edition. The titles of Shapley's two series, *Studies of Color and Magnitude in Stellar Clusters*, in Mt. Wilson Communications, and *Studies of Magnitudes in Star Clusters*, in Mt. Wilson Contributions, have been condensed simply to *Studies*. Readers will find convenient access to the papers of three famous astronomers in the collected volumes of their work, as follows: *The Scientific Papers of Sir William Herschel*, 2 vols., London, 1912; *The Scientific Papers of William Parsons, Third Earl of Rosce,* London, 1926; *The Scientific Papers of Sir William Huggins*, London, 1909.

The abbreviations employed have been selected to combine minimum printing space with maximum ease of identification for the reader. Certain abbreviations, such as M.N., A.N., etc., are so well-known in astronomical literature as to cause no confusion. Abbreviations for other periodicals have been constructed in accordance with principles from the I.A.U. Transactions, vol. III, pp. 19-39, 1928, in conjunction with the Union List of Serials. The latter list has been used extensively in locating the whereabouts on this continent of many of the rarer volumes.

In general the word Observatory has been omitted from the abbreviation, and taken as understood. Where publications are from academies or societies, however, this is always indicated. For most publications the abbreviation has been chosen for ease of locating the reference in the Union List; that is, the place of publication appears first, followed by the series, such as bulletin, circular, etc. We might note that the publication Comptes Rendus is to be found under Académie des Sciences, Paris; and Connaissance des Temps under France, Bureau des Longitudes.

The numbers of the catalogue of Messier and Méchain were assigned in order of discovery. Since these numbers are in frequent use to-day, the following table is given for convenience in locating these clusters by NGC numbers in this bibliography.

Identification of Messier-Méchain with NGC Numbers

Messier	NGC	Messier	NGC	Messier	NGC
2	7089	19	6273	69	6637
3	5272	22	6656	70	6681
4	6121	28	6626	71	6838
5	5904	30	7099	72	6981
9	6333	53	5024	75	6864
10	6254	54	6715	79	1904
12	6218	55	6809	80	6093
13	6205	56	6779	92	6341
14	6402	62	6266	107	6171
15	7078	68	4590		

It is impossible in such a long work as this bibliography to print a summary of each reference. On each card in my catalogue, however, I have written a summary of the reference. For less readily obtainable papers I will be glad to supply any astronomer with further information from my card catalogue.

Richmond Hill, Ontario
June 30, 1947.

SECTION A.

NGC 104 (47 Tucanae) α 00h 21m.9, δ — 72° 21′ *l* 272°, *b* — 45°

1755 Lacaille, Abbé de. First observation.

1891 Bailey, S. I. A catalogue of 7922 southern stars observed with the meridian photometer during the years 1889-91. *Harv. Ann.*, v. 34, p. 108.

1894 Pickering, E. C. Variable stars near 47 Tucanae. *A.N.*, v. 135, p. 129.

1897 Pickering, E. C. Distribution of stars in clusters. *Harv. Ann.*, v. 26, p. 213 (with plate).

1898 Williams, A. S. A catalogue of the magnitudes of 1081 stars lying between −30° Dec. and the South Pole (1885-6). London.

1901 Holetschek, J. Ueber den Helligkeitseindruck von Sternhaufen. *Vienna, K. Ak. Wiss. Math-natur. Kl. Sitz.* 110, abth. II a, pp. 1253-97.

1903 Bailey, S. I., and Pickering, E. C. Observations with the meridian photometer during the years 1899-1902. *Harv. Ann.*, v. 46, p. 5.

1908 Pickering, E. C. Revised Harvard Photometry. *Harv. Ann.*, v. 50, p.19.

1911 Plummer, H. C. On the problem of distribution in globular star clusters. *M.N.*, v. 71, pp. 460-70.

1915 Bailey, S. I. Globular clusters: distribution of stars. *Harv. Ann.*, v. 76, no. 4.

1915 Wood, H. E. Observations of comet 1915a (Mellish) *Union Circ.*, no. 31, p. 239. (Colour of 47 Tucanae).

1923 Shapley, H. Globular cluster containing long period variables. *Harv. Bull.*, no. 783.

1925 Paraskevopoulos, D. W. Integrated magnitude of 47 Tucanae. *Harv. Bull.*, no. 824.

1925 Strömgren, E. Om bevaegelses mulighederne i stjernehobe. *Nord. A. Tids.*, v. 6, pp. 21-28.

1935 Perrine, C. D. Report of Observatorio Nacional Argentino, 1934-1935. *Am. A. S. Pub.*, v. 8, p. 162. (Four spectrograms taken).

1939 Globular Cluster, 47 Tucanae. Cover, *The Telescope*, v. 6, p. 5.

1940 Ekenberg, B. Estimates of the total magnitudes of ξ Tucanae, ω Centauri, M 6 and M 7. *Lund. Medd.*, ser. I, no. 156.

1941 Shapley, H. Galactic studies, XII. The giant globular cluster 47 Tucanae and its long period variables. *Nat. Acad. Sci. Proc.*, v. 27, p. 440. Harv. Repr. No. 228.

1942 47 Tucanae. Cover, *Sky and Telescope*. no. 9, p. 1.

1943 The Small Magellanic Cloud and 47 Tucanae. Cover, *Sky and Telescope*, no. 24, p. 1.

1755 Lacaille I 1, 1828 Dunlop 18 (fig. 1), 1847 J. Herschel 2322 (drawing), 1861 J. Herschel, 1862*IIc* Auwers, 1864 J. Herschel 52, 1867*ab* Chambers, 1868 Webb, 1881 Smyth and Chambers, 1882*ab* Flammarion, 1894 Gore, 1897, 1898*II* Pickering, 1902*abc* Bailey, 1903 Clerke, 1904*a* Webb, 1908 Bailey (plate), 1910 See (plates), 1911*a* Hinks, 1912 See (plate), 1913 Bailey, 1913*b* von Zeipel, 1914 Strömgren and Drachmann, 1915*I, II* Plummer, 1915 Melotte, 1915*ab* Bailey,

NGC 104 (Cont.)

1916 Jeans, 1918*c* Charlier, 1918*IIeg* Shapley, 1918*VI* Shapley, 1919*Ic*, *IIc* Shapley and Shapley, 1919*b* Shapley, 1920 Hoffmeister, 1920 Lous, 1920*a* Lundmark, 1922*II* Becker, 1923 Lundborg, 1923 von Zeipel, 1925 Larink, 1925 Nabokov, 1925*f* Doig, 1926*cf* Parvulesco, 1927*adh* ten Bruggencate, 1927 Sawyer and Shapley, 1927*c* Parvulesco, 1927*I*, *II* Shapley and Sawyer, 1929 Cannon, 1929*ab* Shapley and Sawyer, 1930 Heckmann and Siedentopf, 1930 *abfgknp* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1939*ab* Sawyer, 1941 de Kort, 1944 Shapley, 1945 Finlay-Freundlich, 1945 Sawyer, 1946*d* Mayall.

NGC 288 $\alpha\ 00^h\ 50^m.2,\ \delta -\ 26° 52'$ $l\ 154°, b\ -\ 88°$

1789 Herschel, W. First observation, 1785 Oct. 27.

1943 Oosterhoff, P. Th. A semi-regular variable in N.G.C. 288. *B.A.N.*, v. 9, pp. 397-9.

1789 W. Herschel VI 20, 1818*a* W. Herschel, 1833 J. Herschel 74, 1847 J. Herschel 2354, 1862II*a* Auwers, 1864 J. Herschel 162, 1891-*g* Bigourdan, 1881 Smyth and Chambers, 1904*a* Webb, 1915 Melotte, 1915*a*, 1918*b* Bailey, 1918*c* Charlier, 1918*IIbd* Shapley, 1919*IIc* Shapley and Shapley, 1920*a* Lundmark, 1923 Lundborg, 1926 Doig, 1926*f* Parvulesco, 1927*a* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II* Shapley and Sawyer, 1928 van Rhijn, 1929*ab* Shapley and Sawyer, 1930*afn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1936*a* Stebbins and Whitford, 1936 Duryea, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1944 Shapley, 1945 Sawyer, 1946*d* Mayall, 1946*ab* Mowbray.

NGC 362 $\alpha\ 01^h\ 00^m.6,\ \delta\ -\ 71° 07'$ $l\ 268°, b\ -\ 47°$

1828 Dunlop, J. First observation.

1915 Bailey, S. I. Globular clusters; distribution of stars. *Harv. Ann.*, v. 76, no. 4.

1927 Heckmann, O. P. ten Bruggencate, Sternhaufen. *A. G. Viert.*, v. 62, pp. 180-191. (Analysis).

1931 Sawyer, H. B. The periods of thirty-six variable stars in four globular clusters. (Abs.) *Am. A. S. Pub.*, v. 7, p. 35.

1932 Sawyer, H. B. Periods and light curves of thirty two variable stars in the globular clusters N.G.C. 362, 6121, and 6397. *Harv. Circ.*, no. 366.

1932 Sawyer, H. B. Periods and light curves of twenty two variable stars in the northern border of the Small Magellanic Cloud. (Plate). *Harv. Circ.*, no. 374. (Abs.) Variable stars in the northern edge of the Small Magellanic Cloud. *Am. A. S. Pub.*, v. 7, p. 100.

1935 Greenstein, J. L. Two non-cluster type variables in Messier 3. *Harv. Bull.*, no. 901, p. 14. (Comparison of variables).

1943 The Small Magellanic Cloud and 47 Tucanae. Cover, *Sky and Telescope*, no. 24, p. 1.

1828 Dunlop 62 (fig. 3), 1847 J. Herschel 2375, 1864 J. Herschel 193, 1867*a* Chambers, 1882*b* Flammarion, 1895, 1897, 1898*II* Pickering, 1902*abc* Bailey, 1904*a* Webb, 1908 Bailey, 1911*a* Hinks, 1913, 1915*ab* Bailey, 1915*I* Plummer, 1915 Melotte, 1916 Jeans, 1918*c* Charlier, 1918*IIe* Shapley, 1919*Ic*, *IIc* Shapley and Shapley, 1920 Hoffmeister, 1920*a* Lundmark, 1923 Lundborg, 1925 Nabokov, 1925*f* Doig, 1926*f* Parvulesco, 1927*dh* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*ab* Shapley and Sawyer, 1929 Cannon,

NGC 362 (Cont.)

1930*afkn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1932*ab*, 1935*a* Sawyer, 1935 Shapley and Sayer, 1939*ab* Sawyer, 1941 de Kort, 1942*a* Sawyer, 1943*a* Oosterhoff, 1944 Shapley, 1944*II*, 1945 Sawyer, 1946*d* Mayall.

NGC 1261 $\alpha\ 03^h\ 10^m.9,\ \delta\ -55°\ 25'$ $l\ 236°,\ b\ -52°$

1828 Dunlop, J. First observation.

1828 Dunlop 337, 1847 J. Herschel 2517, 1864 J. Herschel 666, 1908 Bailey, 1911*a* Hinks, 1915 Melotte, 1915*a* Bailey, 1918*c* Charlier, 1918*IIc* Shapley, 1919*IIc* Shapley and Shapley, 1920*a* Lundmark, 1923 Lundborg, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1929 Cannon, 1930*an* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1941 de Kort, 1944 Shapley, 1945 Sawyer, 1946*d* Mayall.

NGC 1841 $\alpha\ 04^h\ 52^m.5,\ \delta\ -84°\ 05'$ $l\ 264°\ b\ -30°$

1847 Herschel, J. First observation, 1836 Jan. 19.

1940 Shapley, H., and Paraskevopoulos, J. S. Southern clusters and galaxies. *Harv. Bull.*, no. 914. (New globular cluster).

1847 J. Herschel 2788, 1864 J. Herschel 1052, 1946*d* Mayall.

NGC 1851 $\alpha\ 05^h\ 12^m.4,\ \delta\ -40°\ 05'$ $l\ 211°,\ b\ -34°$

1828 Dunlop, J. First observation.

1924 Slipher, V. M. The radial velocity of additional globular star clusters. *Pop. Astr.*, v. 32, p. 622.

1935 Perrine, C. D. Report of Observatorio Nacional Argentino, 1934-35. *Am. A. S. Pub.*, v. 8, p. 162. (Spectrogram of 51 hours exp.)

1828 Dunlop 508, 1847 J. Herschel 2777, 1864 J. Herschel 1061, 1867*a* Chambers, 1882*b* Flammarion, 1904*a* Webb, 1911*a* Hinks, 1915 Melotte, 1915*a*, 1918*b* Bailey, 1918*c* Charlier, 1918*IIc* Shapley, 1919*Ic*, *IIc* Shapley and Shapley, 1920*a* Lundmark, 1923 Lundborg, 1925 Nabokov, 1925 Strömberg, 1925*f* Doig, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II* Shapley and Sawyer, 1928 Voûte, 1929 Cannon, 1929*b* Shapley and Sawyer, 1930*afknq* Shapley, 1931 Nabokov, 1932 Moore, 1932, 1933 van de Kamp, 1935*abd* Edmondson, 1935 Shiveshwarkar, 1935 Mineur, 1935 Shapley and Sayer, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1944 Shapley, 1945 Sawyer, 1946*ab* Mayall.

NGC 1904 (Messier 79) $\alpha\ 05^h\ 22^m.2,\ \delta\ -24°\ 34'$ $l\ 195°,\ b\ -28°$

1781 Méchain, P.F.A. First observation, 1780 Oct. 26, Dec. 17.

1899 Holetschek, J. Ueber den Helligkeitseindruck von Nebelflecken und Sternhaufen. *A. G. Viert.*, v. 33, p. 270.

1924 Slipher, V. M. The radial velocity of additional globular star clusters. *Pop. Astr.*, v. 32, p. 622.

1781 Méchain, 1783 Bode, 1784 Messier, 1814*c* W. Herschel, 1818*ac* W. Herschel, 1853 Laugier 7, 1856 d'Arrest, 1862*IIb* Auwers, 1862 Schönfeld, 1864 J. Herschel 1112, 1867 Vogel, 1881 Smyth and Chambers, 1882*b* Flammarion, 1888 Ginzel, 1897, 1898*II* Pickering, 1895*ab* Mönnichmeyer, 1902*abc* Bailey, 1902 Gore, 1904 Webb, 1904, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1909

NGC 1904 (Cont.)

Winnecke, 1910 Porter, 1911*a* Hinks, 1915 Melotte, 1915*a* Bailey, 1915 Kritzinger, 1917 Shapley and Davis, 1917*d* Flammarion, 1918*a* Bailey, 1918*c* Charlier, 1918*IIbd* Shapley, 1919*Ic*, *IIcd* Shapley and Shapley, 1920 Hoffmeister, 1920*a* Lundmark, 1920*b* Shapley, 1925 Nabokov, 1925 Strömberg, 1925*b*, 1926 Doig, 1926*f* Parvulesco, 1926*I* Vorontsov-Velyaminov, 1927*h* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II* Shapley and Sawyer, 1928 van Rhijn, 1928 Voûte, 1929 Cannon, 1929*ab* Shapley and Sawyer, 1930*afknq* Shapley, 1931 Nabokov, 1932 Moore, 1932, 1933 van de Kamp, 1935*ab* Edmondson, 1935 Shiveshwarkar, 1935 Mineur, 1935 Shapley and Sayer, 1936 Duryea, 1937 Wilkens, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1946*ab* Mayall, 1946*ab* Mowbray.

NGC 2298 $\alpha\ 06^h\ 47^m.2,\ \delta - 35°\ 57'$ $l\ 213°,\ b - 15°$

1828 Dunlop, J. First observation.

1828 Dunlop 578, 1847 J. Herschel 3065, 1864 J. Herschel 1463, 1881 Smyth and Chambers, 1915 Melotte, 1915*a* Bailey, 1918*c* Charlier, 1918*IIe* Shapley, 1919*IIc* Shapley and Shapley, 1920*a* Lundmark, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1930*akno* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1946*ab* Mayall, 1946*a* Mowbray.

NGC 2419 $\alpha\ 07^h\ 34^m.8,\ \delta + 39°\ 00'$ $l\ 148°,\ b + 27°$

1802 Herschel, William. First observation 1788 Dec. 31.

1922 Shapley, H. N.G.C. 2419. *Harv. Bull.*, no. 776; *Pop. Astr.*, v. 30, p. 590. (Discussion of Lampland's photograph).

1935 Baade, W. The globular cluster N.G.C. 2419. *Mt. W. Cont.*, no. 529; *Ap. J.*, v. 82, pp. 396-412. (Plate).

1936 Ein merkwürdiger Kugelsternhaufen. *Die Himmelswelt*, v. 46, pp. 152-3.

1937 v. Brunn, A. Der Kugelhaufen N.G.C. 2419. *Die Sterne*, v. 17, pp. 16-8.

1802 W. Herschel I 218, 1833 J. Herschel 457, 1856 d'Arrest, 1861 Earl of Rosse, 1862*IIa* Auwers, 1864 J. Herschel 1548, 1865*b* Rümker, 1874 Schultz, 1875 Schönfeld, 1880 Earl of Rosse, 1891-*h* Bigourdan, 1907 Holetschek, 1909 Winnecke, 1922*a* Shapley, 1925 Nabokov, 1926*f* Parvulesco, 1926 Reinmuth, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1930*afkno* Shapley, 1930 Parenago, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1934, 1935 Lundmark, 1935*ab* Edmondson, 1935 Shapley and Sayer, 1936*ab* Stebbins and Whitford, 1937 Mineur, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1943 (fig. 50), 1944 Shapley, 1945 Sawyer, 1946*ab* Mayall, 1946*ab* Mowbray.

NGC 2808 $\alpha\ 09^h\ 10^m.9,\ \delta - 64°\ 39'$ $l\ 250°,\ b - 11°$

1828 Dunlop, J. First observation.

1898 Williams, A. S. A catalogue of the magnitudes of 1081 stars lying between −30° Dec. and the south pole. (1885-6). London.

1908 Pickering, E. C. Revised Harvard Photometry. *Harv. Ann.*, v. 50, p. 91.

1828 Dunlop 265, 1847 J. Herschel 3152, 1861 J. Herschel, 1864 J. Herschel 1793, 1881 Smyth and Chambers, 1904*a* Webb, 1908 Bailey, 1911*a* Hinks, 1912 Curtis, 1915 Melotte, 1915*a*, 1918*b* Bailey, 1918 Curtis, 1918*c* Charlier, 1918*IIe* Shapley, 1919*Ic*, *IIc* Shapley and Shapley, 1920*a* Lundmark, 1923 Lundborg, 1925 Nabokov, 1925*f* Doig, 1926*f* Parvulesco, 1927*h* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*ab* Shapley and Sawyer, 1929 Cannon, 1930*akn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1939*a* Sawyer, 1941 de Kort, 1946*d* Mayall.

NGC 3201 α 10^h 15^m.5, δ − 46° 09′ l 245°, b + 09°

1828 Dunlop, J. First observation.

1919 Woods, I. E. Variable stars in the cluster N.G.C. 3201. *Harv. Circ.*, no. 216.

1922 Bailey, S. I. Photographic work at Arequipa with the Bruce 24-inch refractor. N.G.C. 3201. *Harv. Circ.*, no. 234.

1940 Dowse, M. Twenty-five new variable stars in the globular cluster N.G.C. 3201. *Harv. Bull.*, no. 913, p. 17.

1941 Wright, F. W. Periods of fifty-nine variable stars in the globular cluster N.G.C. 3201. *Harv. Bull.*, no. 915.

1828 Dunlop 445, 1847 J. Herschel 3238, 1864 J. Herschel 2068, 1881 Smyth and Chambers, 1908 Bailey (plate), 1911*a* Hinks, 1915 Melotte, 1915*a*, 1918*a* Bailey, 1918*c* Charlier, 1918*IIe* Shapley, 1919*IIc* Shapley and Shapley, 1920*a* Lundmark, 1923 Lundborg, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*ab* Shapley and Sawyer, 1930*afn* Shapley, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1939*a* Sawyer, 1941 de Kort, 1941 Copeland, 1944*II* Sawyer, 1946*d* Mayall.

NGC 4147 α 12^h 07^m.6, δ + 18° 49′ l 224°, b + 78°

1786 Herschel, W. First observation, 1784 Mar. 14.

1917 Shapley, H. Descriptive notes relative to nine clusters. *A. S. P. Pub.*, v. 29, pp. 185-6.

1917 Davis, H. Five new variable stars in globular clusters. *A. S. P. Pub.*, v. 29, p. 260.

1930 Baade, W. Der kugelförmige Sternhaufen NGC 4147. *A. N.*, v. 239, pp. 353-8; *Hamb. Mitt.*, v. 7, no. 36, 1932.

1931 Baade, W. Schwache Haufenveränderliche in hohen galaktischen Breiten. (5 Veränderliche in der Umgebung des Kugelhaufens NGC 4147). *A. N.*, v. 244, pp. 153-8; *Hamb. Mitt.*, v. 7, no. 36, 1932.

1931 Vinter Hansen, J. M. Den kugelformede stjernehob NGC 4147. *Nord. A. Tids.*, v. 12, pp. 20-3.

1786 W. Herschel I 19, 1833 J. Herschel 1106, 1856 d'Arrest, 1861 Earl of Rosse, 1862*IIa* Auwers, 1862 Schönfeld, 1864 J. Herschel 2752, 1867 d'Arrest, 1874 Schultz, 1880 Earl of Rosse, 1881 Smyth and Chambers, 1882 Engelmann, 1886 d'Engelhardt, 1891-*i* Bigourdan, 1891 Kempf, 1895*ab* Mönnichmeyer, 1904 Webb, 1907 Holetschek, 1909 Perrine, 1909 Winnecke, 1911 Lorenz, 1912 Curtis, 1915 Melotte, 1915*a* Bailey, 1918 Curtis, 1918*c* Charlier, 1918*IIbdg*, *IVa*, *VI*, Shapley, 1919*IIcd* Shapley and Shapley, 1920*a* Lundmark, 1920*b* Shapley, 1923 Lundborg, 1923 Wirtz, 1923 von Zeipel, 1925 Nabokov, 1925*a* Doig, 1926*f* Parvulesco, 1926 Reinmuth, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*ab* Shapley and Sawyer, 1929 Cannon, 1930*afn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1932*ab* Sawyer, 1933 Stebbins, 1934, 1935 Lundmark, 1935 Shapley and Sayer, 1936*ab* Stebbins and Whitford, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1944 Shapley, 1945 Finlay-Freundlich, 1945 Sawyer, 1946*ab* Mayall, 1946*ab* Mowbray.

NGC 4372 α 12^h 23^m.0, δ − 72° 24′ l 268°, b − 10°

1828 Dunlop, J. First observation.

1828 Dunlop 67? (fig. 2), 1847 J. Herschel 3390, 1864 J. Herschel 2927, 1915 Melotte, 1915*a*, 1918*b* Bailey, 1918*c* Charlier, 1918*IIe*, *Vb* Shapley, 1919*Ic*, *IIbc* Shapley and Shapley, 1920*a* Lundmark, 1926*f* Parvulesco, 1927*ah* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1930*an* Shapley, 1935 Shapley and Sayer, 1939*a* Sawyer, 1946*d* Mayall.

NGC 4590 (Messier 68) α 12^h^ 36^m^.8, δ − 26° 29′ l 268°, b + 37°

1780 Messier, C. First observation, 1780 Apr. 9.
1919 Shapley, H. Nineteen new variable stars. *A. S. P. Pub.*, v. 31, p. 226.
1920 Shapley, H. Studies. XV. A photometric analysis of the globular system Messier 68. *Mt. W. Cont.*, no. 175; *Ap. J.*, v. 51, pp. 49-61 (Plate).
1930 Sticker, B. Über die Farbenhäufigkeitsfunktion in Sternhaufen. *Z. f. Ap.*, v. 1, p. 174.
1947 Greenstein, J. L., Bidelman, W. P. and Popper, D. M. Variable 27 in the globular cluster Messier 68. *A. S. P. Pub.*, v. 59, p. 143.

1780 Messier, 1783 Bode, 1784 Messier, 1814*b* W. Herschel, 1818*a* W. Herschel, 1847 J. Herschel 3404, 1862*IIb* Auwers, 1864 J. Herschel 3128, 1881 Smyth and Chambers, 1882*b* Flammarion, 1891-*i* Bigourdan, 1902 Gore, 1904 Webb, 1904, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1910 Porter, 1911*a* Hinks, 1915 Melotte, 1915*a* Bailey, 1917 Shapley and Davis, 1917*d* Flammarion, 1918*b* Bailey, 1918*c* Charlier, 1918*IIe* Shapley, 1919*IIcd* Shapley and Shapley, 1920*a* Lundmark, 1920*b* Shapley, 1923 Lundborg, 1923 von Zeipel, 1924 ten Bruggencate, 1925 Nabokov, 1925*b*, 1926 Doig, 1926*bf*, 1927*a* Parvulesco, 1927*i* ten Bruggencate, 1927 Sawyer and Shapley, 1927 Lönnquist, 1927*I*, *II*, 1929*ab* Shapley and Sawyer, 1929 Cannon, 1930*aefn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1937 Wilkens, 1939*a* Hachenberg, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland,1943 Cuffey, 1944 Shapley, 1945 Sawyer, 1946*ab* Mayall, 1946*ab* Mowbray.

NGC 4833 α 12^h^ 56^m^.0, δ − 70° 36′ l 271°, b − 08°

1755 Lacaille, Abbé de. First observation.
1923 Bailey, S. I. Eleven new southern variable stars. *Harv. Bull.*, no. 792.
1942 Wright, F. W. Eleven variable stars in the globular cluster NGC 4833. *Harv. Bull.*, no. 916.

1755 Lacaille I 4, 1828 Dunlop 164, 1847 J. Herschel 3444, 1861 J. Herschel, 1862*IIc* Auwers, 1864 J. Herschel 3325, 1881 Smyth and Chambers, 1908 Bailey, 1911*a* Hinks, 1915 Melotte, 1915*a*, 1918*b* Bailey, 1918*c* Charlier, 1918*IIe* Shapley, 1919*IIc* Shapley and Shapley, 1920*a* Lundmark, 1923 Lundborg, 1925 Nabokov, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1930*afkn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1939*a* Sawyer, 1941 de Kort, 1946*d* Mayall.

NGC 5024 (Messier 53) α^n 13^h^ 10^m^.5, δ + 18° 26′ l 306°, b + 79°

1777 Bode, J. E. Observed by him, Feb. 3, 1775.
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NGC 5053 α 13^h 13^m.9, $\delta + 17° 57'$ l 308°, $b + 78°$

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NGC 5139 (*ω* Centauri) α 13^{h} 23^{m}.8, δ − 47° 03′ l 277°, b + 15°

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NGC 5272 (Messier 3) α 13^h $39^m.9$ δ $+ 28° 38'$ l 7°, b + 77°

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1931 Mineur, H. Mises au point d'astronomie stellaire. III. Céphéides et amas. *Soc. Astr. France, Bull.*, v. 45, p. 194.

1932 Grosse, E. Untersuchungen über die veränderlichen Sterne im Kugelsternhaufen Messier 53. *A. N.*, v. 246, pp. 401-5; *Hamb.-Berg. Abh.*, v. 4, no. 2. (Comparison).

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1935 Greenstein, J. L. Two non-cluster type variables in Messier 3. *Harv. Bull.*, no. 901, pp. 11-16.

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1937 Joy, A. H. Spectrographic observations of Barnard's variable star in Messier 3. *Am. A. S. Pub.*, v. 9, p. 45.

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NGC 5286 α 13^h 43^m.0, δ − 51° 07′ *l* 280°, *b* + 10°

1828 Dunlop, J. First observation.

1828 Dunlop 388, 1847 J. Herschel 3533, 1864 J. Herschel 3642, 1881 Smyth and Chambers, 1908 Bailey, 1911*a* Hinks, 1915 Melotte, 1915*a*, 1918*b* Bailey, 1918*c* Charlier, 1918*IIc* Shapley, 1919*Ic*, *IIc* Shapley and Shapley, 1920*a* Lundmark, 1923 Lundborg, 1925 Nabokov, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1929 Cannon, 1930*afn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1939*a* Sawyer, 1941 de Kort, 1946*d* Mayall.

NGC 5466 α 14^h 03^m.2, δ + 28° 46′ *l* 8°, *b* + 72°

1786 Herschel, W. First observation, 1784 May 17.

1922 Hopmann, J. Der kugelförmige Sternhaufen NGC 5466. *A.N.*, v. 217, pp. 333-42.

NGC 5466 (Cont.)

1926 Baade, W. 5 isolierte Haufenveränderliche in der Umgebung des Kugelhaufens NGC 5466. *Hamb. Mitt.*, v. 6, no. 27.

1926 Baade, W. Der kugelförmige Sternhaufen NGC 5466. *Hamb. Mitt.*, v. 6, no. 27.

1927 Hopmann, J. Vergleich der Hamburger und Bonner Vermessungen des kugelförmigen Sternhaufens NGC 5466. *A. N.*, v. 229, p. 209.

1945 Sawyer, H. B. Light curves of the variable stars in the globular cluster NGC 5466. *Dunlap Pub.*, v. 1, no. 17. (Plate).

1786 W. Herschel VI 9, 1818*a* W. Herschel, 1833 J. Herschel 1746, 1856 d'Arrest, 1861 Earl of Rosse, 1862*IIa* Auwers, 1864 J. Herschel 3776, 1880 Earl of Rosse, 1891-*f* Bigourdan, 1904 Webb, 1904, 1907 Holetschek, 1915 Melotte, 1915 Kritzinger, 1918*ab* Charlier, 1918*IIf* Shapley, 1919*IIabcd* Shapley and Shapley, 1920*b* Shapley, 1925 Nabokov, 1925*a* Doig, 1926*f* Parvulesco, 1926 Reinmuth, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*ab* Shapley and Sawyer, 1930*afn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1934, 1935 Lundmark, 1936*ab* Stebbins and Whitford, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1944 Shapley, 1945 Sawyer (plate), 1946*d* Mayall, 1946*ab* Mowbray.

NGC 5634 α 14^h 27^m.0, δ − 05° 45′ l 311°, b + 48°

1786 Herschel, W. First observation, 1785 Mar. 5.

1914 Worssell, W. M. The Wolf-Palisa Chart No. 76: nebulae and condensed clusters. *Union Circ.*, no. 20.

1945 Baade, W. The globular clusters NGC 5634 and NGC 6229. *Mt. W. Cont.*, no. 706; *Ap. J.*, v. 102, pp. 17-25. (Plate.)

1786 W. Herschel I 70, 1833 J. Herschel 1813, 1856, 1861 d'Arrest, 1861 Earl of Rosse, 1862*IIa* Auwers, 1862 Schönfeld, 1864 J. Herschel 3900, 1867 d'Arrest, 1867 Schmidt, 1867 Vogel, 1880 Earl of Rosse, 1881 Smyth and Chambers, 1882 Engelmann, 1882*b* Flammarion, 1886 d'Engelhardt, 1891-*f* Bigourdan, 1891 Kempf, 1893 Stone, 1895*ab* Mönnichmeyer, 1904 Webb, 1907 Holetschek, 1909 Perrine, 1909 Winnecke, 1910 Porter, 1915 Melotte, 1915*a* Bailey, 1918*c* Charlier, 1918*IIe* Shapley, 1919*IIcd* Shapley and Shapley, 1920*a* Lundmark, 1920*b* Shapley, 1923 Lundborg, 1923 Wirtz, 1925 Nabokov, 1925*e* Doig, 1926*f* Parvulesco, 1926 Reinmuth, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1930*an* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1935 Shapley and Sayer, 1936*ab* Stebbins and Whitford, 1939*a* Sawyer, 1941 de Kort, 1944 Shapley, 1945 Sawyer, 1946*ab* Mayall, 1946*a* Mowbray.

NGC 5694 α 14^h 36^m.7, δ − 26° 19′ l 299°, b + 29°

1786 Herschel, W. First observation, 1784 May 22.

1932 Lampland, C. O., and Tombaugh, C. W. Object NGC 5694, a distant globular star cluster. *A. N.*, v. 246, pp. 171-2. See also *Obs.*, v. 55, p. 271.

1934 Baade, W. The distance of the globular cluster N.G.C. 5694. *A. S. P. Pub.*, v. 46, pp. 52-3.

1786 W. Herschel II 196, 1847 J. Herschel 3576, 1856 d'Arrest, 1862*IIa* Auwers, 1864 J. Herschel 3954, 1867 Schmidt, 1886 d'Engelhardt, 1891-*f* Bigourdan, 1893 Stone, 1910 Porter, 1936*ab* Stebbins and Whitford, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1944 Shapley, 1945 Sawyer, 1946*abc* Mayall, 1946*ab* Mowbray.

IC 4499 α 14^h 52^m.7, δ − 82° 02′ *l* 275°, *b* − 21°

1908 Stewart, D. First observation, 1901. Nebulae discovered at the Harvard College Observatory. Table III. List of nebulae and clusters found by Delisle Stewart. *Harv. Ann.*, v. 60, pp. 156-72.

1908 Dreyer, 1915 Melotte, 1918*ab* Charlier, 1919*IIac* Shapley and Shapley, 1922*a* Shapley, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I, II*, 1929*b* Shapley and Sawyer, 1930*an* Shapley, 1932, 1933 van de Kamp, 1941 de Kort, 1946*d* Mayall.

NGC 5824 α 15^h 00^m.9, δ − 32° 53′ *l* 300°, *b* + 21°

1884 Barnard, E. E. First observation. Erroneous description of a nebula. *Sid. Mess.*, v. 3, p. 189.

1926 Innes, R. The globular star-cluster NGC 5824. *Union Circ., no.* 66, p. 328.

1910 Porter, 1927*II*, 1929*b* Shapley and Sawyer, 1929 Cannon, 1930*an* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1936*a* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1946*ab* Mayall, 1946*a* Mowbray.

NGC 5897 α 15^h 14^m.5, δ − 20° 50′ *l* 311°, *b* + 29°

1786 Herschel, W. First observation, 1785 Mar. 10.

1912 Dreyer, J. L. E. Corrections to the New General Catalogue. *M. N.*, v. 73, p. 40.

1915 Knox Shaw, H. Note on the nebulae and star clusters shown on the Franklin-Adams plates. *M. N.*, v. 76, p. 105.

1786 W. Herschel VI 19, 1847 J. Herschel 3596, 1862*IIa* Auwers, 1864 J. Herschel 4075, 1881 Smyth and Chambers, 1891-*a* Bigourdan, 1904 Webb, 1904, 1907 Holetschek, 1915 Melotte, 1915*a* Bailey, 1915 Kritzinger, 1918*c* Charlier, 1918*IIe* Shapley, 1919*IIbcd* Shapley and Shapley, 1920*ab* Lundmark, 1920*b* Shapley, 1925 Nabokov, 1925*b* Doig, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927 *I, II*, 1929*ab* Shapley and Sawyer, 1930*akn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1936*ab* Stebbins and Whitford, 1937 Wilkens, 1940 Christie, 1941 de Kort, 1941 Copeland, 1944 Shapley, 1945 Sawyer, 1946*d* Mayall, 1946*ab* Mowbray.

NGC 5904 (Messier 5) α 15^h 16^m.0, δ + 02° 16′ *l* 332°, *b* + 46°

1702 Kirch, G. Discovery, 1702 May 5. Diary of Marie Margarethe Kirch. See Dreyer, *R. Irish Acad. Trans.*, v. 26, p. 397, 1878.

1771 Messier, C. Observation 1764, May 23. On chart of comet of 1763, *Mém.* 1774, p. 40.

1890 Common, A. A. Note on some variable stars near the cluster 5 M. *M. N.*, v. 50, p. 517.

1890 Packer, D. E. On a new variable star near the cluster 5 M Librae. *Sid. Mess.*, v. 9, p. 381; *Eng. Mech.*, v. 51, p. 378.

1890 Packer, D. E. New variable stars near the cluster 5 M Librae. *Sid. Mess.*, v. 10, p. 107.

1890 Packer, D. E. The variable stars (true and false) near 5 M Librae. *Eng. Mech.*, v. 52, p. 80.

1890 Fleming, W. P. Stars having peculiar spectra. (Contains note on Mr. Packer's variables near 5 M Librae). *Sid. Mess.*, v. 9, p. 380.

NGC **5904** (Cont.)

1890 Fleming, W. P. Two new variable stars near the cluster 5 M Librae. *A. N.*, v. 125, p. 157.

1891 Common, A. A. Mr. Common's Observatory, Ealing. *M. N.*, v. 51, p. 226.

1894 Sprague, R. Star clusters. *Pop. Astr.*, v. 1, pp. 407-9.

1896 Pickering, E. C. The cluster Messier 5 Serpentis, NGC 5904. *A. N.*, v. 140, p. 285.

1897 Pickering, E. C. Measures of positions. *Harv. Ann.*, v. 26, pp. 226-48.

1898 Barnard, E. E. Note on some of the variable stars of the cluster Messier 5. *A. N.*, v. 147, p. 243.

1898 Bailey, S. I. Variable stars in clusters. *Am. A. S. Pub.*, v. 1, p. 49.

1898 Shilow, M. Positionen von 1041 Sternen des Sternhaufens 5 Messiers, aus photographisches Aufnahmen abgeleitet. *Acad. Imp. des Sci. St. Petersbourg, Bull.*, V ser., Bd. 8, No. 4.

1899 Bailey, S. I. The periods of the variable stars in the cluster Messier 5. *Ap. J.*, v. 10, p. 255; *Am. A. S. Pub.*, v. 1, p. 96.

1899 Bailey, S. I. Note on the relation between the visual and photographic light-curves of variable stars of short period. *Ap. J.* v. 10, pp. 261-5; *Am. A. S. Pub.*, v. 1, p. 97.

1899 Barnard, E. E. Variable stars in clusters. *Am. A. S. Pub.*, v. 1, p. 77; *Science*, n. s., v. 10, p. 789. (The cluster is referred to as M 13, but from internal evidence M 5 must be meant).

1899 Barnard, E. E. Triangulation of star clusters. *Am. A. S. Pub.*, v. 1, p. 77; *Science*, v. 10, p. 789.

1902 Barnard, E. E. On some of the variable stars in the cluster M 5 Librae. *Am. A. S. Pub.*, v. 1, p. 193; *Science*, n.s., v. 17, p. 330, 1903.

1902 Barnard, E. E. Micrometrical measures of individual stars in the great globular clusters. *Am. A. S. Pub.*, v. 1, p. 193; *Science*, n. s., v. 17, p. 330, 1903.

1905 Bailey, S. I. Variable stars in the clusters Messier 3 and Messier 5. *Harv. Circ.*, no. 100.

1905 Bailey, S. I. Some variable star problems. *Am. A. S. Pub.*, v. 1, p. 234.

1908 Barnard, E. E. On the constancy of the period of the variable star, M 5 (Librae) No. 33. *Am. A. S. Pub.*, v. 1, p. 298.

1910 Barnard, E. E. On the period and light curve of the variable star no. 33, M 5 (Libra) and on the possible use of such a star as a time constant. *A. N.*, v. 184, p. 273.

1912 Barnard, E. E. The period of the variable star no. 33, M. 5 (Libra). *A. N.*, v. 191, pp. 439-42.

1913 Barnard, E. E. The variable star no. 33 in the cluster M 5. *A. N.*, v. 196, pp. 11-14.

1914 Strömgren, E., and Drachmann, B. Über die Verteilung der Sterne in kugelförmigen Sternhaufen, mit besonderer Rücksicht auf Messier 5. *Kobenhavns Pub.*, no. 16.

1916 Bailey, S. I. Cluster variables with double maxima. *Harv. Circ.*, no. 193.

1916 Shapley, H. Studies. III. The colors of the brighter stars in four globular systems. *Mt. W. Comm.*, no. 34; *Nat. Acad. Sci. Proc.*, v. 2, p. 525.

NGC 5904 (Cont.)

1917 Bailey, S. I. Variable stars in the cluster Messier 5. *Harv. Ann.*, v. 78, pt. 2, pp. 103-93 (Plate).

1917 Bailey, S. I. Note on the form of the light curve of variable stars of cluster type. (Abs.) *Pop. Astr.*, v. 25, p. 307.

1917 Eddington, A. S. Researches on globular clusters. *Obs.*, v. 40, pp. 394-401.

1917 Shapley, H. Studies. V. Further evidence of the absence of scattering of light in space. *Mt. W. Comm.*, no. 44; *Nat. Acad. Soc. Proc.*, v. 3, pp. 267-70.

1917 Shapley, H. Studies. VII. A method for the determination of the relative distances of globular clusters. *Mt. W. Comm.*, no. 47; *Nat. Acad. Sci. Proc.*, v. 3, pp. 479-84.

1917 Lundmark, K., and Lindblad, B. Photographic effective wave-lengths of some spiral nebulae and globular clusters. *Ap. J.*, v. 46, pp. 206-18; *A. N.*, v. 205, pp. 161-70. Second paper, *Ap. J.*, v. 50, pp. 376-90, 1919.

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1918 Shapley, H., and Davis, H. Note on the distribution of stars in the globular cluster Messier 5. *A. S. P. Pub.*, v. 30, p. 164.

1919 Barnard, E. E. On the change in the period of the variable star Bailey no. 33 in the cluster M 5. *Pop. Astr.*, v. 27, p. 522.

1919 Plummer, H. C. An analysis of the magnitude curves of the variable stars in four clusters. *M. N.*, v. 79, pp. 639-57.

1919 Schouten, W. J. A. The parallax of some stellar clusters. *Obs.*, v. 42, pp. 112-19; *A. N.*, v. 208, pp. 317-24.

1920 Turner, H. H. Note on the changes of period in the variable Bailey no. 33 in the cluster M 5. *M. N.*, v. 80, pp. 640-42.

1920 Turner, H. H. Further note on Barnard's observations of variable Bailey no. 33 in the cluster M 5, with a suggestion that the comparison star k is a short-period variable. *M. N.*, v. 81, pp. 71-83.

1921 Shapley, H. The scale of the universe. Pt. I. *Nat. Res. Coun. Bull.*, v. 2, p. 171.

1922 Barnard, E. E. On the change in the period of the variable star Bailey no. 33 in the cluster M 5. (Abs.) *Pop. Astr.*, v. 30, p. 548; *Am. A. S. Pub.*, v. 4, p. 351.

1922 Kapteyn, J. C., and van Rhijn, P. J. The proper motion of δ Cephei stars and the distances of the globular clusters. *B. A. N.*, v. 1, p. 37.

1922 Shapley, H. Note on the velocity of light. *Harv. Bull.*, no. 763; *Pop. Astr.*, v. 30, p. 192.

1922 Shapley, H. Parallax of Messier 5. *Harv. Bull.*, no. 763; *Pop. Astr.*, v. 30, p. 193.

1925 Strömgren, E. Om bevaegelses mulighederne i stjernehobe. *Nord. A. Tids.*, v. 6, pp. 21-8.

1927 Shapley, H. The periods of seventy-three variables in Messier 5. *Harv. Bull.*, no. 851. See also summary, The periods of variable stars in M 5. *Obs.*, v. 50, p. 390, 1927.

1931 Barnard, E. E. Micrometric measures of star clusters. *Yerkes Pub.*, v. 6, pp. 52-61.

NGC 5904 (Cont.)

1931 Mineur, H. Mises au point d'astronomie stellaire. III. Céphéides et amas. *Soc. Astr. France, Bull.*, v. 45, p. 194.

1932 Grosse, E. Untersuchungen über die veränderlichen Sterne im Kugelsternhaufen Messier 53. *A. N.*, v. 246, pp. 401-5; *Hamb.-Berg. Abh.*, v. 4, no. 2. (Comparison of clusters).

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1933 Küstner, F. Die kugelförmigen Sternhaufen Messier 12 und Messier 5. *Bonn. Veröff.*, v. 26, 57 pp. (Catalogue of 1144 stars in M5).

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1936 Lohman, W. Die Verteilung des Lichtes in den kugelförmigen Sternhaufen M 5, M 15 und M 92. *Z. f. Ap.* v. 12, no. 1, pp. 1-39.

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1771 Messier, 1777 Bode 29, 1780, 1784 Messier, 1800, 1814*c*, 1818*ab*. (1912) W. Herschel, 1833 J. Herschel 1916 (fig.), 1852 Secchi, 1853 Laugier 43, 1855, 1856 d'Arrest, 1861 Earl of Rosse, 1861 J. Herschel, 1862*I*, *IIb* Auwers, 1864 J. Herschel 4083, 1865 Auwers, 1867 Schmidt, 1867 Vogel, 1867 d'Arrest, 1867*ab* Chambers, 1868 Webb, 1880 Earl of Rosse, 1881 Smyth and Chambers (fig. 31), 1882 Engelmann, 1882*ab* Flammarion, 1888 Ginzel, 1890 d'Engelhardt, 1891-*a* Bigourdan, 1893 Roberts, 1894 Gore, 1895, 1897, 1898*I*, *II* Pickering, 1897 Barnard, 1895*ab* Mönnichmeyer, 1902*abc* Bailey, 1902 Gore, 1903 Clerke, 1904, 1907 Holetschek, 1908 Bailey (plate), 1908 Keeler (plate 52), 1909 Perrine, 1910 See (plate), 1911 Wirtz, 1911*a* Hinks, 1912 See (plate), 1913 Bailey, 1913 Fath, 1913 Chapman, 1914 Strömgren and Drachmann, 1915*I*, *II* Plummer, 1915 Melotte, 1915*a* Bailey, 1915 Kritzinger, 1916 Wilson, 1916 Shapley, 1917 Slipher, 1917 Shapley and Davis, 1917 Shapley, 1917*a* Flammarion, 1918 Curtis, 1918 Slipher, 1918*c* Charlier, 1918*Iabc*, *IIabd*, *III*, *Va* Shapley, 1919*a* Bailey, Leland, and Woods, 1919*b* Lundmark, 1919*Iac*, *IIcd* Shapley and Shapley, 1920 Hoffmeister, 1920 Hopmann (plate), 1920 Lous, 1920*abc* Lundmark, 1920*b* Shapley, 1922*I* Becker, 1922 Kostitzin, 1923 Lundborg, 1923 Wirtz, 1923 von Zeipel, 1924 Vogt, 1925 Larink, 1925 Nabokov, 1925 Strömberg, 1925*b*, 1926 Doig, 1926 Reinmuth, 1926 *acdef*, 1927*abc* Parvulesco (print), 1927*bh* ten Bruggencate, 1927 Kienle, 1927 Sawyer and Shapley, 1927 Lönnquist, 1927*I*, *II* Shapley and Sawyer, 1928 van Rhijn, 1928 Voûte, 1929 Cannon, 1929*ab* Shapley and Sawyer, 1930 Heckmann and Siedentopf, 1930*afghklmnq* Shapley, 1930 Parenago, 1931 Harrison, 1931 Nabokov, 1932 Bernheimer, 1932 Moore, 1932, 1933 van de Kamp, 1932*ab* Sawyer, 1933*a* Grosse, 1933 Stebbins, 1933 Vyssotsky and Williams, 1934, 1935 Lundmark, 1935*a* Baade, 1935*ab* Edmondson, 1935 Shiveshwarkar, 1935 Mineur, 1935*a* Sawyer, 1935 Shapley and Sayer, 1936 Duryea, 1936*ab* Stebbins and Whitford, 1937 Wilkens, 1939*b* Hachenberg, 1939*ab* Sawyer, 1939 Oosterhoff, 1940 Christie, 1941 de Kort, 1941 Copeland, 1942*a* Sawyer, 1943*a* Oosterhoff, 1944 Shapley, 1944*I*, 1945 Sawyer, 1945 Finlay-Freundlich, 1946*ab* Mayall, 1946*ab* Mowbray. [1904 Perrine, 1904 Webb].

NGC 5927 α 15^h 24^m.4, δ − 50° 29′ l 294°, b + 04°

1828 Dunlop, J. First observation.

1828 Dunlop 389, 1847 J. Herschel 3604, 1864 J. Herschel 4101, 1881 Smyth and Chambers, 1915 Melotte, 1915*a* Bailey, 1918*c* Charlier, 1919*IIac* Shapley and Shapley, 1920*a* Lundmark, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1930*an* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1941 de Kort, 1946*d* Mayall.

NGC 5946 $\alpha\ 15^h\ 31^m.8,\ \delta - 50°\ 30'$ $l\ 295°,\ b + 03°$

1847 Herschel, J. First observation, 1834 July 7.

1847 J. Herschel 3607, 1864 J. Herschel 4108, 1881 Smyth and Chambers, 1915 Melotte, 1915*a* Bailey, 1918*d* Charlier, 1919*IIac* Shapley and Shapley, 1922*a* Shapley, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I, II*, 1929*b* Shapley and Sawyer, 1930*an* Shapley, 1931 Nabokov, 1946*d* Mayall.

NGC 5986 $\alpha\ 15^h\ 42^m.8,\ \delta - 37°\ 37'$ $l\ 305°,\ b + 13°$

1828 Dunlop, J. First observation.

1915 Bailey, S. I. Globular clusters: distribution of stars. *Harv. Ann.*, v. 76, no. 4.

1828 Dunlop 552, 1847 J. Herschel 3611, 1861 J. Herschel, 1864 J. Herschel 4132, 1881 Smyth and Chambers, 1897, 1898*II* Pickering, 1902*a*, 1908 Bailey, 1911*a* Hinks, 1915*I* Plummer, 1915 Melotte, 1915*ab* Bailey, 1918*c* Charlier, 1918*IIe* Shapley, 1919*Ic, IIc* Shapley and Shapley, 1920 Hoffmeister, 1920*a* Lundmark, 1923 Lundborg, 1925 Nabokov, 1926*f* Parvulesco, 1927*d* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I, II*, 1929*b* Shapley and Sawyer, 1929 Cannon, 1930*afn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1936*a* Stebbins and Whitford, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1946*ab* Mayall, 1946*a* Mowbray.

NGC 6093 (Messier 80) $\alpha\ 16^h\ 14^m.1,\ \delta - 22°\ 52'$ $l\ 321°,\ b + 18°$

1781 Méchain, P. F. A. First observation, 1781 Jan. 4, Jan. 27.

1785 Herschel, W. On the construction of the heavens. An opening in the heavens. *Roy. Soc. Phil. Trans.*, v. 75, pp. 213-66.

1860 Luther, E. Aus einem Schreiben des Herrn Prof. Luther, Directors der Sternwarte in Königsberg, an den Herausgeber. *A. N.*, v. 53, p. 293. (Auwers and Luther saw nova on May 21, mag. 6.5.).

1860 Pogson, N. Remarkable changes observed in the cluster 80 Messier. *M. N.*, v. 21, p. 32.

1860 Smyth, W. H. *Speculum Hartwellianum.* London, 1860. Pp. 265-71, and p. 104. 80 M. Scorpii. (Observations on R and S Scorpii).

1861 Schmidt, J. F. J. Über einen neuen veränderlichen Nebelstern. *A. N.*, v. 55, p. 93.

1862 Auwers, A. Verzeichniss der Örter von vierzig Nebelflecken, aus Beobachtungen am Königsberger Heliometer abgeleitet. *A. N.*, v. 58, p. 374. (Accurate position of nova).

1865 Schönfeld, E. Mittlere Oerter für 1855.0 von veränderlichen Sternen mit Einschluss derjenigen neuen Sterne, deren Positionen sich mit einiger Sicherheit bestimmen lassen. *A. N.*, v. 64, p. 169.

1867 Schmidt, J. F. J. Bemerkungen über Nebel und veränderliche Sterne. *A. N.*, v. 70, p. 250. (Positions of nova and variables).

1868 Schönfeld, E. Notiz über die Oerter der Veränderlichen R, S, T Scorpii. *A. N.*, v. 70, p. 333. (Positions).

1868 Schmidt, J. F. J. Ueber veränderliche Sterne, R, S, T Scorpii. *A. N.*, v. 72, p. 56.

1868 Schmidt, J. F. J. Bemerkungen über einige veränderliche Sterne. *A. N.*, v. 72, p. 141. (T Scorpii not seen since 1860).

NGC 6093 (Cont.)

1870 Schmidt, J. F. J. Beobachtungen von veränderlichen Sternen auf der Sternwarte zu Athen im Jahre 1870. *A. N.*, v. 77, p. 123. (T Scorpii not seen since 1860).

1877 Schmidt, J. F. J. Veränderliche Sterne, 1876. *A. N.*, v. 89, p. 159. (He observed this cluster at least a thousand times after 1860, but never saw T Scorpii again after June 1860).

1881 Smyth, W. H., and Chambers, G. F. *A cycle of celestial objects.* P. 452, figs. 32, 33. (Variable stars near 80 M Scorpii).

1886 Auwers, A. Aus einem Schreiben des Herrn Geheimrath Auwers an den Herausgeber betr. die Erklärung der s.g. neuen Sterne, und Beobachtungen der Nova Scorpii von 1860. *A. N.*, v. 114, p. 47. (Observations of the nova from Königsberg records, 1860).

1902 Baxendell, J. Notes on Pogson's observations of U Geminorum, T Scorpii, etc. *A. J.*, v. 22, p. 127. (The nova, or another variable, was seen in 1863.)

1922 Slipher, V. M. Further notes on spectrographic observations of nebulae and clusters. (Abs.) *Pop. Astr.*, v. 30, pp. 9-11.

1930 Shapley, H., and Sawyer, H. B. Variable stars in globular clusters. (Abs.) *Pop. Astr.*, v. 38, p. 408.

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1942 Sawyer, H. B. Variable stars in the globular cluster Messier 80. *Dunlap Pub.*, v. 1, no. 12.

1781 Méchain, 1783 Bode 1784 Messier, 1814*c*, 1818*a* W. Herschel, 1847 J. Herschel 3624, 1855, 1856 d'Arrest, 1861 J. Herschel, 1862*I*, *IIb* Auwers, 1864 J. Herschel 4173, 1865 Auwers, 1867 Schmidt, 1867 Vogel, 1867*ab* Chambers, 1868 Webb, 1875 Schönfeld, 1880 Earl of Rosse, 1882 Engelmann, 1882*b* Flammarion, 1886 d'Engelhardt, 1886- Weinek and Gruss, 1891-*ck* Bigourdan, 1891 Kempf, 1895 Rümker, 1895*ab* Mönnichmeyer, 1898*II* Pickering, 1902*abc* Bailey, 1902 Gore, 1904 Webb, 1904, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1909 Winnecke, 1910 Porter, 1911 Wirtz, 1911*a* Hinks, 1912 Curtis, 1913 Fath, 1915 Melotte, 1915*a* Bailey, 1915 Kritzinger, 1917 Shapley and Davis, 1917 Pease and Shapley, 1917*d* Flammarion, 1918*a* Bailey, 1918 Curtis, 1918*c* Charlier, 1918-*IIbd* Shapley, 1919*Ic*, *IIcd* Shapley and Shapley, 1920 Hoffmeister, 1920*a* Lundmark, 1920*b* Shapley, 1922*I* Becker, 1923 Lundborg, 1925 Strömberg, 1925, 1926 Nabokov, 1925*d*, 1926 Doig, 1926*f* Parvulesco, 1926*II* Vorontsov-Velyaminov, 1927*h* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II* Shapley and Sawyer, 1928 van Rhijn, 1928 Voûte, 1929 Cannon, 1929*ab* Shapley and Sawyer, 1929 Vorontsov-Velyaminov, 1930*afgnq* Shapley, 1931 Nabokov, 1932 Moore, 1932, 1933 van de Kamp, 1935*ab* Edmondson, 1935 Shiveshwarkar, 1935 Mineur, 1935 Shapley and Sayer, 1936 Duryea, 1936*ab* Stebbins and Whitford, 1937 Wilkens, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1946*abc* Mayall, 1946*ab* Mowbray.

NGC 6101 α $16^h\ 20^m.0$, δ $-$ 72° 06′ l 285°, b $-$ 17°

1828 Dunlop, J. First observation.

1828 Dunlop 68, 1847 J. Herschel 3623, 1864 J. Herschel 4175, 1881 Smyth and Chambers, 1915 Melotte, 1915*a* Bailey, 1918*c* Charlier, 1918*IIe* Shapley, 1919*IIc* Shapley and Shapley, 1920*a* Lundmark, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1930*akn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1941 de Kort, 1946*d* Mayall.

NGC 6121 (Messier 4) α 16^h 20^m.6, δ − 26° 24′ l 319°, b + 15°

1746 de Chéseaux, L. Discovery. Letter to French Academy. Published by Bigourdan, *Paris. Ann. Observations*, 1884, G8-10, pub. 1891; *Obs.*, 1907, E135-7, pub. 1917.

1771 Messier, C. Observation 1764 May 8.

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1755 Lacaille I 9, 1771 Messier, 1777 Bode 31, 1780, 1781 Messier, 1814*a*, 1818*a*, (1912) W. Herschel, 1855, 1856 d'Arrest, 1862*IIbc* Auwers, 1864 J. Herschel 4183, 1867*a* Chambers, 1881 Smyth and Chambers, 1882*b* Flammarion, 1891-*c* Bigourdan, 1902 Gore, 1904 Webb, 1904, 1907 Holetschek, 1908 Bailey (plate), 1911*a* Hinks, 1915 Melotte, 1915*a* Bailey, 1916 Wilson, 1916 Shapley, 1917 Shapley and Davis, 1917 Shapley, 1917*a* Flammarion, 1918*a* Bailey, 1918*c* Charlier, 1918*IIbd* Shapley, 1919*Iac*, *IIcd* Shapley and Shapley, 1920 Hoffmeister, 1920*a* Lundmark, 1920*b* Shapley, 1923 Lundborg, 1925 Nabokov, 1925*d*, 1926 Doig, 1926*II* Vorontsov-Velyaminov, 1926*f*, 1927*a* Parvulesco, 1927*h* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II* Shapley and Sawyer, 1928 van Rhijn, 1929 Cannon, 1929*ab* Shapley and Sawyer, 1929 Vorontsov-Velyaminov, 1930 Parenago, 1930*afknp* Shapley, 1931 Nabokov, 1932 Bernheimer, 1932 Hogg, 1932, 1933 van de Kamp, 1932*ab* Sawyer, 1933 Stebbins, 1933 Vyssotsky and Williams, 1935 Shapley and Sayer, 1936 Duryea, 1936*ab* Stebbins and Whitford, 1937 Wilkens, 1939*ab* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1944*II* Sawyer, 1946*d* Mayall, 1946*ab* Mowbray.

NGC 6139 α 16^h 24^m.3, δ − 38° 44′ l 310°, b + 06°

1828 Dunlop. J. First observation.

1919 Hubble, E. Two new globular clusters. *Mt. W. Rep.*, no. 9, p. 233, according to *Harv. Bull.*, no. 776, 1922.

1828 Dunlop 536, 1847 J. Herschel 3628, 1864 J. Herschel 4189, 1881 Smyth and Chambers, 1922*a* Shapley, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1930*akn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1936*a* Stebbins and Whitford, 1941 de Kort, 1946*d* Mayall.

NGC 6144 $\alpha\ 16^h\ 24^m.2,\ \delta - 25°\ 56'$ $l\ 320°, b + 14°$

1786 Herschel, W. First observation, 1784 May 22.

1786 W. Herschel VI 10, 1818*a* W. Herschel, 1847 J. Herschel 3629, 1862*IIa* Auwers, 1864 J. Herschel 4193, 1891-*c* Bigourdan, 1915 Melotte, 1918*ab* Charlier, 1918*IIe* Shapley, 1919*IIbc* Shapley and Shapley, 1920*a* Lundmark, 1926 Doig, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*ab* Shapley and Sawyer, 1929 Vorontsov-Velyaminov, 1930 Parenago, 1930*akn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1935 Shapley and Sayer, 1936*a* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1941 Copeland, 1946*d* Mayall, 1946*ab* Mowbray.

NGC 6171 (Messier 107) $\alpha\ 16^h\ 29^m.7,\ \delta - 12°\ 57'$ $l\ 331°, b + 22°$

1783 Méchain, P.F.A. First observation, 1782 April.

1802 Herschel, W. Independent observation, 1793 May 12.

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1783 Méchain, 1802 W. Herschel VI 40, 1847 J. Herschel 3637, 1856 d'Arrest, 1861 J. Herschel, 1862*IIa* Auwers, 1862 Schönfeld, 1864 J. Herschel 4211, 1867 Vogel, 1867*a* Chambers, 1880 Earl of Rosse, 1881 Smyth and Chambers, 1882*b* Flammarion, 1890 d'Engelhardt, 1891-*c* Bigourdan, 1904 Webb, 1904, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1910 Porter, 1911 Wirtz, 1911*a* Hinks, 1912 Curtis, 1915 Melotte, 1915*a* Bailey, 1915 Kritzinger, 1918 Curtis, 1918*c* Charlier, 1918*IIe* Shapley, 1919*Ic*, *IIcd* Shapley and Shapley, 1920*a* Lundmark, 1920*b* Shapley, 1922*I* Becker, 1923 Wirtz, 1925 Nabokov, 1925*b* Doig, 1926*f* Parvulesco, 1926 Reinmuth, 1927*h* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*ab* Shapley and Sawyer, 1929 Vorontsov-Velyaminov, 1930*an* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1936 Duryea, 1936*ab* Stebbins and Whitford, 1937 Wilkens, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1946*ab* Mayall, 1946*ab* Mowbray.

NGC 6205 (Messier 13) $\alpha\ 16^h\ 39^m.9,\ \delta + 36°\ 33'$ $l\ 26°, b + 40°$

1715 Halley, E. Discovery.

1716 Pound. Positions of nebulae in Hercules and Antinous for 1690, by Pound's observations; deduced by Halley, 1716. Bradley's miscellaneous works [Rigaud] p. iii "Memoirs of Bradley," 1832.

1771 Messier, C. Observation, 1764 June 1. On chart of comet of 1779, *Mém.* 1779.

1839 Bianchi, J. Schreiben des Herrn Bianchi, Directors der Sternwarte zu Modena, an den Herausgeber. *A. N.*, v. 16, pp. 371-4.

1843 Argelander, D. Fr. *Uranometria Nova*, p. 32, Berlin.

1844 von Humboldt, A. *Cosmos.* Milan 1851 edition, v. 3, p. 114. Amas d'étoiles.

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1861 Rosse, Earl of. On the construction of specula of six-feet aperture, and a selection from the observations of nebulae made with them. Plate xxviii, fig. 33 drawing. *Roy. Soc. Phil. Trans.*, v. 151, pp. 681-745. (Dark lanes).

1866 Schultz, H. Historische Nötigen über Nebelflecke. *A. N.*, v. 67, p. 4.

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1891 Holden, E. S. Characteristic forms within the cluster in Hercules. *A. S. P. Pub.*, v. 3, p. 375.

1892 Scheiner, J. Der grossen Sternhaufen im Hercules Messier 13 nach Aufnahmen am Potsdamer photographischen Refractor. *K. Preuss. Ak. Wiss. Abhand.*, Abhang I, pp. 1-55. (Chart).

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1893 Scheiner, J. Der grosse Sternhaufen im Hercules. *Himmel und Erde*, v. 6, pp. 105-14. (Drawings of nebulosities).

1893 Scheiner, J. Über die Liapunow'schen Messungen im Sternhaufen Messier 13. *A. N.*, v. 132, p. 203.

1894 Burnham, S. W. Seventeenth catalogue of new double stars discovered at the Lick Observatory. *Lick Pub.*, v. 2, pp. 215-6.

1894 Flammarion, C. L'amas d'Hercule. *L'Astronomie*, v. 13, pp. 361-71.

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1909 Barnard, E. E. On the colors of some of the stars in the globular cluster M 13 Herculis. *Ap. J.*, v. 29, p. 72.

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1915 Bailey, S. I. Globular clusters: distribution of stars. *Harv. Ann.*, v. 76, no. 4.

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NGC 6205 (Cont.)

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1715 Halley, 1746 de Chéseaux, 1771 Messier, 1777 Bode 30, 1780, 1784 Messier, 1800, 1814*c*, 1818*ab*, (1912) W. Herschel, 1833 J. Herschel 1968 (fig.), 1852 Secchi (drawing), 1853 Laugier 44, 1861 J. Herschel (drawing) 1862*I*, *IIb* Auwers, 1862 Schönfeld, 1864 J. Herschel 4230, 1864 Rümker, 1865 Auwers, 1866 Huggins, 1861, 1867 Schmidt, 1867 Vogel, 1867 d'Arrest, 1867*ab* Chambers, 1868 Webb, 1875 Schönfeld, 1880 Earl of Rosse, 1881 Smyth and Chambers (fig. 34) 1882*ab* Flammarion, 1884 Pickering, Searle and Wendell, 1886 d'Engelhardt, 1891-*c* Bigourdan, 1893, 1899 Roberts, 1894 Gore, 1895 Mönnichmeyer, 1897 Barnard, 1898*II* Pickering, 1899 Rabourdin (photos), 1902*abc* Bailey, 1902 Gore, 1903 Clerke,

NGC 6205 (Cont.)

1904 Perrine, 1904 Webb (photo), 1904, 1907 Holetschek, 1908 Bailey (plate), 1908 Keeler (plate 53), 1909 Perrine, 1910 See (plate), 1911 Fath, 1911*a* Hinks, 1912 See (plate), 1913*ab* von Zeipel, 1913 Chapman, 1913 Fath, 1914 Strömgren and Drachmann, 1915*I, II* Plummer (plate), 1915 Melotte, 1915*ab* Bailey, 1916 Wilson, 1916 Eddington, 1916, 1917 Shapley, 1917 Slipher, 1917 Shapley and Davis, 1917 Pease and Shapley, 1917*b* Flammarion, 1918*a* Bailey, 1918 Curtis, 1918 Slipher, 1918*c* Charlier, 1918*Iac, IIabd, III, IVc, Va, VI* Shapley, 1919*ab* Lundmark, 1919*Iac, IIcd* Shapley and Shapley, 1919*ab* Shapley (plate), 1920 Hoffmeister, 1920 Hopmann, 1920 Lous, 1920*abc* Lundmark, 1920*b* Shapley, 1922*I, II* Becker, 1922 Kostitzin, 1923 Lundborg, 1923 von Zeipel, 1924 ten Bruggencate, 1924*I, II* Silberstein, 1924 Vogt, 1925 Larink, 1925 Nabokov, 1925 Strömberg, 1925*b*, 1926 Doig, 1926 Reinmuth, 1926*I* Vorontsov-Velyaminov, 1926*abcdef*, 1927*abcd* Parvulesco, 1927*abcdeghi* ten Bruggencate (plate), 1927 Kienle, 1927 Sawyer and Shapley, 1927 Lönnquist, 1927*I, II* Shapley and Sawyer, 1928 van Rhijn, 1928 Voûte, 1929 Cannon, 1929*ab* Shapley and Sawyer, 1930 Heckmann and Siedentopf, 1930 Parenago, 1930*aefgknqt* Shapley, 1931 Harrison, 1931 Nabokov, 1932 Bernheimer, 1932 Moore, 1932, 1933 van de Kamp, 1932*b* Sawyer, 1933 Vyssotsky and Williams, 1934, 1935 Lundmark, 1935*abc* Edmondson, 1935 Shiveshwarkar, 1935 Mineur, 1935*a* Sawyer, 1935 Shapley and Sayer, 1936 Duryea, 1936*ab* Stebbins and Whitford, 1937 Wilkens, 1939*a* Hachenberg, 1939*ab* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1943 Cuffey, 1943, 1944 Shapley, 1945 Finlay-Freundlich, 1945 Sawyer, 1946*ab* Mayall, 1946*ab* Mowbray.

NGC 6218 (Messier 12) $\alpha\ 16^{h}\ 44^{m}.6,\ \delta - 01^{\circ}\ 52'$ $l\ 343^{\circ},\ b + 25^{\circ}$

1771 Messier, C. First observation, 1764 May 30. On second chart of comet of 1769, *Mém*, 1775, pl. IX.

1919 Sanford, R. F. Radial velocities of clusters. *Mt. W. Rep.*, no. 15, p. 250.

1925 Parvulesco, C. Sur la distribution des étoiles dans les amas globulaires M 9, M 10, M 12 et la théorie cinétique des gaz. *C.R.*, v. 181, pp. 500-2.

1929 Heckmann, O., and Siedentopf, H. Über die Struktur der kugelförmigen Sternhaufen. *Gött. Veröff.* no. 6; *Z.f. Phys.*, v. 54, p. 183.

1933 Küstner, F. Die kugelförmigen Sternhaufen Messier 12 und Messier 5. *Bonn Veröff.*, no. 26, 57 pp. (Co-ordinates of 489 stars in M 12).

1938 Sawyer, H. B. One hundred and thirty-two new variable stars in five globular clusters. (Plate). *Dom. Ap. Pub.*, v. 7, no. 5.

1938 Sawyer, H. B. The light curves of two variable stars in the globular clusters NGC 6218 and NGC 6254. *Dunlap Pub.*, v. 1, pp. 59-68.

1942 Nassau, J. J., and Hynek, J. A. Magnitudes and colors in the globular cluster Messier 12 and Selected Area 108. *Ap. J.*, v. 96, no. 1; *Warner and Swasey repr.*, no. 22. Summary, Federer, *Sky and Telescope*, v. 1, no. 4, p. 7.

1771 Messier, 1777 Bode 32, 1780, 1784 Messier, 1818*ab*, (1912) W. Herschel, 1833 J. Herschel 1971, 1861 Earl of Rosse, 1862*I, IIb* Auwers, 1864 J. Herschel 4238, 1865 Auwers, 1866 Huggins, 1867 Vogel, 1867 d'Arrest, 1867*a* Chambers, 1868 Webb, 1880 Earl of Rosse, 1881 Smyth and Chambers, 1882*b* Flammarion, 1886 d'Engelhardt, 1886- Weinek and Gruss, 1891-*c* Bigourdan, 1891 Kempf, 1893 Roberts, 1895 Pickering, 1897 Barnard, 1902 Gore, 1904 Perrine, 1904 Webb, 1904, 1907 Holetschek, 1908 Bailey, 1908 Keeler (pl. 54), 1909 Perrine, 1910 See (plate), 1911 Wirtz, 1911*a* Hinks, 1912 See (plate), 1915 Melotte, 1915*a* Bailey, 1915 Kritzinger, 1916 Wilson, 1917 Shapley and Davis, 1917 Pease and Shapley, 1917*b* Flammarion, 1918*b* Bailey, 1918 Curtis, 1918*c* Charlier, 1918*IIbd* Shapley, 1919*Iac, IIcd* Shapley and Shapley, 1920*a* Lundmark, 1920*b*

NGC 6218 (Cont.)

Shapley, 1922*I* Becker, 1923 Lundborg, 1923 Wirtz, 1925 Nabokov, 1925 Strömberg, 1925*b*, 1926 Doig, 1926 Nabokov, 1926 Reinmuth, 1926*II* Vorontsov-Velyaminov, 1926*df*, 1927*d* Parvulesco, 1927*g* ten Bruggencate, 1927 Kienle, 1927 Sawyer and Shapley, 1927*I*, *II* Shapley and Sawyer, 1928 van Rhijn, 1928 Voûte, 1929*ab* Shapley and Sawyer, 1929 Vorontsov-Velyaminov, 1930*anq* Shapley, 1931 Nabokov, 1932 Bernheimer, 1932 Moore, 1932, 1933 van de Kamp, 1933 Sawyer, 1933 Stebbins, 1933 Vyssotsky and Williams, 1935*abd* Edmondson, 1935 Shiveshwarkar, 1935 Mineur, 1935 Shapley and Sayer, 1936 Duryea, 1936*ab* Stebbins and Whitford, 1937 Wilkens, 1939*ab* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1944 Shapley, 1945 Sawyer, 1946*ab* Mayall, 1946*ab* Mowbray.

NGC 6229 $\alpha\ 16^h\ 45^m.6,\ \delta + 47°\ 37'$ $l\ 40°,\ b + 39°$

1789 Herschel, W. First observation 1785, May 12.

1839 Bianchi, J. Schreiben des Herrn *Bianchi*, Directors der Sternwarte zu Modena, an den Herausgeber. *A. N.*, v. 16, pp. 371-4.

1857 Winnecke, A. Notiz über Nebelflecke. *A.N.*, v. 45, pp. 247-50.

1864 Huggins, W. On the spectra of some of the nebulae. *Roy. Soc. Phil. Trans.*, v. 154, pp. 437-44; *Phil. Mag.*, v. 31, p. 523; *Am. Jour. Sci.*, 2nd ser., v. 40, p. 73.

1875 Bredichin, T. Spectre des nébuleuses. *Soc. d. Spett. Ital. Mem.*, Nov., 1875, v. 4, p. 109.

1881 Smyth, W. H., and Chambers, G. F. *A cycle of celestial objects*, p. 472. (Discussion of this cluster as a "prize comet" of 1819).

1917 Davis, H. Five new variable stars in globular clusters. *A. S. P. Pub.*, v. 29, p. 260.

1917 Shapley, H. Descriptive notes relative to nine clusters. *A. S. P. Pub.*, v. 29, p. 185.

1919 Lundmark, K., and Lindblad, B. Photographic effective wave-lengths of nebulae and clusters. Second paper. *Ap. J.*, v. 50, pp. 376-90.

1922 Slipher, V. M. Further notes on spectrographic observations of nebulae and clusters. (Abs.) *Pop. Astr.*, v. 30, pp. 9-11.

1945 Baade, W. The globular clusters NGC 5634 and NGC 6229. *Mt. W. Cont.*, no. 706; *Ap. J.*, v. 102, pp. 17-25. (Plate).

1789 W. Herschel IV 50, 1856 d'Arrest, 1862*IIa* Auwers, 1862 Schönfeld, 1864 J. Herschel 4244, 1865*a* Rümker, 1866 Huggins, 1867 Schmidt, 1867 Vogel, 1867 d'Arrest, 1874 Schultz, 1876 Bredichin, 1877*a* Holden, 1878*a* Dreyer, 1880 Earl of Rosse, 1882 Engelmann, 1886 d'Engelhardt, 1891-*c* Bigourdan, 1891 Kempf, 1894 Loewy and Périgaud, 1895*ab* Mönnichmeyer, 1903 Merecki, 1904 Webb, 1904, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1911 Wirtz, 1911 Fath, 1911*a* Hinks, 1912 Curtis, 1915 Melotte, 1915*a* Bailey, 1917 Pease and Shapley, 1918 Curtis, 1918*c* Charlier, 1918*IIbdg* Shapley, 1919*IIcd* Shapley and Shapley, 1920*a* Lundmark, 1920*b* Shapley, 1922*I* Becker, 1923 Lundborg, 1924 Vogt, 1925 Nabokov, 1925 Strömberg, 1925*b* Doig, 1926*af* Parvulesco, 1926 Reinmuth, 1927 Sawyer and Shapley, 1927*I*, *II* Shapley and Sawyer, 1928 Voûte, 1929 Cannon, 1929*ab* Shapley and Sawyer, 1930*afnq* Shapley, 1931 Nabokov, 1932 Bernheimer, 1932 Moore, 1932, 1933 van de Kamp, 1934, 1935 Lundmark, 1935*ab* Edmondson, 1935 Shiveshwarkar, 1935 Mineur, 1935 Shapley and Sayer, 1936*ab* Stebbins and Whitford, 1937 Wilkens, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1944 Shapley, 1945 Sawyer, 1946*abc* Mayall, 1946*ab* Mowbray.

NGC 6235 $\alpha\ 16^h\ 50^m.4,\ \delta\ -22°\ 06'$ $l\ 327°,\ b\ +12°$

1789 Herschel, W. First observation, 1786 May 26.
1915 Knox Shaw, H. Note on the nebulae and star clusters shown on the Franklin-Adams plates. *M. N.*, v. 76, pp. 106-7.
1946 Mayall, N. U. Says probably NOT a globular cluster.

1789 W. Herschel II 584, 1847 J. Herschel 3653, 1862*IIa* Auwers, 1864 J. Herschel 4246, 1867 Schmidt, 1886 d'Engelhardt, 1891-*c* Bigourdan, 1898*a* Howe, 1904, 1907 Holetschek, 1909 Winnecke, 1910 Porter, 1915 Melotte, 1918*IIeg* Shapley, 1919*IIcd* Shapley and Shapley, 1920*a* Lundmark, 1920*b* Shapley, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I, II*, 1929*ab* Shapley and Sawyer, 1930*akn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1936*abc* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1946*f* Mayall, 1946*a* Mowbray.

NGC 6254 (Messier 10) $\alpha\ 16^h\ 54^m.5,\ \delta\ -04°\ 02'$ $l\ 343°,\ b\ +22°$

1771 Messier, C. First observation, 1764 May 29. On second chart of comet of of 1769, *Mém.* 1775, pl. IX.
1917 Pease, F. G., and Shapley, H. Axes of symmetry in globular clusters. *Mt. W. Comm.*, no. 39; *Nat. Acad. Sci. Proc.*, v. 3, pp. 96-101.
1925 Parvulesco, C. Sur la distribution des étoiles dans les amas globulaires M 9, M 10, M 12 et la théorie cinétique des gaz. *C. R.*, v. 181, pp. 500-2.
1929 Heckmann, O., and Siedentopf, H. Über die Struktur der kugelförmigen Sternhaufen. *Gött. Veröff.* no. 6; *Z. f. Phys.*, v. 54, p. 183.
1931 Barnard, E. E. Micrometric measures of star clusters. *Yerkes Pub.*, v. 6, pp. 74-5.
1938 Sawyer, H. B. One hundred and thirty-two new variable stars in five globular clusters. *Dom. Ap. Pub.*, v. 7. no. 5.
1938 Sawyer, H. B. The light curves of two variable stars in the globular clusters NGC 6218 and NGC 6254. *Dunlap Pub.*, v. 1, pp. 59-68.

1771 Messier, 1777 Bode 33, 1780, 1784 Messier, 1800, 1818*ac*, (1912) W. Herschel, 1833 J. Herschel 1972, 1847 J. Herschel 3659, 1852 Secchi, 1853 Laugier 45, 1855, 1856 d'Arrest, 1861 Earl of Rosse, 1861 Schmidt, 1862*IIb* Auwers, 1864 J. Herschel 4256, 1866 Huggins, 1867 Schmidt, 1867 Vogel, 1867 d'Arrest, 1867*a* Chambers, 1880 Earl of Rosse, 1881 Smyth and Chambers, 1882*b* Flammarion, 1890 d'Engelhardt, 1891-*c* Bigourdan, 1891 Kempf, 1893 Roberts, 1897 Pickering, 1897 Barnard, 1902 Gore, 1904 Webb, 1904, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1911 Wirtz, 1911*a* Hinks, 1912 Curtis, 1913 Fath, 1915 Melotte, 1915*a* Bailey, 1915 Kritzinger, 1916 Wilson, 1917 Shapley and Davis, 1917 Pease and Shapley, 1917*b* Flammarion, 1918*b* Bailey, 1918 Curtis, 1918*c* Charlier, 1918*IIbd* Shapley, 1919*Iac, IIcd* Shapley and Shapley, 1920*a* Lundmark, 1920*b* Shapley, 1922*I* Becker, 1923 Lundborg, 1923 Wirtz, 1925, 1926 Nabokov, 1925*b*, 1926, Doig, 1926*df* Parvulesco, 1926 Reinmuth, 1926*II* Vorontsov-Velyaminov, 1927*g* ten Bruggencate, 1927 Sawyer and Shapley, 1927*d* Parvulesco, 1927*I, II* Shapley and Sawyer, 1928 van Rhijn, 1929 Cannon, 1929*ab* Shapley and Sawyer, 1929 Vorontsov-Velyaminov, 1930*an* Shapley, 1931 Nabokov, 1932 Bernheimer, 1932, 1933 van de Kamp, 1933 Sawyer, 1933 Stebbins, 1933 Vyssotsky and Williams, 1935*ab* Edmondson, 1935 Shapley and Sayer, 1936 Duryea, 1936*ab* Stebbins and Whitford, 1937 Wilkens, 1937 Mineur, 1939*ab* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1944 Shapley, 1945 Sawyer, 1946*ab* Mayall, 1946*ab* Mowbray.

NGC 6266 (Messier 62) α 16^h 58^m.1, δ − 30° 03′ l 321°, b + 06°

1780 Messier, C. First observation, 1771 June 7. Position, June 4, 1779.

1898 Pickering, E. C. Variable stars in clusters. *Harv. Circ.*, no. 33; *A. N.*, v. 147, p. 347; *Ap.J.*, v. 8, p. 257. (Asymmetry).

1915 Bailey, S. I. Globular clusters: distribution of stars. *Harv. Ann.*, v. 76, no. 4.

1918 Shapley, H., and Davis, H. Note on the distribution of stars in the globular cluster Messier 5. *A. S. P. Pub.*, v. 30, pp. 164-5.

1922 Slipher, V. M. Further notes on spectrographic observations of nebulae and clusters. (Abs.) *Pop. Astr.*, v. 30, pp. 9-11.

1780 Messier, 1783 Bode, 1784 Messier, 1814*d*, 1818*a* W. Herschel, 1828 Dunlop 627, 1847 J. Herschel 3661 (drawing), 1856 d'Arrest, 1861 J. Herschel, 1862*IIb* Auwers, 1864 J. Herschel 4261, 1867 Schmidt, 1867*a* Chambers, 1881 Smyth and Chambers, 1882*b* Flammarion, 1886- Weinek and Gruss, 1891-*c* Bigourdan, 1897, 1898*II* Pickering, 1902*abc* Bailey, 1902 Gore, 1903 Clerke, 1904 Webb, 1904, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1909 Winnecke, 1910 See (plate,) 1910 Porter, 1911*a* Hinks, 1912 Curtis, 1913 Chapman, 1913, 1915*ab* Bailey, 1915*I* Plummer, 1915 Melotte, 1916 Jeans, 1917 Shapley and Davis, 1917*c* Flammarion, 1918 Curtis, 1918*c* Charlier, 1918*Ic*, *IIe*, *IVa*, *Vb* Shapley, 1919*Iabc*, *IIcd* Shapley and Shapley, 1920 Barnard, 1920 Hoffmeister, 1920 Lous, 1920*a* Lundmark, 1920*b* Shapley, 1923 Lundborg, 1925 Nabokov, 1925 Strömberg, 1925*d*, 1926 Doig, 1926*f* Parvulesco, 1927*adh* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II* Shapley and Sawyer, 1928 Voûte, 1929 Cannon, 1929*ab* Shapley and Sawyer, 1929 Vorontsov-Velyaminov, 1930*abfklnq* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1932 Moore, 1933 Vyssotsky and Williams, 1935*ab* Edmondson, 1935 Shiveshwarkar, 1935 Mineur, 1935 Shapley and Sayer, 1936 Duryea, 1936*abc* Stebbins and Whitford, 1937 Wilkens, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1945 Finlay-Freundlich, 1946*abc* Mayall, 1946*ab* Mowbray.

NGC 6273 (Messier 19) α 16^h 59^m.5, δ − 26° 11′ l 325°, b + 08°

1771 Messier, C. First observation, 1764 June 5.

1922 Slipher, V. M. Further notes on spectrographic observations of nebulae and clusters. (Abs.) *Pop. Astr.*, v. 30, pp. 9-11.

1943 Sawyer, H. B. New variable stars in four globular clusters in Ophiuchus. *Dunlap Pub.*, v. 1, no. 14 (plate). Investigations in four faint globular clusters in Ophiuchus. (Abs.) *Am. A. S. Pub.*, v. 10, p. 334. Summary, Federer, *Sky and Telescope*, v. 2, no. 21, p. 12.

1771 Messier, 1777 Bode 35, 1780, 1784 Messier, 1814*c*, 1818*ac* W. Herschel, 1833 J. Herschel 1975, 1847 J. Herschel 3663, 1855, 1856 d'Arrest, 1862*IIb* Auwers, 1864 J. Herschel 4264, 1867*a* Chambers, 1881 Smyth and Chambers, 1882*b* Flammarion, 1890 d'Engelhardt, 1891-*c* Bigourdan, 1894 Loewy and Périgaud, 1902 Gore, 1904 Webb, 1904, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1910 Porter, 1911*a* Hinks, 1915 Melotte, 1915*a* Bailey, 1917 Shapley and Davis, 1917*b* Flammarion, 1918*b* Bailey, 1918*c* Charlier, 1918*IIe* Shapley, 1919*Iabc*, *IIcd* Shapley and Shapley, 1920 Barnard, 1920 Lous, 1920*a* Lundmark, 1920*b* Shapley, 1922*II* Becker, 1923 Lundborg, 1923 von Zeipel, 1925 Nabokov, 1925 Strömberg, 1925*b*, 1926 Doig, 1926 Nabokov, 1926*f* Parvulesco, 1927*h* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II* Shapley and Sawyer, 1928 Voûte, 1929 Cannon, 1929*b* Shapley and Sawyer, 1929 Vorontsov-Velyaminov, 1930 Parenago, 1930*abklnq* Shapley, 1931 Nabokov, 1932 Moore, 1932, 1933 van de Kamp, 1933 Vyssotsky and Williams, 1935*ab* Edmondson, 1935 Shiveshwarkar, 1935 Mineur, 1935 Shapley and Sayer, 1936 Duryea, 1936*abc* Stebbins and Whitford, 1937 Wilkens, 1940 Christie, 1941 de Kort, 1941 Copeland, 1945 Finlay-Freundlich, 1946*ab* Mayall, 1946*a* Mowbray.

NGC 6284 α 17^h 01^m.5, δ − 24° 41′ l 326°, b − 09°

1786 Herschel, W. First observation, 1784 May 22.

1943 Sawyer, H. B. New variable stars in four globular clusters in Ophiuchus. *Dunlap Pub.*, v. 1, no. 14 (plate). (Abs.) Investigations in four faint globular clusters in Ophiuchus. *Am. A. S. Pub.*, v. 10, p. 334. Summary, Federer, *Sky and Telescope*, v. 2, no. 21, p. 12.

1786 W. Herschel VI 11, 1814*d*, 1818*a* W. Herschel, 1833 J. Herschel 1976, 1847 J. Herschel 3665, 1856 d'Arrest, 1862*IIa* Auwers, 1864 J. Herschel 4268, 1867 Schmidt, 1867 d'Arrest, 1875 Schönfeld, 1878*a* Dreyer, 1881 Smyth and Chambers, 1888 Ginzel, 1891-*c* Bigourdan, 1894 Loewy and Périgaud, 1898*a* Howe, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1910 Porter, 1911 Wirtz, 1911*a* Hinks, 1915 Melotte, 1915*a* Bailey, 1918*c* Charlier, 1918*IIc* Shapley, 1919*Ic*, *IIcd* Shapley and Shapley, 1920*a* Lundmark, 1920*b* Shapley, 1923 Lundborg, 1926 Doig, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1929 Cannon, 1929 Vorontsov-Velyaminov, 1930 Parenago, 1930*an* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1936*ac* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1946*ab* Mayall, 1946*a* Mowbray.

NGC 6287 α 17^h 02^m.1, δ − 22° 38′ l 328°, b + 10°

1786 Herschel, W. First observation, 1784 May 21.

1943 Sawyer, H. B. New variable stars in four globular clusters in Ophiuchus. *Dunlap Pub.*, v. 1, no. 14 (plate). (Abs.) Investigations in four faint globular clusters in Ophiuchus. *Am. A. S. Pub.*, v. 10, p. 334. Summary, Federer, *Sky and Telescope*, v. 2, no. 21, p. 12.

1786 W. Herschel II 195, 1847 J. Herschel 3666, 1862*IIa* Auwers, 1864 J. Herschel 4269, 1867 Schmidt, 1881 Smyth and Chambers, 1890 d'Engelhardt, 1891-*c* Bigourdan, 1898*a* Howe, 1904, 1907 Holetschek, 1909 Perrine, 1910 Porter, 1911 Wirtz, 1912 Curtis, 1915 Melotte, 1915*a* Bailey, 1918 Curtis, 1918*c* Charlier, 1918*IIeg* Shapley, 1919*IIcd* Shapley and Shapley, 1920*b* Shapley, 1920*a* Lundmark, 1925, 1926 Nabokov, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1929 Vorontsov-Velyaminov, 1930 Parenago, 1930*an* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1936*abc* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1946*d* Mayall, 1946*a* Mowbray.

NGC 6293 α 17^h 07^m.1, δ − 26° 30′ l 325°, b + 07°

1786 Herschel, W. First observation, 1784 May 24.

1915 Knox Shaw, H. Note on the nebulae and star clusters shown on the Franklin-Adams plates. *M. N.*, v. 76, p. 106.

1943 Sawyer, H. B. New variable stars in four globular clusters in Ophiuchus. *Dunlap Pub.*, v. 1, no. 14 (plate). (Abs.) Investigations in four faint globular clusters in Ophiuchus. *Am. A. S. Pub.*, v. 10, p. 334. Summary, Federer, *Sky and Telescope*, v. 2, no. 21, p. 12,

1786 W. Herschel VI 12, 1818*a* W. Herschel, 1833 J. Herschel 1977, 1847 J. Herschel 3667, 1855, 1856 d'Arrest, 1862*IIa* Auwers, 1864 J. Herschel 4270, 1881 Smyth and Chambers, 1890 d'Engelhardt, 1891-*ck* Bigourdan, 1894 Loewy and Périgaud, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1909 Winnecke, 1910 Porter, 1911*a* Hinks, 1915 Melotte, 1915*a*, 1918*b* Bailey, 1918*c* Charlier, 1918*IIc* Shapley, 1919*Ic*, *IIcd* Shapley and Shapley, 1920 Barnard, 1920*a* Lundmark, 1920*b* Shapley, 1923 Lundborg, 1925, 1926 Nabokov, 1926 Doig,

NGC 6293 (Cont.)

1926*II* Vorontsov-Velyaminov, 1926*cf*, 1927*c* Parvulesco, 1927*h* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1929 Cannon, 1929 Vorontsov-Velyaminov, 1930 Parenago, 1930*afn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1935 Shapley and Sayer, 1936*ac* Stebbins and Whitford, 1937 Wilkens, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1946*ab* Mayall, 1946*a* Mowbray.

NGC 6304 α 17^h 11^m.4, δ − 29° 24′ *l* 324°, *b* + 04°

1789 Herschel, W. First observation, 1786 April 30.

1789 W. Herschel I 147, 1814*e* W. Herschel, 1847 J. Herschel 3670, 1856 d'Arrest, 1862*IIa* Auwers, 1864 J. Herschel 4275, 1881 Smyth and Chambers, 1891-*c* Bigourdan, 1908 Bailey, 1909 Winnecke, 1910 Porter, 1911*a* Hinks, 1915 Melotte, 1915*a* Bailey, 1918*c* Charlier, 1918*IIe* Shapley, 1919*Ic*, *IIc* Shapley and Shapley, 1920 Barnard, 1920*a* Lundmark, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1929 Cannon, 1929 Vorontsov-Velyaminov, 1930*an* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1935 Shapley and Sayer, 1936*ac* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1946*ab* Mayall, 1946*a* Mowbray.

NGC 6316 α 17^h 13^m.4, δ − 28° 05′ *l* 325°, *b* + 04°

1786 Herschel, W. First observation, 1784 May 24.

1786 W. Herschel I 45, 1814*e* W. Herschel, 1847 J. Herschel 3671, 1856 d'Arrest, 1862*IIa* Auwers, 1864 J. Herschel 4279, 1867 d'Arrest, 1881 Smyth and Chambers, 1891-*c* Bigourdan, 1909 Perrine, 1910 Porter, 1915*a* Bailey, 1918*c* Charlier, 1918*IIe*, *IVa* Shapley, 1919*IIc* Shapley and Shapley, 1920*a* Lundmark, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1929 Cannon, 1929 Vorontsov-Velyaminov, 1930 Parenago, 1930*an* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1935 Shapley and Sayer, 1936*ac* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1946*d* Mayall, 1946*a* Mowbray.

NGC 6325 α 17^h 15^m.0, δ − 23° 42′ *l* 329°, *b* + 07°

1847 Herschel, J. First observation, 1835 May 24.

1931 van Maanen, A. Photographs of a few nebulae and clusters. *A. S. P. Pub.*, v. 43, pp. 351-2. Plate XIII.

1847 J. Herschel 3676, 1864 J. Herschel 4283, 1899 Howe, 1910 Porter, 1918 Curtis, 1929*b* Shapley and Sawyer, 1930*ano* Shapley, 1932, 1933 van de Kamp, 1933 Stebbins, 1935 Shapley and Sayer, 1936*abc* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1946*d* Mayall, 1946*a* Mowbray.

NGC 6333 (Messier 9) α 17^h 16^m.2, δ − 18° 28′ *l* 333°, *b* + 09°

1771 Messier, C. First observation, 1764 May 28.

1916 Shapley, H. A new variable star. *A. S. P. Pub.*, v. 28, p. 282.

1925 Parvulesco, C. Sur la distribution des étoiles dans les amas globulaires M 9, M 10, M 12 et la théorie cinétique des gaz. *C. R.*, v. 181, pp. 500-2.

1771 Messier, 1777 Bode 36, 1780, 1784 Messier, 1800, 1814*d*, 1818*a*, (1912) W. Herschel, 1833 J. Herschel 1979, 1847 J. Herschel 3677, 1852 Secchi, 1861 Earl of Rosse, 1862*IIb* Auwers, 1862 Schönfeld, 1864 J. Herschel 4287, 1867 Vogel, 1867 d'Arrest, 1867*a* Chambers, 1880 Earl of Rosse, 1881 Smyth and Chambers, 1882*b* Flammarion, 1886 d'Engelhardt, 1891-*c* Bigourdan, 1891 Kempf.

NGC 6333 (Cont.)

1894 Loewy and Périgaud, 1902 Gore, 1904 Webb, 1904, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1909 Winnecke, 1910 Porter, 1911*a* Hinks, 1912 Curtis, 1915 Melotte, 1915*a* Bailey, 1916 Shapley, 1917 Shapley and Davis, 1917 Shapley, 1917*b* Flammarion, 1918*b* Bailey, 1918*c* Charlier, 1918 Curtis, 1918 Slipher, 1918*IIbd*, *Va* Shapley, 1919*b* Lundmark, 1919*IIcd* Shapley and Shapley, 1920 Barnard, 1920*ac* Lundmark, 1920*b* Shapley, 1922*I* Becker, 1923 Lundborg, 1923 Wirtz, 1924*I*, *II* Silberstein, 1925 Strömberg, 1925*b*, 1926 Doig, 1925, 1926 Nabokov, 1926 Reinmuth, 1926*II* Vorontsov-Velyaminov, 1926*df*, 1927*ad* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II* Shapley and Sawyer, 1928 van Rhijn, 1928 Voûte, 1929 Cannon, 1929*ab* Shapley and Sawyer, 1929 Vorontsov-Velyaminov, 1930*afnq* Shapley, 1931 Harrison, 1931 Nabokov, 1932 Moore, 1932, 1933 van de Kamp, 1933 Stebbins, 1935*abd* Edmondson, 1935 Shiveshwarkar, 1935 Mineur, 1935 Shapley and Sayer, 1936 Duryea, 1936*abc* Stebbins and Whitford, 1937 Wilkens, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1946*ab* Mayall, 1946*ab* Mowbray.

NGC 6341 (Messier 92) α 17^h 15^m.6, δ + 43° 12′ l 35°, b +34°

1779 Bode, J. E. First observation Dec. 27, 1777. *Berliner Jahrbuch für 1782*, p. 156.

1781 Messier, C. Observed by him, 1781 March 18.

1843 Argelander, D. Fr. *Uranometria Nova*, p. 33. Berlin.

1848 Butillon. Sur une nébuleuse et une étoile qui paraissent devoir fixer l'attention des astronomes. *C. R.*, v. 27, p. 112.

1848 Babinet. Remarques sur la note de M. Butillon relative à la nébuleuse no. 92 de Messier. *C. R.*, v. 27, p. 132.

1848 Butillon. Note de M. Butillon en réponse à la note de M. Babinet insérée dans le dernier numéro du Compte Rendu. *C. R.*, v. 27, p. 188.

1864 Huggins, W. On the spectra of some of the nebulae. *Roy. Soc. Phil. Trans.*, v. 154, pp. 437-44; *Phil. Mag.*, v. 31, p. 523; *Am. Jour. Sci.*, ser. 2, v. 40, p. 73 (1865).

1865 Schultz, H. Beobachtungen von Nebelflecken. *A. N.*, v. 65, pp. 297-300.

1865 Schultz, H. Schreiben des Herrn Dr. Herman Schultz an den Herausgeber. *A. N.*, v. 66, p. 47. (Correction to previous paper.)

1876 Trouvelot, L. Drawings of the clusters in Hercules. *Harv. Ann.*, v. 8, pt. 2, plate 25.

1887 Schultz, H. Mikrometrische Bestimmung einiger teleskopischen Sternhaufen. Supp. to *Svenska Ak. Proc.*, v. 12, I, no. 2, pp. 1-43. (Chart).

1894 Swift, L. Suggestions to amateurs: nebulae and clusters. *Pop Astr.*, v. 1, pp. 369-71.

1895 Bobrinskoy, N. (la Comtesse). Étude sur l'amas stellaire C. G. 4294 = M. 92. *Acad. des Sci. St. Petersbourg, Bull.*, ser. 5, v. 3, no. 2, pp. 163-72 (2 plates, one chart).

1899 Barnard, E. E. Triangulation of star clusters. *Am. A. S. Pub.*, v. 1, p. 77; *Science*, v. 10, p. 789.

1899 Holetschek, J. Ueber den Helligkeitseindruck von Nebelflecken und Sternhaufen. *A. G. Viert.*, v. 33, p. 270.

1902 Küstner, F. Bonn report. *A. G. Viert.*, v. 36, p. 85 (Mönnichmeyer's work).

1902 Barnard, E. E. Micrometrical measures of individual stars in the great globular clusters. *Am. A. S. Pub.*, v. 1, p. 193; *Science*, v. 17, p. 330, 1903.

NGC 6341 (Cont.)

1906 Bohlin, K. Der zweite Sternhaufen im Hercules, Messier 92. *Stockholm Pub.*, v. 8, p. 3.

1907 Bohlin, K. Ausmessung des zweite Sternhaufens im Hercules (Messier 92). *A. N.*, v. 174, p. 203.

1907 Barnard, E. E. On the motion of the stars in the cluster Messier 92. *A. N.*, v. 176, p. 17; p. 21, Second paper.

1909 Barnard, E. E. On the proper motion of some of the small stars in the dense cluster M 92 Herculis. *Am. A. S. Pub.*, v. 1, p. 323.

1909 Barnard, E. E. On the motion of some of the stars of Messier 92 (Hercules). *A. N.*, v. 182, p. 305; *Pop. Astr.*, v. 18, p. 3.

1916 Kohlman, A. F. Star clusters: some observations and comparisons. *Soc. Pract. Astr., Monthly Reg.*, v. 8, pp. 25-6.

1919 Lundmark, K., and Lindblad, B. Photographic effective wave-lengths of nebulae and clusters. Second paper. *Ap. J.*, v. 50, pp. 376-90.

1923 Hopmann, J. Über die kosmische Stellung der Kugelhaufen und Spiralnebel. *A. N.*, v. 218, pp. 97-110.

1924 Nabokov, M. La grandeur stéllaire intégrale d'amas et de nébuleuses. *Rus. A. J.*, v. 1 (1), pp. 115-18.

1925 Guthnick, P. Kugelhaufen, inbesondere über gemeinsam mit Herrn R. Prager begonnene Untersuchungen an M 3, M 13, M 15, und M 92. (Abs.) *Preuss. Ak. Wiss. Phys.-Math. Kl. Sitz.*, no. 28, p. 508.

1928 Balanowsky, J. Die Eigenbewegung des kugelförmigen Sternhaufens Messier 92 (N.G.C. 6341). *Poulk. Bull.*, v. 11, pp. 167-82; *C. R. Acad. U.S.S.R.*, v. 21, p. 364.

1930 de Sitter, A. A comparison of the angular dimensions of the globular clusters M 3 and M 13. *B. A. N.*, v. 5, pp. 207-9.

1930 Hopmann, J. Der kugelförmige Sternhaufen M 92 im Hercules. *Roma, Mem. Acad. Sci.*, ser. 2, v. 14, pp. 167-202.

1931 Barnard, E. E. Micrometric measures of star clusters. *Yerkes Pub.*, v. 6, pp. 76-81.

1932 Hogg, F. S. The distribution of light in six globular clusters. *A. J.*, v. 42, pp. 77-87.

1934 Schlesinger, F. Relative positions of 72 stars in the globular cluster Messier 92 ($17^h 14^m$, $+43° 15'$, 1900). *A. J.*, v. 44, pp. 21-2.

1936 Lohmann, W. Die Verteilung des Lichtes in den kugelförmigen Sternhaufen M 5, M 15 und M 92. *Z. f. Ap.*, v. 12, no. 1, pp. 1-39.

1937 Guthnick, P. Berlin-Babelsberg report. *A. G. Viert.*, v. 72, p. 160.

1937 Nassau, J. J. Report of the Warner and Swasey observatory, 1936-1937. *Am. A. S. Pub.*, v. 9, p. 92.

1938 Nassau, J. J. A study of the globular cluster Messier 92. *Ap. J.*, v. 87, pp. 361-6; *Perkins Cont.*, no. 9.

1939 Hachenberg, O. Der Aufbau des kugelförmigen Sternhaufen Messier 92. *Z. f. Ap.*, v. 18, pp. 49-88.

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NGC 6341 (Cont.)

1781 Méchain, 1783 Bode, 1784 Messier, 1801 Lalande 31544, 1814*c*, 1818*abc* W. Herschel, 1862*I*, *IIb* Auwers, 1862 Schönfeld, 1864*a* J. Herschel 4294, 1864 Rümker, 1865 Auwers, 1867 Schmidt, 1867 Vogel, 1867 d'Arrest, 1867*ab* Chambers, 1868 Webb, 1874 Schultz, 1876 Bredichin, 1880 Earl of Rosse, 1881 Smyth and Chambers (fig. 36), 1882 Engelmann, 1882*b* Flammarion, 1890 d'Engelhardt, 1891-*c* Bigourdan, 1893 Roberts, 1894 Loewy and Périgaud, 1894 Gore, 1897 Barnard, 1899 Rabourdin, 1902 Gore, 1904 Webb, 1904, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1911 Fath, 1911*a* Hinks, 1912 Curtis, 1913*b* von Zeipel, 1915 Melotte, 1915*a* Bailey, 1916 Wilson, 1917 Shapley and Davis, 1917 Pease and Shapley, 1917*d* Flammarion, 1918*b* Bailey, 1918 Curtis, 1918 Slipher, 1918*c* Charlier, 1918*IIbd*, *Va* Shapley, 1919*ab* Lundmark, 1919*Iac*, *IIcd* Shapley and Shapley, 1920*abc* Lundmark, 1920*b* Shapley, 1922*I* Becker, 1923 Lundborg, 1924*I*, *II* Silberstein, 1924 Vogt, 1925 Strömberg, 1925*b*, 1926 Doig, 1926*af* Parvulesco, 1926 Reinmuth, 1926*I* Vorontsov-Velyaminov, 1927*h* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II* Shapley and Sawyer, 1928 van Rhijn, 1928 Voûte, 1929 Cannon, 1929*ab* Shapley and Sawyer, 1930 Heckmann and Siedentopf, 1930 *afknq* Shapley, 1931 Harrison, 1931 Nabokov, 1932 Bernheimer, 1932, 1933 van de Kamp, 1932 Moore, 1933 Vyssotsky and Williams, 1934, 1935 Lundmark, 1935*abc* Edmondson, 1935 Shiveshwarkar, 1935 Mineur, 1936*ab* Stebbins and Whitford, 1937 Wilkens, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1944 Shapley, 1944*II*, 1945 Sawyer, 1946*abc* Mayall, 1946*ab* Mowbray.

NGC 6342 α 17^h 18^m.2, δ − 19° 32′ l 333°, b + 08°

1789 Herschel, W. First observation, 1786 May 28.

1919 Hubble, E. (Two new globular clusters). *Mt. W. Rep.* no. 9, for 1919, p. 233, cited in *Harv. Bull.* no. 776, 1922.

1789 W. Herschel I 149, 1856 d'Arrest, 1862*IIa* Auwers, 1864 J. Herschel 4293, 1875 Schönfeld, 1891-*c* Bigourdan, 1907 Holetschek, 1909 Winnecke, 1910 Porter, 1922*a* Shapley, 1923 Wirtz, 1926*f* Parvulesco, 1926 Reinmuth, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1930*ano* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1935 Shapley and Sayer, 1936*ac* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1946*d* Mayall, 1946*a* Mowbray.

NGC 6352 α 17^h 21^m.6, δ − 48° 26′ l 309°, b − 08°

1828 Dunlop, J. First observation.

1885 Barnard, E. E. Large nebula not in G.C. *Sid. Mess.*, v. 4, p. 223.

1828 Dunlop 417, 1908 Bailey, 1915 Melotte, 1918*IIe* Shapley, 1919*IIc* Shapley and Shapley, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1930*acn* Shapley, 1931 Collinder, 1931 Nabokov, 1935 Shapley and Sayer, 1946*d* Mayall.

NGC 6355 α 17^h 20^m.9, δ − 26° 19′ l 327°, b + 04°

1786 Herschel, W. First observation, 1784 May 24.

1946 Mayall, N. U. Cites this as a new globular cluster.

1786 W. Herschel I 46, 1847 J. Herschel 3681, 1862*IIa* Auwers, 1864 J. Herschel 4295, 1910 Porter, 1919*IIac* Shapley and Shapley, 1922*b* Shapley, 1926*f* Parvulesco, 1931 Collinder, 1946*de* Mayall.

NGC 6356 $\alpha\ 17^h\ 20^m.7,\ \delta\ -\ 17°\ 46'$ $l\ 334°,\ b\ +\ 09°$

1786 Herschel, W. First observation, 1784 June 17.

1786 W. Herschel I 48, 1814*c* W. Herschel, 1847 J. Herschel 3683, 1856 d'Arrest, 1862 Schönfeld, 1862*IIa* Auwers, 1864 J. Herschel 4296, 1867 Schmidt, 1867 Vogel, 1867 d'Arrest, 1881 Smyth and Chambers, 1882 Engelmann, 1886 d'Engelhardt, 1888 Ginzel, 1891 Kempf, 1891-*c* Bigourdan, 1894 Loewy and Périgaud, 1895*ab* Mönnichmeyer, 1898*b* Howe, 1904, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1909 Winnecke, 1910 Porter, 1911*a* Hinks, 1912 Curtis, 1915 Melotte, 1915*a* Bailey, 1918 Curtis, 1918*c* Charlier, 1918*IIbd* Shapley ,1919*IIcd* Shapley and Shapley, 1920*a* Lundmark, 1920*b* Shapley, 1922*I* Becker, 1923 Lundborg, 1923 Wirtz, 1925, 1926 Nabokov, 1926*f* Parvulesco, 1926 Reinmuth, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*ab* Shapley and Sawyer, 1929 Cannon, 1929 Vorontsov-Velyaminov, 1930*akno* Shapley, 1931 Nabokov, 1933 Stebbins, 1935 Shapley and Sayer, 1936*abc* Stebbins and Whitford, 1937 Wilkens, 1940 Christie, 1941 de Kort, 1941 Copeland, 1945 Finlay-Freundlich, 1946*abc* Mayall, 1946*ab* Mowbray.

NGC 6362 $\alpha\ 17^h\ 26^m.6,\ \delta\ -\ 67°\ 01'$ $l\ 293°,\ b\ -\ 18°$

1828 Dunlop, J. First observation.

1919 Woods, I. E. Variable stars in the cluster, N.G.C. 6362. *Harv. Circ.*, no. 217.

1922 Shapley, H. New faint cluster variable (near N.G.C. 6362). *Harv. Bull.*, no. 777.

1828 Dunlop 225, 1847 J. Herschel 3684, 1864 J. Herschel 4300, 1881 Smyth and Chambers, 1915 Melotte, 1915*a*, 1918*b* Bailey, 1918*c* Charlier, 1918*IIe* Shapley, 1919*Ic*, *IIc* Shapley and Shapley, 1920*a* Lundmark, 1926*f* Parvulesco, 1927*h* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1930*afkn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1939*a* Sawyer, 1941 de Kort, 1946*d* Mayall.

NGC 6366 $\alpha\ 17^h\ 25^m.1,\ \delta\ -\ 05°\ 02'$ $l\ 346°,\ b\ +\ 15°$

1862 Winnecke, A. First observation, 1860 April 12. See Auwers, 1862*IId*.

1928 Baade, W. Der Sternhaufen N.G.C. 5053. *Hamb. Mitt.*, v. 6, no. 29; *A. N.*, v. 232, p. 200. (Comparison).

1940 Sawyer, H. B. Twelve new variable stars in the globular clusters NGC 6205, NGC 6366, and NGC 6779. (Plate). *Dunlap Pub.*, v. 1, no. 5.

1862*IId* Auwers, 1864 J. Herschel 4301, 1867 d'Arrest, 1891-*c* Bigourdan, 1915 Melotte, 1918 Curtis, 1919*IIabc* Shapley and Shapley, 1926*f* Parvulesco, 1926 Reinmuth, 1927 Sawyer and Shapley, 1927*I*. *II*, 1929*b* Shapley and Sawyer, 1930*an* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1936*ab* Stebbins and Whitford, 1939*a* Sawyer, 1941 de Kort, 1946*d* Mayall, 1946*a* Mowbray.

NGC 6388 $\alpha\ 17^h\ 32^m.6,\ \delta\ -\ 44°\ 43'$ $l\ 313°,\ b\ -\ 08°$

1828 Dunlop, J. First observation.

1828 Dunlop 457 (fig. 18), 1847 J. Herschel 3690, 1864 J. Herschel 4307, 1881 Smyth and Chambers, 1904*a* Webb, 1908 Bailey (plate), 1911*a* Hinks, 1915 Melotte, 1915*a* Bailey, 1918*c* Charlier, 1918*IIe* Shapley, 1919*IIc* Shapley and Shapley, 1920*a* Lundmark, 1923 Lundborg, 1925*f* Doig, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1929 Cannon, 1930*an* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1941 de Kort, 1941 Copeland, 1945 Finlay-Freundlich, 1946*d* Mayall.

NGC 6397 $\alpha\ 17^h\ 36^m.8,\ \delta\ -\ 53°\ 39'$ $l\ 306°,\ b\ -\ 13°$

1755 Lacaille, Abbé de. First observation.

1932 Sawyer, H. B. Periods and light curves of thirty-two variable stars in the globular clusters N.G.C. 362, 6121, and 6397. *Harv. Circ.*, no. 366. Pt. 3. (Abs.) The periods of thirty-six variable stars in four globular clusters. *Am. A. S. Pub.*, v. 7, p. 35, 1931.

1755 Lacaille III 11, 1828 Dunlop 366, 1847 J. Herschel 3692, 1861 J. Herschel, 1862*IIc* Auwers, 1864 J. Herschel 4311, 1867*a* Chambers, 1868 Webb, 1881 Smyth and Chambers, 1882*b* Flammarion, 1895, 1898*II* Pickering, 1902*abc*, 1908 Bailey, 1911*a* Hinks, 1915 Melotte, 1915*a*, 1918*a* Bailey, 1918*c* Charlier, 1918*IIe*, *Vb* Shapley, 1919*Ic*, *IIc* Shapley and Shapley, 1920 Hoffmeister, 1920*a* Lundmark, 1923 Lundborg, 1925 Nabokov, 1926*cf*, 1927*c* Parvulesco, 1927*h* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*ab* Shapley and Sawyer, 1929 Cannon, 1930*afknp* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1932*b* Sawyer, 1935 Shapley and Sayer, 1939*ab* Sawyer, 1941 de Kort, 1946*d* Mayall.

NGC 6401 $\alpha\ 17^h\ 35^m.6,\ \delta\ -\ 23°\ 53'$ $l\ 331°,\ b\ +\ 03°$

1786 Herschel, W. First observation, 1784 May 21.

1919 *Mt. W. Rep.*, no 9, p. 233, mentions photo by Pease.

1946 Mayall, N. U. Cites this as a new globular cluster.

1786 W. Herschel I 44, 1833 J. Herschel 1982, 1847 J. Herschel 3697, 1862*IIa* Auwers, 1864 J. Herschel 4314, 1910 Porter, 1918 Curtis, 1946*de* Mayall, 1946*a* Mowbray.

NGC 6402 (Messier 14) $\alpha\ 17^h\ 35^m.0,\ \delta\ -\ 03°\ 13'$ $l\ 349°,\ b\ +\ 13°$

1771 Messier, C. First observation, 1764 June 1. On chart of comet of 1769, *Mém.*, 1775, pl. IX.

1827 Harding. Beobachtungen und Nachrichten. *Berliner Jahrbuch*, p. 134. (Letter to Dr. Westphal with list of nebulae).

1857 Winnecke, A. Notiz über Nebelflecke. *A. N.*, v. 45, pp. 247-50.

1917 Shapley, H. Descriptive notes relative to nine clusters. *A. S. P. Pub.*, v. 29, p. 185.

1937 Sawyer, H. B. Variable stars in the globular cluster N.G.C. 6402. *R. A. S. C. Jour.*, v. 31, pp. 57-9.

1938 Sawyer, H. B. One hundred and thirty-two new variable stars in five globular clusters. *Dom. Ap. Pub.*, v. 7, no. 5. (Plate).

1942 Scheuer, S. Some astronomical methods. *Sky and Telescope*, v. 1, no. 8, p. 9. (Photos).

1771 Messier, 1777 Bode 37, 1780, 1784 Messier, 1800, 1814*d*, 1818*a*, (1912) W. Herschel, 1833 J. Herschel 1983, 1847 J. Herschel 3698, 1861 J. Herschel, 1862 Schönfeld, 1862*IIb* Auwers, 1864 J. Herschel 4315, 1866 Huggins, 1867 Schmidt, 1867 d'Arrest, 1867*ab* Chambers, 1875 Schönfeld, 1878*b* Dreyer, 1880 Earl of Rosse, 1881 Smyth and Chambers, (fig. 37), 1882*ab* Flammarion, 1891-*c* Bigourdan, 1895 Mönnichmeyer, 1899 Roberts, 1902 Gore, 1904 Webb, 1904, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1909 Winnecke, 1910 See (plate), 1910 Porter, 1911*a* Hinks, 1912 Curtis, 1915 Melotte, 1915*a* Bailey, 1915 Kritzinger, 1916 Shapley, 1917 Shapley and Davis, 1917 Pease and Shapley, 1917 Shapley, 1917*b* Flammarion, 1918 Curtis, 1918*c* Charlier, 1918*IIbd* Shapley, 1919*Iac*, *IIcd* Shapley and Shapley, 1920*a* Lundmark, 1920*b* Shapley, 1922*I* Becker, 1923 Lundborg, 1923 Wirtz, 1925 Nabokov, 1925*b*, 1926 Doig, 1926

NGC 6402 (Cont.)

Nabokov, 1926 Reinmuth, 1926 *II* Vorontsov-Velyaminov, 1926*f*, 1927*a* Parvulesco, 1927 Sawyer and Shapley, 1927*h* ten Bruggencate, 1927*I*, *II* Shapley and Sawyer, 1928 van Rhijn, 1929*ab* Shapley and Sawyer, 1929 Vorontsov-Velyaminov, 1930 Parenago, 1930*abkn* Shapley, 1931 Nabokov, 1932 Bernheimer, 1932, 1933 van de Kamp, 1933 Sawyer, 1933 Stebbins, 1935*abd* Edmondson, 1935 Shapley and Sayer, 1936 Duryea, 1936*ab* Stebbins and Whitford, 1937 Wilkens, 1938, 1939*ab* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1942*a* Sawyer, 1946*ab* Mayall, 1946*ab* Mowbray.

NGC 6426 α 17^h 42^m.4, δ + 03° 12′ l 356°, b + 15°

1789 Herschel, W. First observation, 1786 June 3.

1876 Stéphan, E. Nébuleuses découvertes et observées à l'observatoire de Marseille. *C. R.*, v. 83, p. 328.

1789 W. Herschel II 587, 1862*IIa* Auwers, 1864 J. Herschel 4325, 1867 d'Arrest, 1878*c* Dreyer, 1891-*c* Bigourdan, 1909 Winnecke, 1918 Curtis, 1919*IIac* Shapley and Shapley, 1926*f* Parvulesco, 1926 Reinmuth, 1927 Sawyer and Shapley, 1927*I*, *II* 1929*b* Shapley and Sawyer, 1930*acfn* Shapley, 1931 Nabokov, 1933 Stebbins, 1934, 1935 Lundmark, 1936*ab* Stebbins and Whitford, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1946*d* Mayall, 1946*a* Mowbray.

No Number α 17^h 45^m.7, δ − 60° 45′ l 300°, b − 17°

1936 Shapley, H. Five planetary nebulae and a globular cluster. *Harv. Bull.*, no. 902, p. 26. (Object appears as faint, remote globular cluster).

NGC 6440 α 17^h 45^m.9, δ − 20° 21′ l 335°, b + 02°

1789 Herschel, W. First observation, 1786 May 28.

1918 Curtis, H. D. A spiral nebula in the Milky Way. *A. S. P. Pub.*, v. 30, p. 161.

1931 van Maanen, A. Photographs of a few nebulae and clusters. *A. S. P. Pub.*, v. 43, pp. 351-2, Plate XIII.

1934 Humason, M. L. The radial velocities of three globular clusters. *A. S. P. Pub.*, v. 46, p. 357.

1937 Baade, W. Stellar photography in the red region of the spectrum. *Am. A.S. Pub.*, v. 9, p. 31; *I. A. U. Trans.*, v. 6, p. 452, 1938.

1789 W. Herschel I 150, 1833 J. Herschel 1985, 1862*IIa* Auwers, 1864 J. Herschel 4331, 1867 d'Arrest, 1874 Schönfeld, 1891-*c* Bigourdan, 1893 Stone, 1907 Holetschek, 1909 Winnecke, 1910 Porter, 1918 Curtis, 1919*IIac* Shapley and Shapley, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1930*akno* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1935*abd* Edmondson, 1935 Shiveshwarkar, 1935 Mineur, 1936*abc* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1946*ab* Mayall, 1946*a* Mowbray.

NGC 6441 α 17^h 46^m.8, δ − 37° 02′ l 321°, b − 06°

1828 Dunlop, J. First observation.

1828 Dunlop 557, 1847 J. Herschel 3705, 1864 J. Herschel 4332, 1881 Smyth and Chambers, 1908 Bailey, 1910 Porter, 1911*a* Hinks, 1915 Melotte, 1915*a* Bailey, 1918*c* Charlier, 1918*IIeg* Shapley, 1919*IIc* Shapley and Shapley, 1920*a* Lundmark, 1923 Lundborg, 1925 Nabokov, 1925*f* Doig, 1926*f* Parvulesco, 1927 Sawyer

NGC 6441 (Cont.)

and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1929 Cannon, 1930*akn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1935 Shapley and Sayer, 1936*ac* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1941 Copeland, 1946*ab* Mayall, 1946*a* Mowbray.

NGC 6453 α 17^h 48^m.0, δ − 34° 37′ *l* 323°, *b* − 05°

1847 Herschel, J. First observation, 1837 June 8.

1847 J. Herschel 3708, 1864 J. Herschel 4336, 1910 Porter, 1922*a* Shapley, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1930*ano* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1935 Shapley and Sayer, 1936*ac* Stebbins and Whitford, 1941 de Kort, 1946*d* Mayall, 1946*a* Mowbray.

NGC 6496 α 17^h 55^m.5, δ − 44° 15′ *l* 316°, *b* − 11°

1828 Dunlop, J. First observation.

1828 Dunlop 460? (fig. 19), 1847 J. Herschel 3715, 1864 J. Herschel 4347, 1881 Smyth and Chambers, 1915 Melotte, 1918*ab* Charlier, 1918*IIf* Shapley, 1919*IIac* Shapley and Shapley, 1922*a* Shapley, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1930*an* Shapley, 1931*a* Collinder, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1941 de Kort, 1941 Copeland, 1946*d* Mayall.

NGC 6517 α 17^h 59^m.1, δ − 08° 57′ *l* 347°, *b* + 05°

1786 Herschel, W. First observation, 1784 June 16.

1922 Shapley, H. N.G.C. 2419. *Harv. Bull.*, no. 776; *Pop. Astr.*, v. 30, p. 590.

1786 W. Herschel II 199, 1847 J. Herschel 3719, 1862*IIa* Auwers, 1864 J. Herschel 4357, 1866 Huggins, 1867 d'Arrest, 1874 Schönfeld, 1891-*c* Bigourdan, 1909 Winnecke, 1910 Porter, 1912 Curtis, 1915 Melotte, 1918 Curtis, 1919*IIac* Shapley and Shapley, 1923 Wirtz, 1925 Nabokov, 1926*f* Parvulesco, 1926 Reinmuth, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1930*akno* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1936*ab* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1946*d* Mayall, 1946*a* Mowbray.

NGC 6522 α 18^h 00^m.4, δ − 30° 02′ *l* 329°, *b* − 05°

1786 Herschel, W. First observation, 1784 June 24.

1946 Baade, W. A search for the nucleus of our galaxy. *A.S.P. Pub.*, v. 58, pp. 249-52. (Distance of 6522).

1786 W. Herschel I 49, 1847 J. Herschel 3720, 1856 d'Arrest, 1862*IIa* Auwers, 1864 J. Herschel 4359, 1867 Schmidt, 1881 Smyth and Chambers, 1891-*c* Bigourdan, 1909 Perrine, 1910 Porter, 1915*a* Bailey, 1918*c* Charlier, 1920*a* Lundmark, 1929*b* Shapley and Sawyer, 1930*an* Shapley, 1932, 1933 van de Kamp, 1933 Stebbins, 1936*ac* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1946*d* Mayall, 1946*a* Mowbray.

NGC 6528 α 18^h 01^m.6, δ − 30° 04′ *l* 328°, *b* − 06°

1786 Herschel, W. First observation, 1784 June 24.

1786 W. Herschel II 200, 1847 J. Herschel 3723, 1862*IIa* Auwers, 1864*a* J. Herschel 4364, 1867 Schmidt, 1891-*c* Bigourdan, 1910 Porter, 1915*a* Bailey, 1918*c* Charlier, 1920 Barnard, 1920*a* Lundmark, 1929*b* Shapley and Sawyer, 1930*ano* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1936*ac* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1946*d* Mayall, 1946*a* Mowbray.

NGC 6535 α 18^h 01^m.3, δ − 00° 18′ l 355°, b + 09°

1852 Hind, J. R. New nebula. *M. N.*, v. 12, p. 208.

1946 Mayall, N. U. Says probably *not* a globular cluster.

1862*IId* Auwers, 1864 J. Herschel 4369, 1890 d'Engelhardt, 1891-*c* Bigourdan, 1909 Winnecke, 1910 Porter, 1915 Melotte, 1918*IIf* Shapley, 1919*IIac* Shapley and Shapley, 1926*f* Parvulesco, 1926 Reinmuth. 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*ab* Shapley and Sawyer, 1930*acn* Shapley, 1931 Nabokov, 1933 Stebbins, 1936*ab* Stebbins and Whitford, 1939*a* Sawyer, 1941 de Kort, 1946*f* Mayall.

NGC 6539 α 18^{h}02^m.1, δ − 07° 35′ l 349°, b + 05°

1856 Brorson, T. Entdeckung und Beobachtungen von Herrn Observator Theodor Brorson. *Jahn's Unterh.*, p. 292.

1928 Baade, W. Der Sternhaufen NGC 5053. *Hamb. Mitt.*, v. 6, no. 29; *A. N.*, v. 232, p. 200. (Comparison).

1862*IId* Auwers, 1864 J. Herschel 4370, 1890 d'Engelhardt, 1891-*c* Bigourdan, 1909 Winnecke, 1910 Porter, 1911 Wirtz, 1915 Melotte. 1919*IIac* Shapley and Shapley, 1926*f* Parvulesco, 1926 Reinmuth, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1930*acfn* Shapley, 1931 Nabokov, 1933 Stebbins, 1936*ab* Stebbins and Whitford, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1946*d* Mayall, 1946*a* Mowbray.

NGC 6541 α 18^h 04^m.4, δ − 43° 44′ l 317°, b − 12°

1826 Cacciatore, N. First observation, 1826 Mar. 19. *Sull' origine del sistema solare*, p. 15. *Palermo*, 1826.

1826 Zach. *Correspondance Astronomique*, v. 14, p. 410. (On the new nebula).

1826 Olbers, W. Auszug aus einem Schreiben des Herrn Doctors und Ritters Olbers an den Herausgeber. *A. N.*, v. 5, p. 121. (Questions whether new nebula may be a comet).

1826 Cacciatore, N. Neuer Nebelflecke. *A. N.*, v. 5, p. 281. (Reprint of original article).

1827 von Biela, W. Schreiben des Herrn Hauptmanns und Ritters v. Biela an den Herausgeber. *A. N.*, v. 5, p. 425. (Position of new nebula).

1828 Olbers, W. Auszug aus einem Schreiben des Herrn Doctors und Ritters Olbers an den Herausgeber. *A. N.*, v. 7, p. 64.

1922 Woods, I. E. New variable in N.G.C. 6541. *Harv. Bull.*, no. 764; *Pop. Astr.*, v. 30, p. 174.

1922 Shapley, H. Neuer Veränderlicher 2, 1922, Coronae Australis in NGC 6541. *A. N.*, v. 215, p. 391.

1828 Dunlop 473, 1847 J. Herschel 3726, 1864*a* J. Herschel 4372, 1868 Webb, 1881 Smyth and Chambers, 1908 Bailey, 1911*a* Hinks, 1915 Melotte, 1915*a* Bailey, 1918*b* Bailey, 1918*c* Charlier, 1918*IIe* Shapley, 1919*Ic*, *IIc* Shapley and Shapley, 1920*a* Lundmark, 1925 Nabokov, 1926 Parvulesco, 1927*h* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*ab* Shapley and Sawyer, 1929 Cannon, 1930*afn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1939*a* Sawyer, 1941 de Kort, 1941 Copeland, 1946*d* Mayall.

NGC 6544 α 18^h 04^m.3, δ − 25° 01′ l 334°, b − 04°

1786 Herschel, W. First observation, 1784 May 22.

1946 Mayall, N. U. Cites this as a new globular cluster.

NGC 6544 (Cont.)

1786 W. Herschel II 197, 1833 J. Herschel 1994, 1862*IIa* Auwers, 1864 J. Herschel 4374, 1910 Porter, 1915 Melotte, 1922*b* Shapley, 1931 Collinder, 1946*abe* Mayall, 1946*a* Mowbray.

NGC 6553 α 18h 06m.3, δ − 25° 56′ *l* 333°, *b* − 04°

1786 Herschel, W. First observation, 1784 May 22.

1893 Spitaler, R. Beobachtungen von Nebelflecken. *A. N.*, v. 132, p. 375.

1937 Adams, W. S. Report of Mount Wilson Observatory, 1936-37. *Am.A.S. Pub.*, v. 9, p. 80.

1937 Baade, W. Stellar photography in the red region of the spectrum. *Am. A.S. Pub.*, v. 9, p. 31; *I. A. U. Trans.*, v. 6, p. 452, 1938.

1941 Photos by Baade. Bok and Bok, *The Milky Way*, p. 145. Harvard.

1786 W. Herschel IV 12, 1847 J. Herschel 3730, 1856 d'Arrest, 1862*IIa* Auwers, 1864 J. Herschel 4378, 1891-*d* Bigourdan, 1910 Porter, 1911 Wirtz, 1915 Melotte, 1915*a* Bailey, 1918*c* Charlier, 1919*IIac* Shapley and Shapley, 1920*a* Lundmark, 1926*cf*, 1927*c* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1929 Vorontsov-Velyaminov, 1930*afn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1935 Shapley and Sayer, 1936*ac* Stebbins and Whitford, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1946*d* Mayall, 1946*a* Mowbray.

NGC 6569 α 18h 10m.4, δ − 31° 50′ *l* 328°, *b* − 08°

1786 Herschel, W. First observation, 1784 July 13.

1786 W. Herschel II 201, 1828 Dunlop 619, 1847 J. Herschel 3736, 1862*IIa* Auwers, 1864 J. Herschel 4389, 1891-*d* Bigourdan, 1909 Perrine, 1910 Porter, 1912 Curtis, 1915 Melotte, 1915*a* Bailey, 1918 Curtis, 1918*c* Charlier, 1918*IIf* Shapley, 1919*IIac* Shapley and Shapley, 1920*a* Lundmark, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1929 Vorontsov-Velyaminov, 1930*an* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1936 Duryea, 1936*ac* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1946*d* Mayall, 1946*a* Mowbray.

NGC 6584 α 18h 14m.6, δ − 52° 14′ *l* 310°, *b* − 18°

1828 Dunlop, J. First observation.

1828 Dunlop 376, 1847 J. Herschel 3737, 1864 J. Herschel 4393, 1881 Smyth and Chambers, 1908 Bailey, 1911*a* Hinks, 1915 Melotte, 1915*a*, 1918*b* Bailey, 1918*c* Charlier, 1918*IIe* Shapley, 1919*Ic*, *IIc* Shapley and Shapley, 1920*a* Lundmark, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1930*afn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1939*a* Sawyer, 1941 de Kort, 1946*d* Mayall.

NGC 6624 α 18h 20m.5, δ − 30° 23′ *l* 330°, *b* − 09°

1786 Herschel, W. First observation, 1784 June 24.

1786 W. Herschel I 50, 1847 J. Herschel 3742, 1862*IIa* Auwers, 1864 J. Herschel 4404, 1881 Smyth and Chambers, 1891-*d* Bigourdan, 1908 Bailey, 1909 Perrine, 1910 Porter, 1911*a* Hinks, 1912 Curtis, 1915 Melotte, 1915*a* Bailey, 1918 Curtis, 1918*c* Charlier, 1918*IIe* Shapley, 1919*IIc* Shapley and Shapley, 1920*a* Lundmark, 1923 Lundborg, 1926 Nabokov, 1926*f* Parvulesco, 1926*II* Vorontsov-Velyaminov, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1929 Cannon, 1929 Vorontsov-Velyaminov, 1930 Parenago, 1930*an* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1936*ac* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1941 Copeland, 1946*ab* Mayall, 1946*a* Mowbray.

NGC 6626 (Messier 28) α 18^h 21^m.5, δ − 24° 54′ *l* 335°, *b* − 07°

1771 Messier, C. First observation, 1764 July 26.

1847 Laugier, E. Sur le mouvement propre de trois amas du Catalogue de Messier. *C. R.*, v. 24, p. 1021.

1771, 1780, 1784 Messier, (1912) W. Herschel, 1833 J. Herschel 2010, 1847 J. Herschel 3743, 1853 Laugier 46, 1856 d'Arrest, 1861 Schmidt, 1862 Schönfeld, 1862*IIb* Auwers, 1864 J. Herschel 4406, 1867 Schmidt, 1867 Vogel, 1867*a* Chambers, 1881 Smyth and Chambers, 1882*b* Flammarion, 1886- Weinek and Gruss, 1891-*dk* Bigourdan, 1895*ab* Mönnichmeyer, 1895, 1897, 1898*II* Pickering, 1902*abc* Bailey, 1902 Gore, 1904 Webb, 1904, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1910 Porter, 1911 Wirtz, 1911*a* Hinks, 1912 Curtis, 1915 Melotte, 1915*a* Bailey, 1917 Shapley and Davis, 1917*b* Flammarion, 1918*a* Bailey, 1918 Curtis, 1918 Slipher, 1918*c* Charlier, 1918*Ic*, *IIbd*, *Va* Shapley, 1919*b* Lundmark, 1919*Iac*, *IIcd* Shapley and Shapley, 1920 Hoffmeister, 1920*ac* Lundmark, 1920*b* Shapley, 1923 Lundborg, 1925 Nabokov, 1925 Strömberg, 1925*d* Doig, 1926 Nabokov, 1926*II* Vorontsov-Velyaminov, 1926*cf*, 1927*c* Parvulesco, 1927*h* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II* Shapley and Sawyer, 1928 van Rhijn, 1928 Voûte, 1929 Cannon, 1929*ab* Shapley and Sawyer, 1929 Vorontsov-Velyaminov, 1930 Parenago, 1930*afknq* Shapley, 1931 Harrison, 1931 Nabokov, 1932, 1933 van de Kamp, 1932 Moore, 1933 Stebbins, 1933 Vyssotsky and Williams, 1935*ab* Edmondson, 1935 Shiveshwarkar, 1935 Mineur, 1935 Shapley and Sayer, 1936 Duryea, 1936*ac* Stebbins and Whitford, 1937 Wilkens, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1946*ab* Mayall, 1946*ab* Mowbray.

NGC 6637 (Messier 69) α 18^h 28^m.1, δ − 32° 23′ *l* 329°, *b* − 12°

1781 Messier, C. First observation, 1780 Aug. 31.

1781 Messier, 1783 Bode, 1784 Messier, 1814*e*, 1818*a* W. Herschel, 1828 Dunlop 613, 1862*IIb* Auwers, 1864*a* J. Herschel 4411, 1881 Smyth and Chambers, 1891-*d* Bigourdan, 1902 Gore, 1904*a* Webb, 1904, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1910 Porter, 1911*a* Hinks, 1912 Curtis, 1915 Melotte, 1915*a* Bailey, 1917 Shapley and Davis, 1917*d* Flammarion, 1918*b* Bailey, 1918 Curtis, 1918*c* Charlier, 1918*IIe* Shapley, 1919*IIcd* Shapley and Shapley, 1920*a* Lundmark, 1920*b* Shapley, 1923 Lundborg, 1925*f* Doig, 1925, 1926 Nabokov, 1926 Doig, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1929 Cannon, 1929 Vorontsov-Velyaminov, 1930*an* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1935 Shapley and Sayer, 1936*ac* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1941 Copeland, 1946*abc* Mayall, 1946*a* Mowbray.

NGC 6638 α 18^h 27^m.9, δ − 25° 32′ *l* 336°, *b* − 09°

1786 Herschel, W. First observation, 1784 July 12.

1893 Spitaler, R. Beobachtungen von Nebelflecken. *A. N.*, v. 132, p. 375.

1786 W. Herschel I 51, 1814*e* W. Herschel, 1847 J. Herschel 3748, 1855, 1856 d'Arrest, 1861 Schmidt, 1862 Schönfeld, 1862*IIa* Auwers, 1864 J. Herschel 4412, 1867 Schmidt, 1877*a* Holden, 1881 Smyth and Chambers, 1891-*d* Bigourdan, 1904, 1907 Holetschek, 1909 Perrine, 1909 Winnecke, 1910 Porter, 1918*c* Charlier, 1918*IIbd* Shapley, 1919*IIc* Shapley and Shapley, 1920*a* Lundmark, 1925, 1926 Nabokov, 1926 Doig, 1926*f* Parvulesco, 1926*II* Vorontsov-Velyaminov, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*ab* Shapley and Sawyer, 1929 Vorontsov-Velyaminov, 1930 Parenago, 1930*akn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1935 Shapley and Sayer, 1936*ac* Stebbins and Whitford, 1937 Wilkens, 1940 Christie, 1941 de Kort, 1946*ab* Mayall, 1946*ab* Mowbray.

NGC 6652 α 18^h 32^m.5, δ − 33° 02′ *l* 329°, *b* − 13°

1828 Dunlop, J. First observation.

1828 Dunlop 607, 1847 J. Herschel 3752, 1864 J. Herschel 4421, 1867 Schmidt, 1881 Smyth and Chambers, 1908 Bailey, 1910 Porter, 1915 Melotte, 1915*a* Bailey, 1918*c* Charlier, 1918*IIe* Shapley, 1919*IIc* Shapley and Shapley, 1920*a* Lundmark, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1929 Cannon, 1930*akn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1936*ac* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1941 Copeland, 1946*ab* Mayall, 1946*a* Mowbray.

NGC 6656 (Messier 22) α 18^h 33^m.3, δ − 23° 58′ *l* 337°, *b* − 09°

1682 Ihle, A. Discovery, Aug. 26, 1665. Kirch in *Ephemeriden*, Appendix. According to Smyth and Chambers, 1881, seen by Hevelius before 1665.

1759 LeGentil, G. H. J. J. B. Remarques sur les étoiles nébuleuses. *Acad. des Sci. Mém.*, pp. 453-71. (Drawing).

1771 Messier, C. Observation, 1764 June 5.

1866 Schultz, H. Historische Nötigen über Nebelflecke. *A. N.*, v. 67, p. 4.

1881 Smyth, W. H., and Chambers, G. F. *A cycle of celestial objects*, p. 532. Fig. 39. (Variation in brightness of star noted by LeGentil).

1918 Chevalier, A. Amas d'étoiles Messier 22 (N.G.C. 6656). *Zô-Sè Ann.*, v. 10, C, pp. 1-51. (Catalogue of 1019 stars).

1919 Shapley, H., and Duncan, J. C. The globular cluster Messier 22 (N.G.C. 6656). (Abs.) *Pop. Astr.*, v. 27, p. 100.

1920 Duncan, J. C. Bright nebulae and star clusters in Sagittarius and Scutum photographed with the 60-inch reflector. *Mt. W. Cont.*, no. 177; *Ap. J.*, v. 51, p. 4. (Plate).

1920 Bailey, S. I. Variable stars in M 22. (Abs.) *Pop. Astr.*, v. 28, pp. 518-9.

1923 Shapley, H. Five new variable stars. *Harv. Bull.*, no. 781.

1927 Shapley, H. The distance of Messier 22. *Harv. Bull.*, no. 848.

1930 Shapley, H. The mass-spectrum relation for giant stars in the globular cluster Messier 22. *Harv. Bull.*, no. 874.

1930 Sticker, B. Über die Farbenhäufigkeitsfunktion in Sternhaufen. *Z. f. Ap.*, v. 1, p. 174.

1932 Hogg, F. S. The distribution of light in six globular clusters. *A. J.*, v. 42, pp. 77-87.

1944 Sawyer, H. B. Variable stars in the globular cluster Messier 22. *Dunlap Pub.*, v. 1, no. 15. (Abs.) Lengths of cluster-type periods in Messier 22 and other globular clusters. *A. J.*, v. 51, p. 70.

1715 Halley, 1746 de Chéseaux, 1755 Lacaille I 12, 1771 Messier, 1777 Bode 57, 1780, 1784 Messier, 1800, 1818*ac* W. Herschel, 1833 J. Herschel 2015, 1847 J. Herschel 3753, 1855, 1856 d'Arrest, 1861 J. Herschel, 1862*IIbc* Auwers, 1862 Schönfeld, 1864 J. Herschel 4424, 1867 Vogel, 1867*ab* Chambers, 1868 Webb, 1882*b* Flammarion, 1886 d'Engelhardt, 1891-*d* Bigourdan, 1895, 1897, 1898*II* Pickering, 1902*abc* Bailey, 1902 Gore, 1903 Clerke, 1904 Webb, 1904 Perrine, 1904, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1911 Fath, 1911*a* Hinks, 1912 Curtis, 1913 Chapman, 1915 Melotte, 1915*a* Bailey, 1916 Wilson, 1917 Shapley and Davis, 1917*b* Flammarion, 1918 Curtis, 1918*c* Charlier, 1918*Ic*, *IIabd*, *IVa*, *Vb* Shapley, 1919*Iabc*, *IIcd* Shapley and Shapley, 1919*ab* Shapley, 1920 Barnard, 1920 Hoffmeister, 1920 Lous, 1920*ab* Lundmark, 1920*b* Shapley,

NGC 6656 (Cont.)

1923 Lundborg, 1923 von Zeipel, 1925 Nabokov, 1925*d*, 1926 Doig, 1926 Nabokov, 1926 Vorontsov-Velyaminov, 1926*cef*, 1927*c* Parvulesco, 1927*ah* ten Bruggencate, 1927 Sawyer and Shapley, 1927 Lönnquist, 1927*I*, *II* Shapley and Sawyer, 1928 van Rhijn, 1929*ab* Shapley and Sawyer, 1929 Vorontsov-Velyaminov, 1930 Parenago, 1930*aefgjklnpr* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1932*ab* Sawyer, 1933 Stebbins, 1933 Vyssotsky and Williams (extrafocal plate), 1935*ab* Edmondson, 1935 Shapley and Sayer, 1936 Duryea, 1936*abc* Stebbins and Whitford, 1937 Wilkens, 1937 Mineur, 1939*ab* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1943 Shapley (fig. 126), 1944*II* Sawyer, 1945 Finlay-Freundlich, 1946*abc* Mayall, 1946*ab* Mowbray.

NGC 6681 (Messier 70) α 18^h 40^m.0, δ − 32° 21′ l 330°, b − 14°

1781 Messier, C. First observation, 1780 Aug. 31.

1781 Messier, 1783 Bode, 1784 Messier, 1828 Dunlop 614, 1847 J. Herschel 3756, 1862*IIb* Auwers, 1864*a* J. Herschel 4428, 1881 Smyth and Chambers, 1891-*d* Bigourdan, 1902 Gore, 1904*a* Webb, 1904, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1910 Porter, 1911*a* Hinks, 1912 Curtis, 1915 Melotte, 1915*a* Bailey, 1917 Shapley and Davis, 1918*b* Bailey, 1918 Curtis, 1918*c* Charlier, 1918*IIe* Shapley, 1919*Ic*, *IIcd* Shapley and Shapley, 1920*a* Lundmark, 1920*b* Shapley, 1925 Nabokov, 1925*f* Doig, 1926*f* Parvulesco, 1927*h* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*b* Shapley and Sawyer, 1929 Vorontsov-Velyaminov, 1930*an* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1936*ac* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1941 Copeland, 1946*ab* Mayall, 1946*a* Mowbray.

NGC 6684 α 18^h 44^m.1, δ − 65° 14′ l 297°, b − 25°

1847 Herschel, J. First observation, 1836 Aug. 31.

1921 Innes, R. T. A. Nebulae and clusters (in the Melbourne zone). *Union Circ.*, no. 53, p. 103. (Says fine globular cluster).

1847 J. Herschel 3757, 1864 J. Herschel 4431, 1881 Smyth and Chambers, 1923 Lundborg.

NGC 6712 α 18^h 50^m.3, δ − 08° 47′ l 353°, b − 06°

1786 Herschel, W. First observation, 1784 June 16.

1917 Shapley, H. Descriptive notes relative to nine clusters. *A. S. P. Pub.*, v. 29, p. 186.

1917 Davis, H. Five new variable stars in globular clusters. *A. S. P. Pub.*, v. 29, p. 260.

1924 Cannon, A. J. Fifty-nine new variable stars. *Harv. Circ.*, no. 265. (Harv. Var. 3832).

1930 Harwood, M. A survey of the variable stars in the Scutum cloud; preliminary results. *Harv. Bull.*, no. 880, p. 14. (AP Scuti).

1943 Oosterhoff, P. Th. New observations and improved elements for twenty variable stars in or near the constellation Scutum. *B. A. N.*, v. 9, p. 411.

1786 W. Herschel I 47, 1847 J. Herschel 3762, 1855, 1856 d'Arrest, 1853 Laugier 47, 1862 Schönfeld, 1862*IIa* Auwers, 1864 J. Herschel 4441, 1866 Huggins, 1867 Vogel, 1867 d'Arrest, 1881 Smyth and Chambers, 1886- Weinek and Gruss, 1890 d'Engelhardt, 1891-*d* Bigourdan, 1903 Merecki, 1904 Webb, 1907 Holetschek, 1908 Bailey (plate), 1909 Perrine, 1910 Porter, 1911 Wirtz, 1911*a* Hinks, 1912 Curtis, 1915 Melotte, 1915*a* Bailey, 1915 Kritzinger, 1918 Curtis, 1918*c* Charlier,

NGC 6712 (Cont.)

1918*IIbd* Shapley, 1919*IIcd* Shapley and Shapley, 1920 Barnard, 1920*a* Lundmark, 1920*b* Shapley, 1922*I* Becker, 1923 Wirtz, 1925 Nabokov, 1925*d* Doig, 1926*f* Parvulesco, 1926 Reinmuth, 1927 Sawyer and Shapley, 1927*I, II* Shapley and Sawyer, 1928 van Rhijn, 1929*ab* Shapley and Sawyer, 1929 Vorontsov-Velyaminov, 1930 Parenago, 1930*acfn* Shapley, 1931 Nabokov, 1932 Bernheimer, 1933 Stebbins, 1936*ab* Stebbins and Whitford, 1937 Wilkens, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1942*a* Oosterhoff, 1943 Shapley (fig. 111), 1946*ab* Mayall, 1946*ab* Mowbray.

NGC 6715 (Messier 54) α 18^h 52^m.0, δ − 30° 32′ l 333°, b − 16°

1780 Messier, C. First observation, 1778 July 24.

1780 Messier, 1783 Bode, 1783 Messier, 1828 Dunlop 624, 1847 J. Herschel 3763, 1862*IIb* Auwers, 1864 J. Herschel 4442, 1881 Smyth and Chambers, 1882*b* Flammarion, 1891-*d* Bigourdan, 1902 Gore, 1904*a* Webb, 1908 Bailey, 1909 Perrine, 1910 Porter, 1911*a* Hinks, 1912 Curtis, 1915 Melotte, 1915*a* Bailey, 1917 Shapley and Davis, 1917*c* Flammarion, 1918 Curtis, 1918*c* Charlier, 1918*IIe* Shapley, 1919*Ic, IIc* Shapley and Shapley, 1920*a* Lundmark, 1923 Lundborg, 1925*f* Doig, 1925, 1926 Nabokov, 1926*f* Parvulesco, 1927*h* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I, II*, 1929*b* Shapley and Sawyer, 1929 Cannon, 1929 Vorontsov-Velyaminov, 1930*an* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1936*a* Stebbins and Whitford, 1940 Christie, 1941 de Kort, 1941 Copeland, 1946*ab* Mayall, 1946*a* Mowbray.

NGC 6723 α 18^h 56^m.2, δ − 36° 42′ l 328°, b − 19°

1828 Dunlop, J. First observation.

1924 Bailey, S. I. Variable stars in the cluster N.G.C. 6723. *Harv. Circ.*, no. 266.

1932 van Gent, H. Provisional ephemerides of 63 new and 3 known variable stars in or near the constellation Corona Australis. *B. A. N.*, v. 6, pp. 163-84.

1933 van Gent, H. Discussion of 122, mostly new, variable stars in or near the constellation Corona Australis. *B. A. N.*, v. 7, p. 21.

1828 Dunlop 573, 1847 J. Herschel 3770, 1864 J. Herschel 4450, 1867 Schmidt, 1881 Smyth and Chambers, 1897, 1898*II* Pickering, 1902*abc*, 1908 Bailey, 1910 Porter, 1911*a* Hinks, 1915 Melotte, 1915*a*, 1918*a* Bailey, 1918*c* Charlier, 1918*Ic, IIe* Shapley, 1919*Ic, IIc* Shapley and Shapley, 1920 Hoffmeister, 1920*a* Lundmark, 1923 Lundborg, 1926*f* Parvulesco, 1927 Sawyer and Shapley, 1927*I, II*, 1929*ab* Shapley and Sawyer, 1929 Cannon, 1929 Vorontsov-Velyaminov, 1930*afn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1932*a* Sawyer, 1935 Shapley and Sayer, 1936*a* Stebbins and Whitford, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1944*II* Sawyer, 1946*abc* Mayall, 1946*ab* Mowbray.

NGC 6752 α 19^h 06^m.4, δ − 60° 04′ l 304°, b − 27°

1828 Dunlop, J. First observation.

1828 Dunlop 295, 1847 J. Herschel 3778, 1861 J. Herschel, 1864 J. Herschel 4467, 1868 Webb, 1881 Smyth and Chambers, 1895, 1897, 1898*II* Pickering, 1902*a*, 1908 Bailey, 1911*a* Hinks, 1913 Chapman, 1915 Melotte, 1915*a* Bailey, 1918*c* Charlier, 1918*IIe* Shapley, 1919*Ic, IIc* Shapley and Shapley, 1920 Hoffmeister, 1920*a* Lundmark, 1926*f* Parvulesco, 1927*h* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I, II*, 1929*ab* Shapley and Sawyer, 1929 Cannon, 1930*afn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1935 Shapley and Sayer, 1939*a* Sawyer, 1941 de Kort, 1944 Shapley, 1945 Sawyer, 1946*d* Mayall.

NGC 6760 α 19^h 08^m.6, δ + 00° 57′ *l* 04°, *b* − 05°

1846 Hind, J. R. Discovery, Mar. 30, 1845. Ephemeris of Biela's Comet, 1845. *A. N.*, v. 23, no. 549, p. 356.

1914 Pease, F. G. The star cluster N.G.C. 6760. *A. S. P. Pub.*, v. 26, p. 204.

1931 van Maanen, A. Photographs of a few nebulae and clusters. *A. S. P. Pub.*, v. 43, pp. 351-2, Plate XIII.

1855, 1856 d'Arrest, 1861 Schmidt, 1862 Schönfeld, 1862*IId* Auwers, 1864 J. Herschel 4473, 1866 Huggins, 1867 Schmidt, 1867 Vogel, 1867 d'Arrest, 1874 Schultz, 1878*a* Dreyer, 1880 Earl of Rosse, 1881 Smyth and Chambers, 1882 Winlock and Pickering, 1886 d'Engelhardt, 1886- Weinek and Gruss, 1891-*d* Bigourdan, 1891 Kempf, 1907 Holetschek, 1909 Winnecke, 1912 Curtis, 1915 Melotte, 1918 Curtis, 1918*IIf* Shapley, 1919*IIacd* Shapley and Shapley, 1920*b* Shapley, 1923 Wirtz, 1926*f* Parvulesco, 1926 Reinmuth, 1927 Sawyer and Shapley, 1927*I, II*, 1929*b* Shapley and Sawyer, 1930 Parenago, 1930*acn* Shapley, 1931 Nabokov, 1932 Bernheimer, 1933 Stebbins, 1934, 1935 Lundmark, 1936*ab* Stebbins and Whitford, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1946*d* Mayall, 1946*a* Mowbray.

NGC 6779 (Messier 56) α 19^h 14^m.6, δ + 30° 05′ *l* 30°, *b* + 08°

1780 Messier, C. First observation, 1779 Jan. 23. On map of comet of 1779.

1902 Küstner, F. Bonn report. *A. G. Viert.*, v. 36, p. 85. (Work of Mönnichmeyer).

1916 Kohlman, A. F. Star clusters: some observations and comparisons. *Soc. Prac. Astr., Monthly Reg.*, v. 8, pp. 25-6.

1917 Shapley, H. Descriptive notes relative to nine clusters. *A. S. P. Pub.*, v. 29, p. 186.

1917 Davis, H. A bright variable star in N.G.C. 6779 (Messier 56). *A. S. P. Pub.*, v. 29, p. 210.

1920 Shapley, H. Studies. XVII. Miscellaneous results. Pt. 1. Position co-ordinates of new variable stars. (Plate). *Mt. W. Cont.*, no. 190; *Ap. J.*, v. 52, p. 73.

1920 Küstner, F. Der kugelförmige Sternhaufen Messier 56. *Bonn Veröff.*, no. 14. 47 pp. (Catalogue of 532 stars).

1927 van Maanen, A. Investigations on proper motion. Twelfth paper. The proper motions and internal motions of Messier 2, 13, 56. *Mt. W. Cont.*, no. 338; *Ap. J.*, v. 66, pp. 89-112.

1927 van Maanen, A. The proper motions of the globular clusters Messier 13, 56, and 2, and their internal motions. *K. Ak. wetens. Amsterdam Verslag.*, v. 30, no. 6, pp. 680-4.

1929 Heckmann, O., and Siedentopf, H. Über die Struktur der kugelförmigen Sternhaufen. *Gött. Veröff.*, no. 6; *Z. f. Phys.*, v. 54, p. 183.

1940 Sawyer, H. B. Twelve new variable stars in the globular clusters NGC 6205, NGC 6366, and NGC 6779. *Dunlap Pub.*, v. 1, no. 5 (Plate).

1942 Sawyer, H. B. Some interesting variable stars in the globular cluster Messier 56. *Am. A. S. Pub.*, v. 10, p. 233.

1944 Rosino, L. Sull' ammasso globulare NGC 6779 = M 56. *Univ. Bologna Oss. Pub.*, v. IV, no. 7. 19 pp. (Plate). *Soc. Astr. Ital. Mem.* v. 16, no. 4.

NGC 6779 (Cont.)

1780 Messier, 1783 Bode, 1784 Messier, 1814*c*, 1818*a* W. Herschel, 1833 J. Herschel 2036, 1852 Secchi, 1855, 1856, 1861 d'Arrest, 1861 Earl of Rosse, 1862 Schönfeld, 1862*IIb* Auwers, 1864 J. Herschel 4485, 1865*b* Rümker, 1866 Huggins, 1867 Schmidt, 1867 Oppolzer, 1867 Vogel, 1867 d'Arrest, 1867*ab* Chambers, 1880 Earl of Rosse, 1881 Smyth and Chambers (fig. 43), 1882 Engelmann, 1882*ab* Flammarion, 1890 d'Engelhardt, 1891-*d* Bigourdan, 1891 Kempf, 1893 Roberts, 1895 Mönnichmeyer, 1899 Rabourdin, 1902 Gore, 1904 Webb, 1904, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1911*a* Hinks, 1912 Curtis, 1915 Melotte, 1915*a* Bailey, 1915 Kritzinger, 1917 Shapley and Davis, 1917 Pease and Shapley, 1917*c* Flammarion, 1918 Curtis, 1918*c* Charlier, 1918*IIbd* Shapley, 1919*Iac, IIcd* Shapley and Shapley, 1920*a* Lundmark, 1920*b* Shapley, 1922*I, II* Becker, 1923 Lundborg, 1923 Wirtz, 1924 Vogt, 1925*b*, 1926 Doig, 1926 Reinmuth, 1926*cf*, 1927*c* Parvulesco, 1927 Kienle, 1927*g* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I, II* Shapley and Sawyer, 1928 van Rhijn, 1929*ab* Shapley and Sawyer, 1930 Heckmann and Siedentopf, 1930*afkn* Shapley, 1931 Nabokov, 1932 Bernheimer, 1932, 1933 van de Kamp, 1933 Stebbins, 1934, 1935 Lundmark, 1935*abcd* Edmondson, 1935 Shapley and Sayer, 1936 Duryea, 1936*ab* Stebbins and Whitford, 1937 Wilkens, 1937 Mineur, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1945 Finlay-Freundlich, 1946*ab* Mayall, 1946*ab* Mowbray.

NGC 6809 (Messier 55) $\alpha\ 19^h\ 36^m.9,\ \delta\ -\ 31°\ 03'$ $l\ 337°,\ b\ -\ 25°$

1755 Lacaille, Abbé de. First observation.

1783 Messier, C. Observed by him, 1778 July 24.

1915 Bailey, S. I. Globular clusters: distribution of stars. *Harv. Ann.*, v. 76, no. 4.

1925 Bailey, S. I. Eight new variable stars near N.G.C. 6809. *Harv. Bull.*, no. 813.

1925 Paraskevopoulos, J. S. Five new variable stars. *Harv. Bull.*, no. 813.

1755 Lacaille I 14, 1777 Bode 63, 1780 Messier, 1783 Bode, 1784 Messier, 1818*a* W. Herschel, 1828 Dunlop 620, 1847 J. Herschel 3798, 1856 d'Arrest, 1862*IIbc* Auwers, 1864 J. Herschel 4503, 1881 Smyth and Chambers, 1882*b* Flammarion, 1891-*d* Bigourdan, 1898*II* Pickering, 1902*abc* Bailey, 1902 Gore, 1904*a* Webb, 1908 Bailey, 1909 Perrine, 1911*a* Hinks, 1912 Curtis, 1915*I* Plummer, 1915 Melotte, 1915*ab* Bailey, 1916 Jeans, 1917 Shapley and Davis, 1917*c* Flammarion, 1918*a* Bailey, 1918 Curtis, 1918*c* Charlier, 1918*IIe* Shapley, 1919*Ic, IIc* Shapley and Shapley, 1920 Hoffmeister, 1920*a* Lundmark, 1923 Lundborg, 1925*f*, 1926 Doig, 1926*acf*, 1927*c* Parvulesco, 1927*dh* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I, II*, 1929*ab* Shapley and Sawyer, 1930*afn* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1933 Vyssotsky and Williams, 1935 Shapley and Sayer, 1936*a* Stebbins and Whitford, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1943 (fig. 4), 1944 Shapley, 1945 Sawyer, 1946*d* Mayall, 1946*ab* Mowbray.

NGC 6838 (Messier 71) $\alpha\ 19^h\ 51^m.5,\ \delta\ +\ 18°\ 39'$ $l\ 24°,\ b\ -\ 06°$

1779 Köhler. Discovery. *Berliner Jahrbuch f. 1782*, p. 155.

1781 Méchain, P. F. A. Observation, 1780 June 28, Oct. 4. On chart of comet of 1779.

1917 Shapley, H. Descriptive notes relative to nine clusters. *A. S. P. Pub.*, v. 29, pp. 185-6.

NGC 6838 (Cont.)

1936 Krug, W. Photometrische Bearbeitung der galaktischen Sternhaufen M 71 und Harv. 20. (Plate). *Z. f. Ap.*, v. 13, pp. 205-14.
Summary by Hartwig, G. Photometrische Untersuchung dreier offener Sternhaufen. *Die Sterne*, v. 17, pp. 161-3.

1943 Cuffey, J. NGC 5053 and NGC 6838. *Ap. J.*, v. 98, pp. 49-53; *Kirkwood Pub.*, no. 6.

1946 Mayall, N. U. Cites this as a new globular cluster.

1781 Méchain, 1783 Bode, 1784 Messier, 1833 J. Herschel 2056, 1862*IIb* Auwers, 1864 J. Herschel 4520, 1867 d'Arrest, 1877*a* Holden, 1881 Smyth and Chambers, 1890 d'Engelhardt, 1902 Gore, 1904 Webb, 1909 Perrine, 1912 Curtis, 1915 Melotte, 1917 Shapley and Davis, 1917*d* Flammarion, 1918 Curtis, 1918*ab* Charlier, 1923 Lundborg, 1925*d* Doig, 1926*f* Parvulesco, 1926 Reinmuth, 1930*s* Shapley, 1931 Collinder, 1931 Nabokov, 1936 Duryea, 1946*abe* Mayall, 1946*a* Mowbray.

(References on this cluster are incomplete because of its recent inclusion in the list of globular clusters).

NGC 6864 (Messier 75) α 20^h 03^m.2, δ − 22° 04′ l 348°, b − 27°

1781 Méchain, P. F. A. First observation, 1780 August 27, Oct. 18.

1920 Shapley, H. Studies. XVII. Miscellaneous results. Pt. 1. Position co-ordinates of new variable stars. (Plate). *Mt. W. Cont.*, no. 190; *Ap. J.*, v. 52, p. 73.

1781 Méchain, 1783 Bode, 1784 Messier, 1814*d*, 1818*abcd* W. Herschel, 1833 J. Herschel 2064, 1855, 1856 d'Arrest, 1861 Earl of Rosse, 1862 Schönfeld, 1862*IIb* Auwers, 1864 J. Herschel 4543, 1867 Schmidt, 1867 Oppolzer, 1867 Vogel, 1867 d'Arrest, 1880 Earl of Rosse, 1881 Smyth and Chambers, 1882 Englemann, 1882*b* Flammarion, 1886-Weinek and Gruss, 1890 d'Engelhardt, 1891-*e* Bigourdan, 1895*ab* Mönnichmeyer, 1902 Gore, 1904 Webb, 1904, 1907 Holetschek, 1908 Bailey, 1909 Perrine, 1909 Winnecke, 1910 Porter, 1911*a* Hinks, 1915 Melotte, 1915*a* Bailey, 1917 Shapley and Davis, 1917*d* Flammarion, 1918 Curtis, 1918*c* Charlier, 1918*IIbdg* Shapley, 1919*IIcd* Shapley and Shapley, 1920*a* Lundmark, 1920*b* Shapley, 1922*I* Becker, 1923 von Zeipel, 1925*d*, 1926 Doig, 1926*acf*, 1927*c* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*ab* Shapley and Sawyer, 1929 Cannon, 1930*afno* Shapley, 1931 Nabokov, 1933 Stebbins, 1935 Shapley and Sayer, 1936 Duryea, 1936*ab* Stebbins and Whitford, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1944 Shapley, 1945 Finlay-Freundlich, 1945 Sawyer, 1946*ab* Mayall, 1946*ab* Mowbray.

NGC 6934 α 20^h 31^m.7, δ + 07° 14′ l 20°, b − 20°

1789 Herschel, W. First observation, 1785 Sept. 24.

1819 Olbers, W. Beobachtungen und Nachrichten. *Berliner Jahrbuch für 1819*, p. 20.

1917 Shapley, H. Descriptive notes relative to nine clusters. *A. S. P. Pub.*, v. 29, p. 186.

1935 Sawyer, H. B. Variable stars in the globular cluster NGC 6934. *Am. A. S. Pub.*, v. 8, p. 149.

1937 Sawyer, H. B. Variable stars in the globular cluster N.G.C. 6402. *R. A. S. C. Jour.*, v. 31, p. 59. (Comparison).

1938 Sawyer, H. B. One hundred and thirty-two new variable stars in five globular clusters. *Dom. Ap. Pub.*, v. 7, no. 5. (Plate).

NGC 6934 (Cont.)

1789 W. Herschel I 103, 1833 J. Herschel 2081, 1856 d'Arrest, 1861 Earl of Rosse, 1862*I*, *IIa* Auwers, 1862 Schönfeld, 1864 J. Herschel 4585 = 4586, 1865 Auwers, 1866 Rümker, 1866 Huggins, 1867 Schmidt, 1867 Oppolzer, 1867 Vogel, 1867 d'Arrest, 1874 Schultz, 1876 Bredichin, 1878*a* Dreyer, 1880 Earl of Rosse, 1881 Smyth and Chambers, 1882 Engelmann, 1886- Weinek and Gruss, 1888 Ginzel, 1890 d'Engelhardt, 1891-*e* Bigourdan, 1891 Kempf, 1895*ab* Mönnichmeyer, 1904 Webb, 1904, 1907 Holetschek, 1909 Perrine, 1909 Winnecke, 1911 Fath, 1912 Curtis, 1915 Melotte, 1915*a* Bailey, 1915 Kritzinger, 1917 Pease and Shapley, 1918 Curtis, 1918 Slipher, 1918*c* Charlier, 1918*IIbd*, *Va* Shapley, 1919*b* Lundmark, 1919*IIcd* Shapley and Shapley, 1920*ac* Lundmark, 1920*b* Shapley, 1923 Lundborg, 1923 Wirtz, 1924*I*, *II* Silberstein, 1924 Vogt, 1925 Nabokov, 1925 Strömberg, 1925*a* Doig, 1926*af* Parvulesco, 1926 Reinmuth, 1927 Sawyer and Shapley, 1927*I*, *II* Shapley and Sawyer, 1928 van Rhijn, 1928 Voûte, 1929 Cannon, 1929*ab* Shapley and Sawyer, 1930*anq* Shapley, 1931 Harrison, 1931 Nabokov, 1932 Bernheimer, 1932 Moore, 1932, 1933 van de Kamp, 1933 Sawyer, 1933 Stebbins, 1934, 1935 Lundmark, 1935*ab* Edmondson, 1935 Shiveshwarkar, 1935 Mineur, 1936*ab* Stebbins and Whitford, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1944 Shapley, 1945 Sawyer, 1946*ab* Mayall, 1946*ab* Mowbray.

NGC 6981 (Messier 72) $\alpha\ 20^h\ 50^m.7$, $\delta\ -\ 12°\ 44'$ l 03°, $b\ -\ 34°$

1781 Méchain, P. F. A. First observation, 1780 Aug. 29, Oct. 4.

1917 Davis, H. Five new variable stars in globular clusters. *A. S. P. Pub.*, v. 29, p. 260.

1920 Shapley, H. Studies. XVII: Miscellaneous results. Pt. 1. Position co-ordinates of new variable stars. (Plate). *Mt. W. Cont.*, no. 190; *Ap. J.*, v. 52, p. 73.

1920 Shapley, H., and Ritchie, M. Studies. XVIII. The periods and light-curves of 26 Cepheid variables in Messier 72. *Mt. W. Cont.*, no. 195; *Ap. J.*, v. 52, p. 232.

1931 Mineur, H. Mises au point d'astronomie stellaire. Céphéides et amas. *Soc. Astr. France, Bull.*, v. 45, p. 194.

1934 Humason, M. L. The radial velocities of three globular clusters. *A. S. P. Pub.*, v. 46, p. 357.

1781 Méchain, 1783 Bode, 1784 Messier, 1814*c* W. Herschel (drawing), 1818*a*, (1912) W. Herschel, 1833 J. Herschel 2090, 1855, 1856 d'Arrest, 1861 Earl of Rosse, 1862*I*, *IIb* Auwers, 1862 Schönfeld, 1864 J. Herschel 4608, 1865 Auwers, 1867 Schmidt, 1867 Vogel, 1867 d'Arrest, 1867*a* Chambers, 1880 Earl of Rosse, 1881 Smyth and Chambers, 1882 Engelmann, 1882*b* Flammarion, 1886- Weinek and Gruss, 1890 d'Engelhardt, 1891-*e* Bigourdan, 1895 Mönnichmeyer, 1898*b* Howe, 1902 Gore, 1904, 1907 Holetschek, 1909 Perrine, 1909 Winnecke, 1910 Porter, 1915 Melotte, 1915*a* Bailey, 1917 Shapley and Davis, 1917*d* Flammarion, 1918 Curtis, 1918*c* Charlier, 1918*IIbd* Shapley, 1919*IIcd* Shapley and Shapley, 1920*a* Lundmark, 1920*b* Shapley, 1923 Wirtz, 1926 Doig, 1926 Reinmuth, 1926*acf*, 1927*c* Parvulesco, 1927 Sawyer and Shapley, 1927*I*, *II* Shapley and Sawyer, 1928 van Rhijn, 1929*ab* Shapley and Sawyer, 1930*afn* Shapley, 1931 Nabokov, 1932 Bernheimer, 1932, 1933 van de Kamp, 1933*a* Sawyer, 1933 Stebbins, 1935*ab* Edmondson, 1935 Shiveshwarkar, 1935 Mineur, 1935 Shapley and Sayer, 1936 Duryea, 1936*ab* Stebbins and Whitford, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1941 Copeland, 1944 Shapley, 1944*II* Sawyer, 1945 Sawyer, 1946*ab* Mayall, 1946*ab* Mowbray.

NGC 7006 $\alpha\ 20^h\ 59^m.1,\ \delta + 16°\ 00'$ $l\ 32°, b - 20°$

1786 Herschel, W. First observation, 1784 Aug. 21.

1920 Shapley, H. Studies. XVII. Miscellaneous results. Pt. 5. Note on the distant cluster N.G.C. 7006. *Mt. W. Cont.*, no. 190; *Ap. J.*, v. 52, p. 84.

1921 Shapley, H., and Mayberry, B. W. Studies. XIII. Variable stars in N.G.C. 7006. *Nat. Acad. Sci. Proc.*, v. 7, pp. 152-4.

1931 van Maanen, A. Photographs of a few nebulae and clusters. *A. S. P. Pub.*, v. 43, pp. 351-2. Plate XIII.

1931 Hubble, E. *Mt. W. Rep.* from *Carnegie Yearbook* 31, p. 158. (Fifteen new variables and a photometric study).

1934 Humason, M. L. The radial velocities of three globular clusters. *A. S. P. Pub.*, v. 46, p. 357.

1935 Baade, W. The globular cluster NGC 2419. *Mt. W. Cont.*, no. 529; *Ap. J.*, v. 82, p. 462. (Correction to magnitudes of 7006).

1786 W. Herschel I 52, 1833 J. Herschel 2097, 1855, 1856 d'Arrest, 1861 Earl of Rosse, 1862 Schönfeld, 1862*IIa* Auwers, 1864 J. Herschel 4625, 1866 Huggins, 1867 Schmidt, 1867 Vogel, 1867 d'Arrest, 1874 Schultz, 1876 Vogel, 1880 Earl of Rosse, 1881 Smyth and Chambers, 1882 Engelmann, 1886- Weinek and Gruss, 1890 d'Engelhardt, 1891-*e* Bigourdan, 1891 Kempf, 1895 Rümker, 1895*ab* Mönnichmeyer, 1907 Holetschek, 1909 Winnecke, 1911 Lorenz, 1912 Curtis, 1915 Melotte, 1918 Curtis, 1918*IIefg*, *IVabc*, *VI* Shapley, 1919*Ic*, *IIcd* Shapley and Shapley, 1919*b* Shapley, 1920 Hopmann, 1920*a* Lundmark, 1920*b* Shapley, 1922*II* Becker, 1923 Wirtz, 1923 von Zeipel, 1924 Vogt, 1925 Larink, 1925 Nabokov, 1926 Reinmuth, 1926*cef*, 1927*c* Parvulesco, 1927*h* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II*, 1929*ab* Shapley and Sawyer, 1930*abefno* Shapley 1931 Nabokov, 1932, 1933 van de Kamp, 1933 Stebbins, 1934, 1935 Lundmark, 1935*ab* Edmondson, 1935 Shiveshwarkar, 1935 Mineur, 1936*ab* Stebbins and Whitford, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1944 Shapley, 1945 Sawyer, 1946*abc* Mayall, 1946*ab* Mowbray.

NGC 7078 (Messier 15) $\alpha\ 21^h\ 27^m.6,\ \delta + 11°\ 57'$ $l\ 33°, b - 28°$

1746 Maraldi, G. C. (Discovery of N.G.C. 7078, 1746 Sept. 7). Observations de la comète qui a paru au mois d'août 1746. *Acad. des Sci. Mém.*, p. 58.

1771 Messier, C. Observation, 1764 June 3. Also comments that this may be Hevelius no. 11 if position in error.

1843 Argelander, D. Fr. *Uranometria Nova*, p. 81. Berlin.

1865 Huggins, W. On the spectrum of the great nebula in the sword-handle of Orion. *Roy. Soc. Proc.*, v. 14, p. 39; *M. N.*, v. 25, p. 155.

1866 Schultz, H. Historische Nötigen über Nebelflecke. *A. N.*, v. 67, p. 4.

1891 Denza, F. Gruppo Stellare di Pegaso. Rome. *Specola Vaticana, Pub.* Plate V.

1892 Roberts, I. Photographs of the region of the globular cluster 15 M Pegasi. *M. N.*, v. 52, pp. 543-4.

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NGC 7089 (Messier 2) α 21^h 30^m.9, δ − 01° 03′ l 22°, b − 37°

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NGC 7099 (Messier 30) α 21^{h} 37^{m}.5, δ − 23° 25′ *l* 355°, *b* − 48°

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NGC 7099 (Cont.)

marion, 1918*a* Bailey, 1918 Curtis, 1918*c* Charlier, 1918*IIbd* Shapley, 1919*Ic*, *IIcd* Shapley and Shapley, 1920 Hoffmeister, 1920*a* Lundmark, 1920*b* Shapley, 1923 Lundborg, 1925 Nabokov, 1925 Strömberg, 1925*a*, 1926 Doig, 1926*af* Parvulesco, 1927*h* ten Bruggencate, 1927 Sawyer and Shapley, 1927*I*, *II* Shapley and Sawyer, 1928 van Rhijn, 1928 Voûte, 1929 Cannon, 1929*ab* Shapley and Sawyer, 1930*afnq* Shapley, 1931 Nabokov, 1932, 1933 van de Kamp, 1932 Moore, 1933 Stebbins, 1935*ab* Edmondson, 1935 Shiveshwarkar, 1935 Mineur, 1935 Shapley and Sayer, 1936 Duryea, 1936*ab* Stebbins and Whitford, 1937 Wilkens, 1939*a* Sawyer, 1940 Christie, 1941 de Kort, 1946*abc* Mayall, 1946*ab* Mowbray.

NGC 7492 α 23^h 05^m.7, δ − 15° 54′ *l* 22°, *b* − 65°

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b. Sec. 15. Of the gradual concentration and insulation of clusters of stars.
c. Sec. 16. Of globular clusters of stars.
d. Sec. 17. Of more distant globular clusters of stars.
e. Sec. 18. Of still more distant globular clusters of stars.

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g. " 74, 79. Ellipsoidal clusters.
h. " 80. Inclination of clusters to Milky Way.
i. " 119ff. Color-magnitude diagrams.

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b. Plate I. Photographs.
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n. " 173. Co-ordinates of globular clusters. *Hd.*, p. 756.
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r. " 203. On the masses of giant stars. *Hd.*, p. 714.
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b. Spectral types, color classes, and nebular counts.

c. Plate VIII, Spectra.

d. Values of cos A for clusters of unknown velocity.

e. Clusters added to list of globulars.

f. Clusters rejected as globular. *Lick Cont.*, ser. 2, no. 15, p. 207. *Ap. J.*, v. 104, p. 314.

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SPURIOUS PERIODS IN SPECTROSCOPIC BINARIES, II

By R. W. Tanner

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SPURIOUS PERIODS IN SPECTROSCOPIC BINARIES, II*

By R. W. Tanner

WHEN radial-velocity measurements are always made at nearly the same time of day, the possibility arises of representing the observations equally well by alternative periods. To determine which of these related periods is the true one, other observations made at times differing as widely as possible from the usual time are needed.

If such observations are not at hand, a study of the phase errors of the observations correlated with even slight variations in the time of observation may be informative.

A detailed account of the method, with examples of its application, will be found in the Journal of the Royal Astronomical Society of Canada, vol. 42, p. 177, 1948 (Paper I).

For each observation recorded a relative hour angle, α, measured in sidereal days, is calculated, together with the departure in phase, $\Delta\phi$, of the observation from the mean curve drawn through all the observations assembled using the published period. A correlation diagram of $\Delta\phi$ against α is made. It is readily shown that if the published period is the true one, $\Delta\phi$ is independent of α, but if the period is spurious, $\Delta\phi$ depends linearly on α.

In view of the importance of the correct determination of period a systematic survey of a large number of published spectroscopic binary orbits has been made.

The published orbits of 149 spectroscopic binaries have been surveyed for alternative periods. Four stars were found to have spurious periods, and one other was found to be better represented by an unrelated period. This paper supplements the Paper I by providing

(1) a list of the stars examined, roughly classified according to reliability of period

(2) notes on some individual stars of interest

(3) revised orbits for the four stars whose periods were spurious.

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*From a thesis submitted in partial fulfilment of the requirements for the degree of Master of Arts at the University of Toronto, May 1948. The investigation summarized in this and Paper I was carried out under a scholarship of the Ontario Research Council.

The periods of the stars investigated are not all equally well determined, and the following classification, while unfortunately rather vague and subjective, aims at furnishing some sort of index to the degree of confidence to be placed in the periods assigned.

Class A.—If observations for radial velocity are numerous and well distributed in phase and hour angle, and if the errors of measurement are small compared with the amplitude of variation, then the correlation diagram based on the true period will show a strong concentration of points along the α-axis. No other period can so well represent the observations, and one may repose complete confidence in the published period. Such cases, 57 in number, are listed in *A* below.

Class B.—Under *B* are listed 70 stars for which the clustering along the α-axis, while not so pronounced, is yet sufficient to leave very little possibility of an alternative period. It will be realized that the classes shade off insensibly one into another; the correctness of the *A* periods is more evident prima facie than that of the *B*.

Class C.—In unfavourable cases the correlation figure may fail to give definite indication of the truth or otherwise of the published period. This may be due to a paucity of observations, large errors of measurement, little variation in the hour angle at which the star was observed, or to non-orbital variations in the lines. All such orbits were very carefully scrutinized, and although no better period than the published one could be found for 17 of them, it is believed that further observation would be desirable to put the periods beyond doubt. Perhaps some of these stars are not true binaries, and might be relegated to the appendix of Moore's Catalogue after further investigation. In concluding this explanation of the grouping below, it should be mentioned that two stars at first placed in *C* have now been included in *A* in the light of evidence subsequently available. The stars for which new periods are found are also listed under *C*.

The numbers are those of Moore's Fourth Catalogue up to 372; the others are H.D. numbers.

A	1	5	6	12	13	18	30	31	34	38
	46	48	50	61	62	65	67	69	71	73
	80	81	92	93	106	107	108	110	111	113
	116	123	126	128	129	140	148	162	171	174
	180	181	182	184	193	243	270	282	301	303
	331	336	367	22124	34762	93075		179094		

B	2	3	9	16	17	21	24	29	33	40
	41	47	55	57	58	60	63	66	70	76
	83	85	86	87	88	89	91	94	96	103
	109	120	125	133	134	139	141	142	144	145
	149	150	159	166	167	172	183	186	203	207
	227	235	246	259	260	288	311	317	324	328
	361	363	364	372	9312	96528	99967	181144		
	209813	213389								
C	27	28	32	35	49	52	56	95	99	105
	161	165	221	254	325	65626	218066			
Spurious	68	230	278	1826						
Erroneous	340									

The following notes on some of the stars in the last class will perhaps make the basis of classification a little clearer.

Moore 27. Although more than 100 observations with a variation in α of 0.4 day are available, the period is still doubtful. Luyten has suggested a 2.34 day period, and the Lick and Ottawa velocities indeed show a trace of the correlation appropriate to this period, but the Victoria plates do not confirm this. The residuals are worse with this period than with the published period of 1.74 days. Possibly the star is not binary?

Moore 35. A little positive correlation was seen, but both P_2 and ${}_2P_2$ fail to assemble the observations as well as the published period. There seems no possibility of a long period other than the published one.

Moore 49. This is a southerly star for which the range in α is necessarily small for northern observers, and the errors of measurement are large. No correlation was evident, and the alternative periods do not improve the fit. Trials were made for unrelated periods without success.

Moore 52. This is a double-line binary whose lines are resolved for only about 0.1 period; consequently a test for alternative period is inconclusive. The star might be examined profitably with higher dispersion.

Moore 56. There is some evidence of correlation between large hour angles and large residuals, but of conflicting sign, so that this does not appear to be due to a short period; flexure in spectrograph, or other systematic observational error, perhaps?

Moore 221. The scatter diagram vaguely suggests ${}_2P_1$, and this period represented the published observations about as well as the longer period. When inquiry was made to Victoria, Dr. Pearce made available another 19 plates for examination and measurement here. It was concluded from a study of these that the two components could be differentiated pretty consistently, thus ruling out a ${}_2P_1$ period, but the representation is still not quite satisfactory, and the star should be further investigated.

Revised Orbit, H.D. 1826

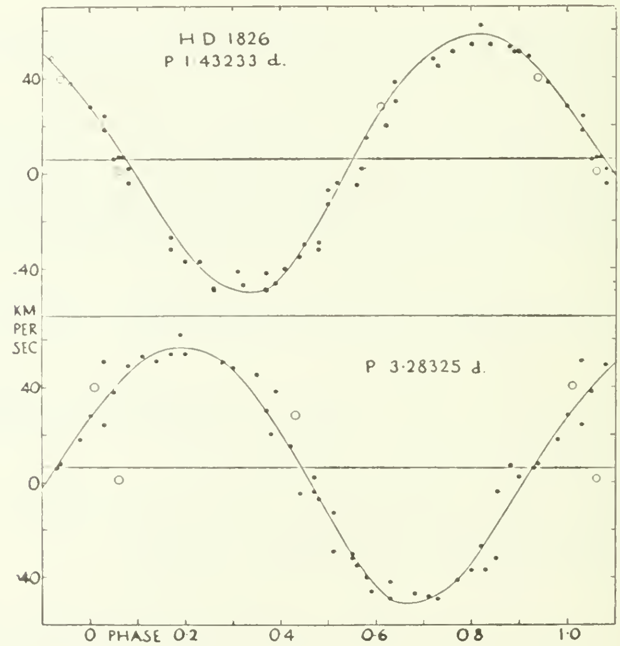
This star appeared in *Pub. D.D.O.*, vol. I, no. 6, with period 3.28 days. A strong positive correlation has indicated P_2, 1.43 days. The fit with the new period was at first only slightly better. One plate omitted from the original orbit was found:

J.D. 2429556.767	Velocity −24.3 km./sec.

Three confirmatory plates were obtained in 1947:

J.D. 2432516.590	Velocity +28.0 km./sec.
2432518.492	+40.4
2432518.660	−01.2

These enabled the period to be estimated at 1.43233 ± 0.00002 days from observations over 3100 revolutions.



A few preliminary trials showed a good fit with a circular orbit. Using the preliminary elements

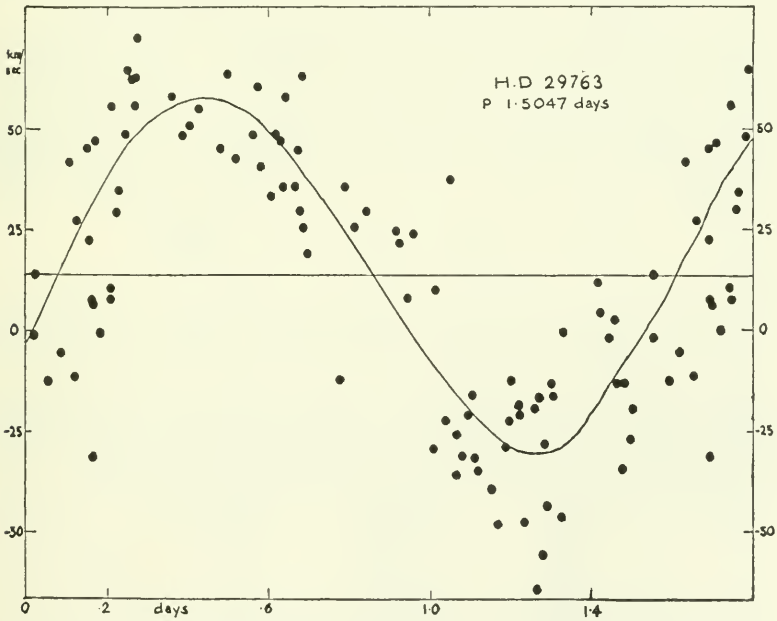
T_0 2429189.573 J.D., $K = 53.3$ km./sec., $\gamma \doteq 4.5$ km./sec., $e = 0$ a least-squares solution by Sterne's method was made on the 48 available plates. Equal weights were employed, and the observations were not grouped.

The new elements with their mean errors follow; the former values are given on the right for comparison.

	Revised Elements	Previous Elements
P	1.43233 ± 0.00002 days	3.28325
T_0	2429189.577 ± 0.004 J.D.	
e	0.024 ± 0.017	0.056
ω	$202° \pm 39°$	152°
γ	$+4.43 \pm 0.62$ km./sec.	5.90
K	53.40 ± 0.92 km./sec.	54.5
$a \sin i$	1.05×10^6 km.	2.46×10^6
mass function	$0.023 \odot$	$0.055 \odot$
mean error single plate	± 4.22 km./sec.	± 6.1

Revised Orbit, H.D. 29763, τ Tauri

The original orbit is by Parker, *Report Chief Astronomer, Canada*, vol. I, p. 166, 1910. The correlation figure showed a strong positive correlation, indicating the period 2.9572 days. The observations were reassembled with this period and the sum of the squares of the

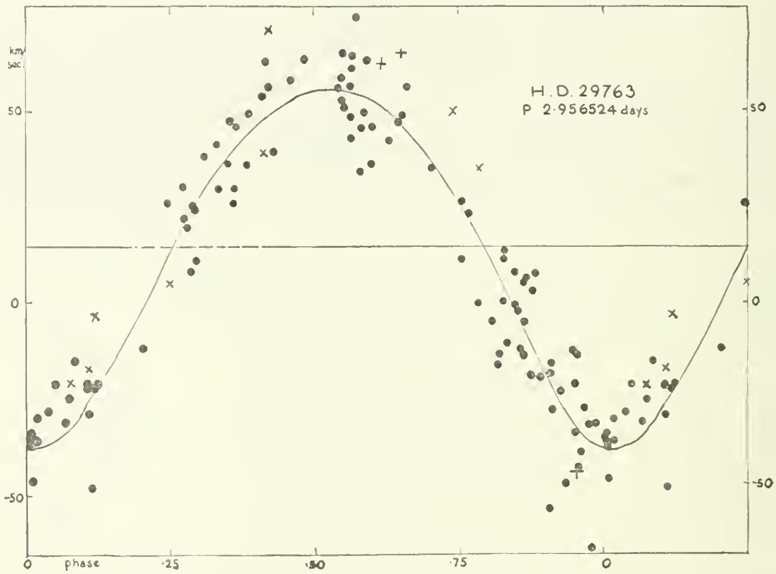


residuals was reduced by a quarter. Because of the large scatter of the observations, not much improvement could be made in the period, although the Ottawa observations covered a two-year interval.

Recourse was had to eight velocities given by Frost, Barrett and Struve, *Ap. J.*, vol. 64, p. 1, 1926, obtained from 1903 to 1922. The number of cycles elapsed between the last Ottawa plate and the single plate of 1922 was doubtful, so three plates were taken here to help fix the period:

J.D. 2432602.523	Velocity	−44	(Ca II +22) km./sec.
604.486		+61	
607.537		+65	(Ca II +25)

By assuming the period to be constant, an estimate of 2.956524 ±0.000050 days was derived.



The present orbit is based on the Ottawa observations only. Parker's weights were adhered to, and his 104 plates were grouped into 9 normal places, using the first plate as origin, as follows:

Phase	Velocity	Weight
.1446	+22.50	0.4
.2444	+ 2.28	1.2
.2925	−17.47	1.4
.3893	−37.55	1.6
.5158	−23.41	1.0
.6823	+20.81	0.8
.7501	+33.75	0.7
.8192	+52.68	0.9
.9764	+53.73	2.2

The uneven distribution of weights results largely from the nearness of the period to three days, which makes the observations fall into three groups.

A couple of solutions by the Wilsing-Russell method suggested the preliminary elements: phase of periastron = 0.4110, $\gamma = 14.5$ km./sec., $K = 46.6$ km./sec., $e = .13$, $\omega = 175°$. A least-squares solution led to the following final elements; the original elements are given on the right for comparison.

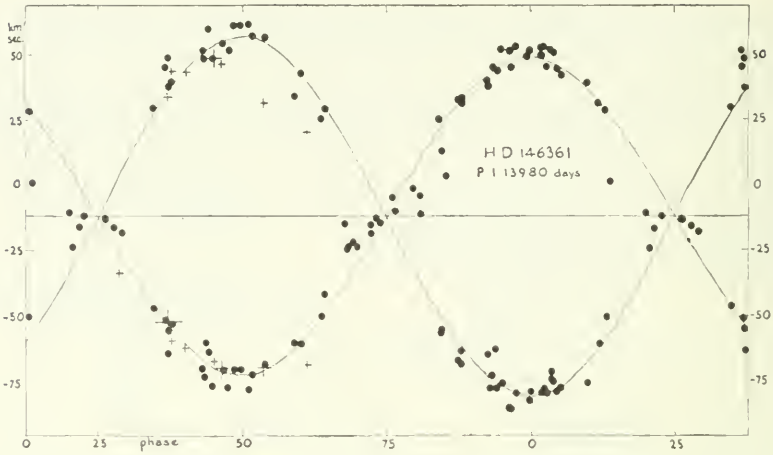
Revised Elements	Previous Elements
P 2.956524 ± 0.000050 days (not varied)	1.5047
γ + 14.56 ± 2.75 km./sec.	13.55
K 46.72 ± 1.73 km./sec.	44.34
e 0.128 ± 0.040	0.087
ω 172° ± 18°	243°
T_0 2417898.451 ± 0.020 J.D.	
$a \sin i$ 1.0 × 10^6 km.	0.9 × 10^6
mass function 0.03 ☉	0.0135 ☉
mean error single plate ± 12.3 km./sec.	± 16

It will be seen that the shape of the curve is somewhat altered by the change of period. Because of the drastic grouping, the elements are possibly even less reliable than the mean errors would suggest. In the diagram the solid circles represent Ottawa observations; ×'s, Yerkes observations; and +'s, Dunlap observations.

Revised Orbit, H.D. 146361, σ^2 CrB

Sixty-seven measures are given in *Pub. D.A.O.* vol. 3, p. 232, including four Mount Wilson plates; a further five plates appear in *Pub. D.A.O.*, vol. 6, p. 234. A strong positive correlation with unit slope indicated P_2. Dr. Pearce of Victoria kindly furnished a couple of corrections to the dates given in volume 3, as well as the velocity for an out of the meridian plate. All of these confirm the short period. With these data, the revised period is estimated at 1.13980 ± 0.00001 days; the observations cover more than 6000 revolutions.

The present orbit is based entirely on these 73 plates. As a preliminary step γ and the mass-ratio, r, were determined by the methods of Zurhellen, Paddock and O. C. Wilson (*Bulletin L.O.*, vol. 8, p. 156; *Ap. J.*, vol. 93, p. 30) applied to the 47 plates showing both spectra; this much reduces the subsequent labour in the least-squares determination of the remaining elements.



A circular orbit gave a good fit; preliminary elements were: $K_1 = 60$ km./sec., $K_2 = 67$, km./sec., $e = 0$, $T_0 = 2423869.113$ together with $\gamma = -11.87$ km./sec. ($r = 1.12$). The observations assembled on the period mentioned above were grouped into 10 normal places as follows, the weights being roughly proportional to the number of plates in the group, and phases reckoned from T_0:

Phase	V_1 km./sec.	V_2	Weight
.03312	48.64	−76.95	3
.12200	32.07	−61.77	1
.24856	−13.72		3
.37320	−54.14	39.58	1
.44937	−68.93	53.07	2
.51115	−72.13	57.38	2
.62500	−52.85	31.82	1
.74886	−12.96		4
.87137	27.38	−61.75	2
.95360	45.11	−77.06	3

γ and P as above were accepted; a least-squares solution by Sterne's method was made for the remaining elements, including both K's as a check. It may be noted in passing that the forms of the equations of condition for double-line binaries as given in *Pub. D.O.*, vol. 1, p. 327 and *Pub. D.A.O.*, vol. 7, no. 17, p. 291, are at first sight a little misleading; each observation gives rise to *two* equations of condition, e.g. for Sterne's method,

$$\delta V_1 = \delta\gamma + \cos L_1 \delta K_1 + \sin L_1 K_1 \mu \delta T_0 + \cos 2L_1 K_1 \, e \cos \omega_1 + \sin 2L_1 K_1 \, e \sin \omega_1$$

$$\delta V_2 = \delta\gamma - \cos L_1 \delta K_2 - \sin L_1 K_2 \mu \delta T_0 - \cos 2L_1 K_2\ e \cos \omega_1 - \sin 2L_1 K_2\ e \sin \omega_1$$

For markedly unequal components, Paddock's method, which leads to a single equation for each pair of measures would be preferable.

The solution resulted in the following elements:

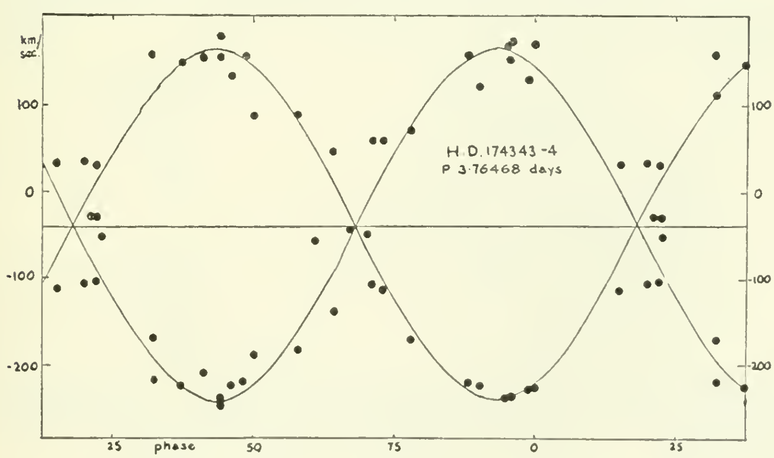
Revised Elements	Previous Elements
P 1.13980 + 0.00001 days	7.975
T_0 2423869.1110 $\pm$.0016 J.D.	
K_1 60.12 $\pm$ 0.77 km./sec.	60.12
K_2 68.18 $\pm$ 0.77 km./sec.	68.77
e 0.0166 $\pm$ 0.011	0.081
ω 94° $\pm$ 29°	90°
γ 11.87 $\pm$ 0.50 km./sec. (Wilson's method)	$-$10.63
mean error single plate $\pm$ 4.7 km./sec.	about 10
$a_1 \sin i$ 9.42 $\times$ 10^5 km.	6.57 $\times$ 10^6
$a_2 \sin i$ 10.68 $\times$ 10^5 km.	7.52 $\times$ 10^6
K_1/K_2 1.13 $\pm$.02 (cf. 1.12 by Wilson's method)	
$m_1 \sin^3 i$ 0.133 $\odot$	0.94 $\odot$
$m_2 \sin^3 i$ 0.117 $\odot$	0.82 $\odot$

Eight more measures were made available April 1948, after the orbit had been completed.

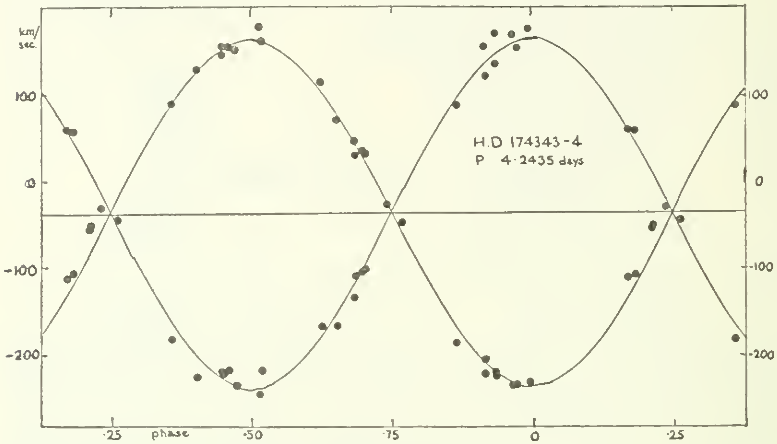
By revising the period to 1.139789 $\pm$ 7 $\times$ 10^{-6}, the plates, marked +, fit the curve, as shown above. T_0 should be revised to 3869.105; the other changes in the orbit are less than the mean errors of the elements.

Revised Orbit, H.D. 174343–4, 205 Draconis

The correlation in this case was positive, but one could not be



certain from the figure whether ${}_1P_2$ or ${}_2P_2$ was indicated. The lines of the two components are so alike that no reliable indication of phase can be drawn from them. On trial, ${}_2P_2 = 4.24$ days was found to give the greater improvement in fit. Only 105 cycles are covered by the observations, so that the period is not fixed with great precision. $P = 4.2435 \pm .003$ days was finally adopted.



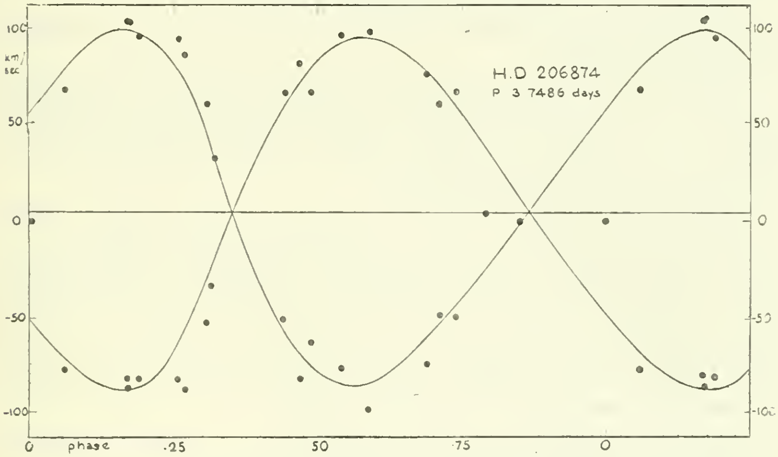
In view of this uncertainty only the best circular orbit was sought. Five measures not used in the original solution were included as they now fit the curves tolerably well. Six plates nearer the γ-axis were omitted as before. The orbit then rests on 24 pairs of observations. Preliminary elements: $K_1 = K_2 = 98$ km./sec., $\gamma = -19$ km./sec., $T_0 =$ J.D. 2,422,160.050, $e = 0$. A least-squares solution for the best values of K_1, K_2, γ and T_0 gave the following final elements with their mean errors:

	Revised Elements	Previous Elements
P	4.2435 ± 0.0030 days	3.76468
γ	−18.6 ± 0.8 km./sec.	−18.8
K_1	101.0 ± 1.5 km./sec.	98.3
K_2	100.2 ± 1.5 km./sec.	97.7
T_0	2422160.044 ±.009 J.D.	
mean error single plate	± 5.7 km./sec.	± 7.0
$a_1 \sin i$	5.89×10^6 km.	5.09×10^6
$a_2 \sin i$	5.85×10^6 km.	5.06×10^6
$m_1 \sin^3 i$	1.72 $\odot$	1.47
$m_2 \sin^3 i$	1.73 $\odot$	1.48

The changes in the elements, except for the period, are seen to be trifling. The component designated 1, happens to have the larger amplitude.

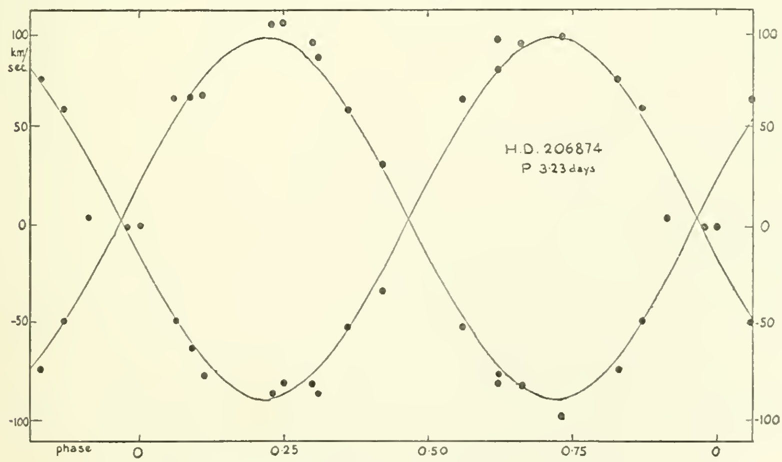
H.D. 206874, Boss 5591

This orbit appears in *Ap. J.*, vol. 53, p. 218, based on only 19 plates. The spectra are indistinguishable; the probable error of



Published velocity curve of H. D. 206874

6 km./sec. is a little large. Because of the sparseness of the observations, no conclusion can be drawn from a correlation diagram. The phase distribution obtained with the published period seemed unsatisfactory, and a thorough trial of alternative periods was made. None of the four simplest spurious periods showed any improvement.



Suggested alternative unrelated velocity curve.

The distribution of observations in time seemed to allow the possibility of an alternative *unrelated* period, and after several trials, 3.23 days was found to give a rather good fit to a circular orbit. The residuals are reduced by about one-half.

Further observations are desirable to establish with certainty the period suggested.

Diagrams of the representations obtained with the two periods are given. In the lower figure is shown the 3.23 day period; the curves are for symmetric circular orbits. Above are shown the same observations on the original period.

The writer's thanks are due to Dr. F. S. Hogg, director of the David Dunlap Observatory, for several suggestions of basic importance to this inquiry, and for guidance throughout. Acknowledgment is made also to Drs. J. A. Pearce and R. M. Petrie of Victoria, who provided material on some of the Victoria stars, and to Dr. R. F. Sanford of Mt. Wilson, who supplied information on Moore 278 and gave permission to revise the orbit.

The writer wishes to express his thanks to the Ontario Research Council for its grant in support of this study.

Richmond Hill, Ontario,
April 1949.

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VOLUME I NUMBER 22

THE ORBITS OF THREE SPECTROSCOPIC BINARIES H.D. 2019, H.D. 10588 and H.D. 14688

BY JOHN F. HEARD AND RUTH J. NORTHCOTT

1949
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TORONTO, CANADA

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 2019

By John F. Heard

THE star H.D. 2019 ($\alpha\ 00^h\ 19.^m4$, $\delta + 30° 49'$, vis. mag. 6. 8, type B9) was announced as a spectroscopic binary from seven plates taken at this observatory between 1935 and 1938,[1] using the 12½-inch camera of the one-prism spectrograph. Between 1945 and 1947, 32 additional plates were obtained with the 25-inch camera. An orbit has been computed from these 32 plates, the earlier plates serving only to fix the period.

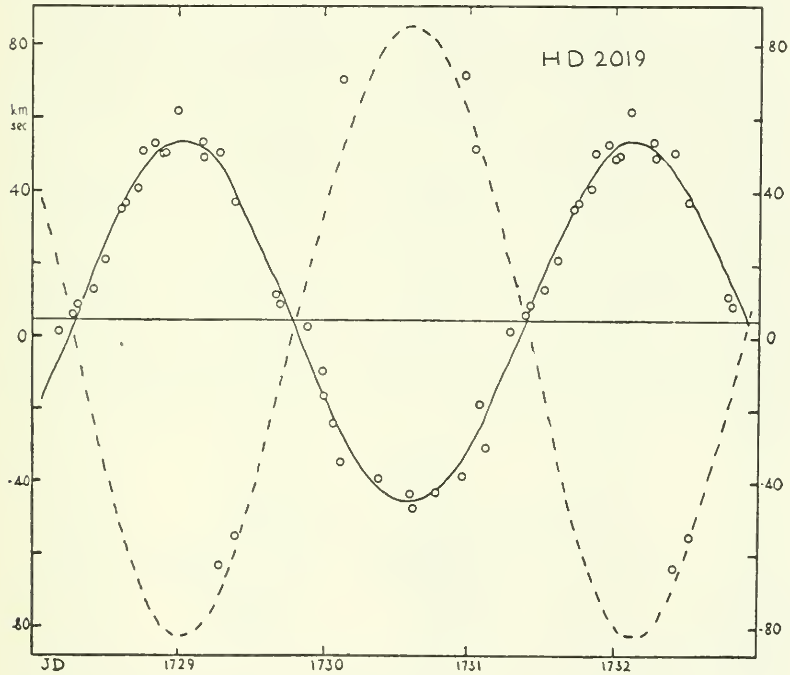

Fig. 1

The spectrum of H.D. 2019 is not of good quality for velocity measures, the lines being poor and few. Generally speaking, the lines measured were λ3933, 4101, 4128, 4130, 4340, 4481, and 4549A. Probable errors for the plates ranged from 2 to 4 km./sec. for the most part.

On five of the plates faint components to some of the lines were measured. These were presumed to be due to the secondary star,

[1] *Pub. D.D.O.*, v. 1, no. 3, 1939.

a conclusion borne out by the accordance of the measures when later fitted to the orbit of the primary. That the components were not seen on more of the plates is attributed to their faintness which would mean that the density of the spectrum needed to be just right.

A preliminary circular orbit was used and differential corrections to the elements were computed by least squares using the method of Sterne.[2] In the solution twenty of the observations were combined in pairs to give twenty-two normal places which were weighted 1 or 2. Since the preliminary period was determined by the use of the early observations which were not used in the least-squares solution, no differential correction to the period was computed.

After the solution for the primary orbit was computed, the velocities attributed to the secondary star were examined. Regarding all the other elements as already fixed by the solution for the primary, a least-squares solution for the half-range of the secondary was made, weights being attributed to the five measures in proportion to the number of lines measured. From the value of K_2 so derived the mass ratio and the value of $(m_1 + m_2) \sin^3 i$ were derived.

The results are summarized in table I, and table II lists the individual times, phases, computed and observed velocities and residuals. Figure 1 shows the individual observations plotted with the final curves. The probable error for a single observation for the primary is ± 5.0 km./sec. and for the secondary ± 10.3 km./sec.

TABLE I

ORBITAL ELEMENTS FOR H.D. 2019

		Preliminary	*Final*	*P.E.*
Period	P	$3^d.11276$	$3^d.11276$	
Eccentricity	e	0	0.026	± .015
Angle of periastron	ω		339°	± 35°
Velocity of system	γ	+ 5.0 km./sec.	+ 4.76 km./sec.	± 0.92
Epoch of mean longitude	To	J.D. 2431732.178	J.D. 2431732.152	± 0.008
Date of periastron	T		J.D. 2431731.970	
Semi-amplitude, primary	K_1	82 km./sec.	79.6 km./sec.	± 1.35
Semi-amplitude, secondary	K_2		134.7 km./sec.	± 4.7
$a_1 \sin i$			3.41×10^6 km.	
$a_2 \sin i$			5.76×10^6 km.	
$\frac{m_1}{m_2}$			1.69	± 0.07
$(m_1 + m_2) \sin^3 i$			1.70 ⊙	

[2]*Proc. Nat. Acad. Sc.*, v. 27, no. 3, 1941.

TABLE II

J.D.	Vo km./sec.	Phase from final T	Vc km./sec.	Vo-Vc km./sec.
2428770.805	+ 82.4*	2.183	+ 90.7	− 8.3
2431733.717	− 69.3	1.747	− 72.9	+ 3.6
1746.655	− 29.2	2.234	− 39.6	+10.4
1751.683	+ 3.8	1.037	− 9.2	+13.0
1756.657	+ 59.0	2.898	+ 60.8	− 1.8
1757.690	+ 18.4	0.819	+ 25.0	− 6.6
1764.633	− 62.2	1.536	− 67.0	+ 4.8
1765.618	+ 9.6	2.521	+ 3.6	+ 6.0
1790.567	+ 13.8	2.568	+ 11.3	+ 2.5
1812.474	+ 20.5	2.685	+ 30.3	− 9.8
2067.801	+ 33.9	2.766	+ 42.8	− 8.9
2078.765	− 54.8	1.279	− 42.8	−12.0
	+113*		+ 85.4	+27.6
2079.754	− 48.8	2.264	− 35.6	−13.2
2386.868	− 38.3	1.219	− 35.3	− 3.0
2390.866	− 61.3	2.104	− 54.6	− 6.7
	+115*		+105.2	+ 9.8
2395.832	+ 13.8	0.844	+ 21.2	− 7.4
2399.876	− 75.8	1.776	− 72.8	− 3.0
2404.867	+ 59.3	0.541	+ 63.7	− 4.4
	− 88*		− 94.9	+ 6.9
2407.878	+ 80.9	0.439	+ 74.2	+ 6.7
	−102*		−112.6	+10.6
2409.875	+ 2.4	2.436	− 10.2	+12.6
2421.805	− 69.2	1.915	− 68.8	− 0.4
2425.869	+ 56.2	2.867	+ 57.0	− 0.8
2428.682	+ 13.9	2.568	+ 11.3	+ 2.5
2432.760	+ 78.0	0.319	+ 82.5	− 4.5
2435.760	+ 86.0	0.306	+ 83.1	+ 2.9
2441.822	+ 99.2	0.143	+ 86.1	+13.1
2444.778	+ 84.7	3.099	+ 80.1	+ 4.6
2467.726	− 15.4	1.143	− 24.9	+ 9.5
2469.597	+ 81.2	3.016	+ 73.5	+ 7.7
2469.730	+ 78.4	0.036	+ 82.9	− 4.5
2470.842	− 25.6	1.149	− 25.7	+ 0.1
2472.677	+ 64.5	2.983	+ 70.4	− 5.9
2472.861	+ 78.8	0.054	+ 83.8	− 5.0

*Secondary spectrum

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 10588

By Ruth J. Northcott

THE star H.D. 10588, $\alpha(1900)\ 01^h38^m.2$, $\delta(1900)\ 31°43'$, vis. mag. 6.42, type G5, was announced as a binary from six plates taken at this observatory during 1936-1938.[1] Thirty-nine spectrograms were taken between the dates 1945 and 1947; these forty-five plates have been made the basis of a least-squares solution for the orbital elements. The early plates were taken with the one-prism spectrograph and the $12\frac{1}{2}$-inch camera giving a dispersion of 66 A./mm. at $H\gamma$; the rest of the plates were taken with the 25-inch camera giving 33 A./mm. at $H\gamma$. The data from the plates are given in table III.

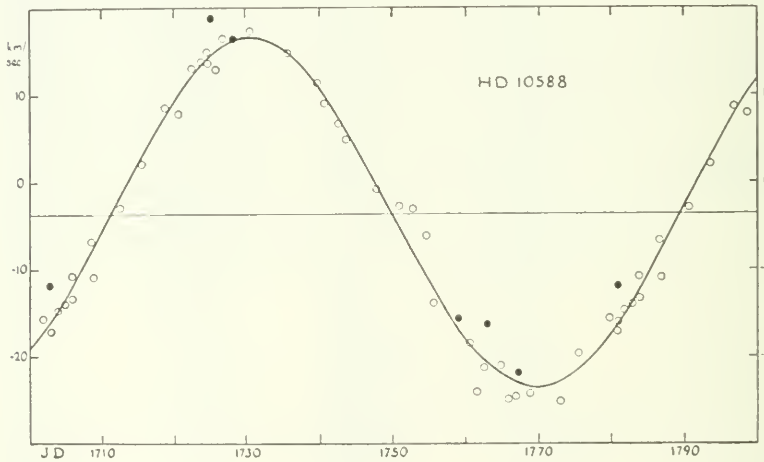

Fig. 2

The observations were grouped into 33 observational equations; in no case did the observations to be grouped differ in time by more than one revolution. Weights (1, 2, 3) were assigned according to the number of plates.

The preliminary elements were derived using R. K. Young's graphical method. A circular orbit was found to fit the observations reasonably well. Final elements were derived using T. E. Sterne's form of least-squares solution for very small eccentricities. All six elements were included in the solution. The observations were

[1] *Pub. D.D.O.*, v. 1, no. 3, 1939.

TABLE III

J.D. 242-243	*Vo* km./sec.	*Phase from final T*	*Vc* km./sec.	*Vo-Vc* km./sec.
8412.820	− 21.9	36.585	− 23.0	+ 1.1
8763.842	+ 16.7	75.578	+ 16.4	+ 0.3
8794.798	− 15.6	28.526	− 16.9	+ 1.3
8838.674	+ 19.1	72.402	+ 14.6	+ 4.5
8894.490	− 11.9	50.211	− 16.3	+ 4.4
9188.716	− 16.3	32.408	− 20.7	+ 4.4
1687.897	− 25.1	35.355	− 22.6	− 2.5
1688.891	− 24.7	36.349	− 23.0	− 1.7
1694.883	− 25.2	42.341	− 22.8	− 2.4
1701.853	− 15.8	49.311	− 17.4	+ 1.6
1702.865	− 16.2	50.323	− 16.2	0.0
1703.842	− 14.6	51.300	− 15.0	+ 0.4
1704.868	− 14.0	52.326	− 13.6	− 0.4
1705.838	− 13.4	53.306	− 12.2	− 1.2
1708.835	− 11.0	56.293	− 07.7	− 3.3
1739.749	+ 11.5	9.200	+ 11.4	+ 0.1
1780.651	− 17.1	50.102	− 16.5	− 0.6
1786.639	− 06.5	56.090	− 08.0	+ 1.5
1793.614	+ 02.3	63.065	− 03.1	− 0.8
1802.575	+ 15.0	72.026	+ 14.3	+ 0.7
1840.506	− 21.4	31.950	− 20.3	− 1.1
2059.902	− 00.8	17.324	− 00.2	− 0.6
2062.869	− 05.5	20.291	− 05.0	− 0.5
2064.874	− 05.1	22.296	− 08.2	− 3.1
2076.835	− 21.8	34.257	− 21.8	0.0
2113.809	+ 13.9	71.231	+ 13.6	+ 0.3
2114.801	+ 13.8	72.223	+ 14.6	− 0.8
2115.759	+ 13.0	73.181	+ 14.0	− 1.0
2116.754	+ 16.7	74.176	+ 15.8	+ 0.9
2120.731	+ 17.5	0.146	+ 16.9	+ 0.6
2125.724	+ 15.1	5.139	+ 15.1	0.0
2144.675	− 10.0	24.090	− 11.0	+ 1.0
2145.665	− 13.9	25.080	− 12.4	− 1.5
2165.590	− 19.7	45.005	− 21.4	+ 1.7
2173.707	− 10.7	53.122	− 12.5	+ 1.8
2190.552	+ 13.4	69.967	+ 12.4	+ 1.0
2228.509	− 18.5	29.916	− 18.4	− 0.1
2229.498	− 24.2	30.905	− 19.4	− 4.8
2392.856	− 24.9	38.249	− 23.4	− 1.5
2414.740	− 02.9	60.133	− 01.6	− 1.3
2420.897	+ 08.8	66.290	+ 04.8	+ 4.0
2422.836	+ 08.1	68.229	+ 10.4	− 2.3
2442.774	+ 09.1	10.159	+ 10.3	− 1.2
2444.858	+ 06.8	12.243	+ 07.5	− 0.7
2445.809	+ 05.0	13.194	+ 06.2	− 1.2

tested for a fictitious period by the method of R. W. Tanner.[2] Reduction of Σpv^2 was from 240 to 176. The following table IV gives the preliminary and final elements obtained.

The individual observations are shown in figure 2. The probable error of a single plate is 1.4 km./sec.

TABLE IV

ORBITAL ELEMENTS OF H.D. 10588

		Preliminary	Final	P. E.
Period............	P	77.98 days	78.0073	± 0.0128
Eccentricity.......	e	0	0.0173	± 0.0104
Angle of periastron.	ω		359°.40	±28.34
Periastron passage .	T		J.D. 2431730.549	± 0.160
Velocity of system .	γ	−03.5 km./sec.	−03.654	± 0.188
Semi-amplitude....	K	21.5 km./sec.	20.142	± 0.270
$a \sin i$............			2.160×10^7 km.	
$\dfrac{m_2^3 \sin^3 i}{(m_1+m_2)^2}$			0.0662 ⊙	
Absolute magnitude M (spectroscopic)			+2.0	
Spectroscopic parallax			0″.013	

[2] *Comm. D.D.O.*, no. 16, 1948.

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 14688

By John F. Heard

THE star H.D. 14688 (α 02^{h}17^m.1, δ + 16°24′, vis. mag. 7.8, type A1s) was announced as a spectroscopic binary from five plates taken at this observatory between 1935 and 1938.[1] The plates were taken with the $12\frac{1}{2}$-inch camera of the one-prism spectrograph. During 1945 and 1946, 27 additional plates have been obtained with the 25-inch camera which gives a dispersion of about 33 A./mm. at Hγ. From these latter plates an orbit has been computed. The earlier plates were used to fix the period but were not otherwise used in the solution.

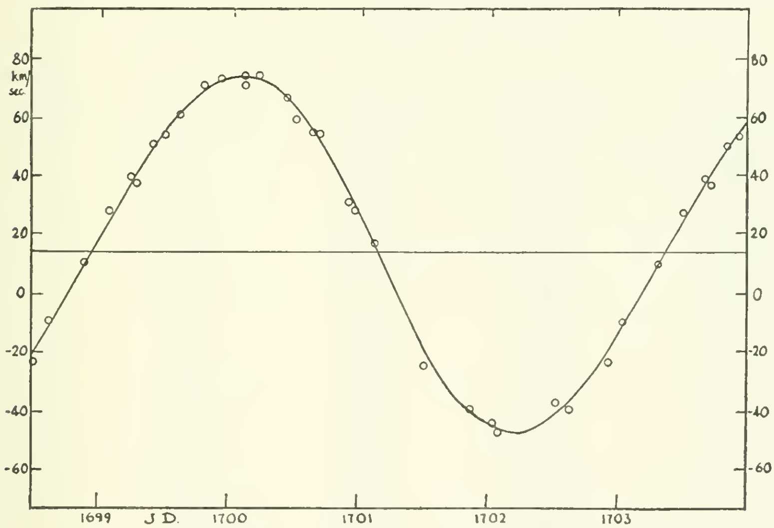

Fig. 3

The spectrum of H.D. 14688 is of very good quality for measuring, the lines being numerous and sharp. Between 27 and 41 lines were measured on each plate. The probable errors of the velocities from inter-agreement among the lines ranged from 0.6 to 1.2 km./sec. An apparent variation in the intensity of the line 4226 reported earlier[1] was not confirmed on the plates of greater dispersion, and no other peculiarities of the spectrum were noticed.

[1] *Pub. D.D.O.*, v. 1, no. 3, 1939.

TABLE V

ORBITAL ELEMENTS FOR H.D. 14688

	Preliminary	*Final*	P. E.
Period . . . . P	4.37140 days	4.37140 days	
Eccentricity . . . . e	0.05	0.047	± .007
Angle of Periastron . . . . ω	90°	90°.00	±7.45
Velocity of system . . . . γ	+13.7 km./sec.	+13.86 km./sec.	± .47
Semi-amplitude . . . . K	59.5 km./sec.	59.54 km./sec.	± .38
Epoch of mean longitude . . . T_0	J.D. 2431704.404	J.D. 2431704.406	± .005
Date of periastron . . . . T	J.D. 2431705.497	J.D. 2431705.498	
$a \sin i$		3,574,000 km.	
$\dfrac{m_2^3 \sin^3 i}{(m_1+m_2)^2}$		0.092 ⊙	

TABLE VI

J.D. 243	*Vo* km./sec.	*Phase from final T*	*Vc* km./sec.	*Vo-Vc* km./sec.
1701.881	−37.3	0.754	−40.9	+3.6
1702.885	−22.2	1.758	−18.3	−3.9
1703.884	+53.3	2.757	+54.7	−1.4
1704.896	+59.1	3.769	+61.9	−2.8
1705.874	−23.7	0.376	−19.3	−4.4
1708.853	+73.5	3.355	+73.4	+0.1
1728.831	−38.4	1.476	−34.3	−4.1
1745.728	−43.1	0.887	−44.4	+1.3
1746.717	− 8.4	1.876	− 9.4	+1.0
1747.708	+60.0	2.867	+60.6	−0.6
1748.742	+53.8	3.901	+53.9	−0.1
1751.718	+39.2	2.506	+38.2	+1.0
1755.725	+10.7	2.141	+10.2	+0.5
1757.756	+30.8	4.172	+32.3	−1.5
1763.703	−34.9	1.376	−38.7	+3.8
1764.659	+28.0	2.332	+25.0	+3.0
1765.689	+70.7	3.362	+73.4	−2.7
1766.690	+17.9	4.363	+14.7	+3.2
1791.635	+71.1	3.080	+69.3	+1.8
1795.578	+50.4	2.652	+48.2	+2.2
1805.637	+52.4	3.968	+49.1	+3.3
1813.590	+71.8	3.178	+71.7	+0.1
1831.583	+66.4	3.685	+66.0	+0.4
1836.483	+28.1	4.214	+28.5	−0.4
1837.583	−45.7	0.943	−45.2	−0.5
1843.536	+36.2	2.524	+39.5	−3.3
1844.478	+73.6	3.466	+72.5	+1.1

A preliminary orbit was determined by the graphical method of R. K. Young and a least-squares solution was made using 19 normal places. Since the eccentricity is small, the method of Sterne was used in the least-squares solution, that is, a differential correction was computed for T_0, the date at which the mean longitude $\omega + M$ is zero. Both T_0 and the corresponding T, time of periastron passage, are shown in table V, which lists the preliminary and final elements and their probable errors. The period was not included in the least-squares solution since it was possible to fix it with considerable accuracy by use of the earlier observations.

Table VI lists the individual times, phases, computed and observed velocities and residuals.

Figure 3 shows the individual observations plotted with the final curve. The probable error of a single observation is $\pm$ 1.6 km./sec.

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VOLUME I NUMBER 23

THE ORBITS OF FOUR SPECTROSCOPIC BINARIES, H.D. 3264, H.D. 158013, H.D. 170829 and H.D. 201032

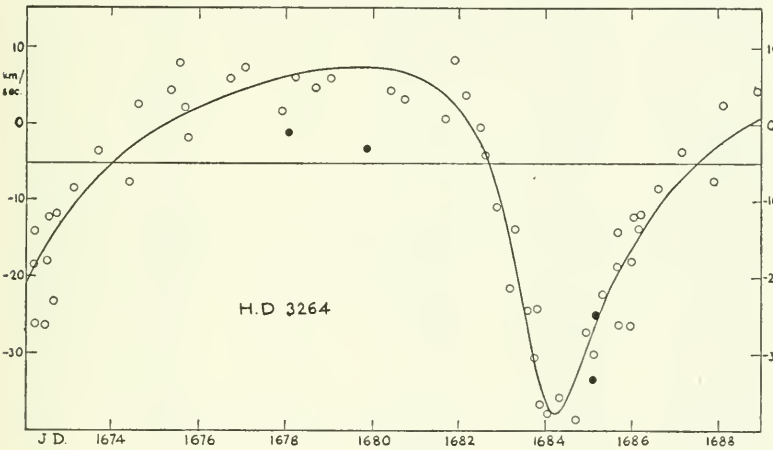
BY D. K. NORRIS, W. T. SHARP AND R. W. TANNER

1949
THE UNIVERSITY OF TORONTO PRESS
TORONTO, CANADA

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 3264

By William T. Sharp

The star H.D. 3264, $\alpha(1900)\ 00^h30^m.7$, $\delta(1900) + 48°00'$, vis. mag. 7.42, type B2, was found to have variable velocity in the course of the third radial-velocity programme at the David Dunlap Observatory.[1] Four plates taken with the $12\frac{1}{2}$-inch camera in the course of this programme between 1939 and 1941 showed a radial-velocity range of at least 30 km./sec. Further observation was undertaken in 1945 and completed in 1946, 43 plates being obtained with the 25-inch camera and one-prism spectrograph, giving a dispersion of about 33 A./mm. at $H\gamma$. The information obtained from these plates is summarized in Table I. Weights were assigned to each



observation on the basis of the probable error of the measured radial velocity. The character of the spectral lines was generally good so that it was usually possible to measure ten or more lines on each plate with an average probable error of about 2 km./sec. The observations with the 25-inch camera were then grouped according to phase as indicated in the accompanying table to form twenty normal places of equal weight.

In Table I, V_o is the measured radial velocity, reduced to the sun and V_c is the radial velocity computed from the final orbital elements.

Preliminary elements were derived using R. K. Young's graphical method. A least-squares solution was carried through for T_o, e,

[1] *Pub. D.D.O.*, v. 1, no. 13, 1942.

TABLE I

J.D. 242–243	V_o km./sec.	Phase from final T	Normal place	V_c km./sec.	V_o–V_c km./sec.
9508.848	−03.5	9.44	..	+07.8	−11.3
9878.802	−26.0	1.28	..	−27.0	+ 1.0
9905.697	−35.0	1.17	..	—28.7	− 6.3
0249.772	−01.0	7.64	..	+06.6	− 7.6
1678.882	−01.9	5.332	1	+01.7	− 3.6
1683.867	+03.5	10.317	2	+07.1	− 3.6
1684.819	+00.8	11.269	2	+04.1	− 3.3
1686.861	−42.0	13.311	3	−32.2	− 9.8
1687.853	−40.5	0.799	11	−34.6	− 5.9
1688.848	−27.5	1.794	8	−19.9	− 7.6
1694.831	+06.7	7.777	5	+06.8	− 0.1
1701.822	−26.1	1.264	4	−27.2	+ 1.1
1702.820	−12.2	2.262	6	−14.8	+ 2.6
1703.797	−03.8	3.239	6	−07.3	+ 3.5
1705.812	+02.3	5.254	10	+01.5	+ 0.8
1706.876	+06.2	6.318	10	+04.3	+ 1.9
1708.803	+05.0	8.245	5	+07.4	− 2.4
1715.826	−14.9	1.764	8	−20.3	+ 5.4
1728.773	−31.5	1.207	4	−28.1	− 3.4
1732.708	+08.4	5.142	1	+01.1	+ 7.3
1747.683	+07.9	6.613	7	+04.9	+ 3.0
1756.696	−12.9	2.122	9	−16.2	+ 3.3
1783.600	−27.7	2.018	9	−17.4	−10.3
1791.586	+04.7	10.004	2	+07.5	− 2.8
1802.529	+01.8	7.443	7	+06.4	− 4.6
1808.488	−25.1	13.402	3	−34.6	+ 9.5
1812.512	−07.9	3.992	1	−05.6	− 2.3
1822.496	−37.6	0.402	11	−39.2	+ 1.6
2046.786	+06.3	8.628	12	+07.7	− 1.4
2053.729	−18.0	2.067	13	−16.8	− 1.2
2053.860	−24.2	2.198	13	−16.0	− 8.2
2066.589	−23.2	1.423	14	−24.8	+ 1.6
2066.913	−19.5	1.747	14	−20.5	+ 1.0
2067.841	−08.9	2.675	17	−11.2	+ 2.3
2076.619	+08.9	11.453	15	+03.0	+ 5.9
2076.920	+04.0	11.754	15	+00.6	+ 3.4
2077.916	−22.5	12.750	20	−15.8	− 6.7
2078.631	−38.3	13.465	16	−35.9	− 2.4
2078.782	−39.8	0.112	18	−38.4	− 1.4
2079.703	−28.5	1.033	18	−30.9	+ 2.4
2083.615	+14.7	4.945	17	+00.5	+14.2
2090.835	−04.3	12.165	19	−04.1	− 0.2
2091.516	−14.3	12.846	20	−18.5	+ 4.2
2091.812	−25.5	13.142	16	−27.4	+ 1.9
2109.849	+02.7	4.171	17	−02.5	+ 5.2
2117.760	−00.4	12.082	19	−03.0	+ 2.6
2131.642	−11.3	12.460	20	−09.2	− 2.1

ω, γ, and K. In view of the confirmatory evidence of the $12\frac{1}{2}$-inch camera observations and the high eccentricity, it was not considered necessary to correct the period. The preliminary and final elements obtained are given in Table II below; the errors given are mean errors except in the case of the period where the error is estimated from graphical considerations. The values of V_o-V_c given for the individual plates in Table I seem reasonable in view of the quality of the observational material and the mean errors of the orbital elements. For the normal places, $\Sigma(V_o\text{-}V_c)^2$ was reduced by the least-squares solution from 243 to 156.

TABLE II

Orbital Elements of H.D. 3264

Element		Preliminary	Final	
Period	P	13.504 days	13.504 days	$\pm$ 0.003
Eccentricity	e	0.46	0.507	$\pm$ 0.035
Angle of periastron	ω	160°	152°.35	$\pm$ 6°.8
Periastron passage	T	J.D. 2431673.58	J.D. 2431673.550	$\pm$ 0.25
Velocity of system	γ	− 5.6 km./sec.	− 5.15 km./sec.	$\pm$ 0.61
Semi-amplitude	K	24 km./sec.	23.65 km./sec.	$\pm$ 1.16
$a \sin i$			3.8×10^5 km.	
$\dfrac{m_2^3 \sin^3 i}{(m_1+m_2)^2}$			0.000012 $\odot$	

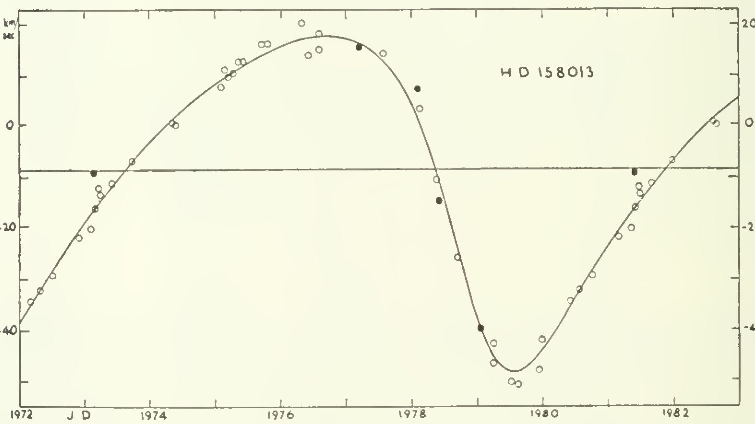
The individual observations are plotted on the graph in figure 1, with $12\frac{1}{2}$-inch camera plates shown as solid circles on the curve.

Measures of the velocity from the K-line of ionized calcium indicated that this originated in interstellar space. From 26 plates this velocity was found to be -12.7 ± 1.5 km./sec. Of this velocity the component of the solar motion was -6 km./sec., leaving a residual velocity of -7 ± 1.5 km./sec. On the assumption that this velocity was due to galactic rotation and that the interstellar material was uniformly distributed, an estimate of the distance of the star was made. Taking $A = +0.017$ km./sec./parsec, $l_o = 331°$, $l = 88°$, $b = -13°$ this distance was found to be 1100 parsecs. Neglecting interstellar absorption, this gives for the absolute magnitude the reasonable value -2.8.

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 158013

By D. K. Norris

H.D. 158013, $\alpha(1900)$ $17^h21^m.7$, $\delta(1900)+57°05'$, vis. mag. 6.55, type A2, was announced as a binary from five plates taken at this observatory during 1939-1941.[1] These plates were taken with the $12\frac{1}{2}$-inch camera giving a dispersion of 66A./mm. at Hγ. Thirty-four plates were taken during 1946-1947 with the 25-inch camera, giving 33A./mm. By using the early plates, the period was well determined; the other plates were grouped according to phase into 22 observational equations. Weights (1, 2) were assigned according to the number of plates. Table III gives the data from the plates.



The preliminary elements were determined graphically using R. K. Young's method. Final elements were derived using T. E. Sterne's form of least-squares solution. These elements are given in Table IV. The probable error of a single plate is 1.3 km./sec. The individual observations are plotted on the graph; the early observations are indicated by solid circles.

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[1]*Pub. D.D.O.*, v. 1, no. 13, 1942.

TABLE III

J.D. 242-243	V_o km./sec.	Phase from final T	V km./sec.	V_o–V_c km./sec.
9382.834	−40.3	0.053	−40.3	0.0
9759.823	+07.0	7.332	+06.9	+0.1
9817.660	−15.0	7.653	−11.7	−3.3
9824.658	+15.3	6.437	+15.8	−0.5
0132.822	−09.5	2.395	−16.8	+7.3
1971.785	−42.7	0.998	−45.2	+2.5
1975.752	+15.9	4.996	+14.0	+1.9
1980.754	−29.8	1.754	−29.4	−0.4
2027.674	−10.8	7.595	−09.5	−1.3
2340.760	−43.3	0.258	−46.5	+3.2
2362.763	+17.8	5.829	+17.7	+0.1
2363.731	+13.9	6.798	+12.9	+1.0
2365.663	−50.9	0.513	−49.6	−1.3
2367.621	−12.5	2.469	−15.8	+3.3
2367.812	−11.7	2.666	−12.4	+0.7
2368.774	+00.1	3.627	+01.4	−1.3
2369.736	+12.4	4.588	+11.3	+1.1
2370.829	+13.6	5.681	+17.6	−4.0
2386.651	+16.1	5.065	+14.7	+1.4
2390.756	−48.6	0.957	−46.1	−2.5
2392.764	−07.0	2.970	−07.0	0.0
2395.624	+14.7	5.829	+17.7	−3.0
2397.716	−26.4	7.916	−25.2	−1.2
2398.630	−51.4	0.620	−49.7	−1.7
2399.585	−32.8	1.573	−32.8	0.0
2401.606	+00.3	3.594	+01.2	−0.9
2402.689	+12.6	4.679	+12.0	+0.6
2403.578	+20.1	5.566	+17.3	+2.8
2407.645	−34.9	1.417	−36.5	+1.6
2408.574	−20.6	2.345	−17.9	−2.7
2408.646	−16.5	2.419	−16.5	0.0
2408.728	−13.7	2.502	−15.4	+1.7
2410.565	+07.5	4.334	+08.9	−1.4
2410.613	+10.8	4.383	+09.5	+1.3
2410.672	+09.5	4.440	+09.9	−0.4
2410.742	+10.3	4.514	+10.6	−0.3
2413.580	+03.1	7.349	+00.7	+2.4
2414.681	−47.3	0.234	−46.3	−1.0
2416.605	−22.4	2.156	−21.4	−1.0

TABLE IV

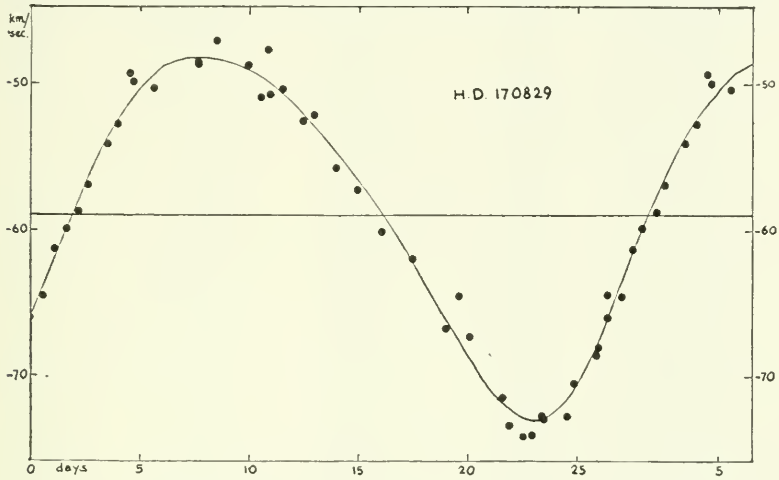
ORBITAL ELEMENTS OF H.D. 158013

Element	Preliminary	Final	P.E.
Period	8.2159 days	8.2159	
Eccentricity	0.33	0.333	±0.009
Angle of periastron	140°	132°.1	±2°.1
Periastron passage	J.D. 2431979.130	2431979.003	±0.049
Velocity of system	−8.53 km./sec.	−8.427	±0.523
Semi-amplitude	33.6 km./sec.	33.931	±0.356
$a \sin i$		3.62×10^6 km.	
$\frac{m_2^3 \sin^3 i}{(m_1+m_2)^2}$		0.0280 ⊙	

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 170829

By D. K. Norris

THE star H.D. 170829, $\alpha 18^h 26^m.4$, $\delta + 20°46'$(1900), vis. mag. 6.59, spectral class G5, showed a variable radial velocity on four plates obtained at this observatory in 1942-43.[1] A long run of plates was taken in 1945, and a few plates in each of 1946 and 1947 to improve the period and eliminate the possibility of a short period.



The orbit is based on 39 plates with 33A./mm. dispersion at Hγ listed in Table V. One weak plate with a large error of measurement was rejected. The observations cover nearly 60 revolutions; the period best assembling them is 26.39 days.

By trial, preliminary elements of $\omega = 235°$, $e = 0.17$, $\gamma = -58.9$ km./sec., K = 12.85 km./sec., T = J.D. 2430574. 662 were found. The plates were grouped into 25 normal places and the usual least-squares solution carried out, reducing the sum of the squares of the residuals from 56 to 33.

The final elements and their probable errors are:

P 26.390 days
K 12.42 $\pm$0.18 km./sec.
γ $-$ 58.96 $\pm$ 0.28 km./sec.
ω 222°$\pm$ 5°
e 0.176 $\pm$ 0.014
T_0 J.D. 2430557.26 $\pm$ 0.07;T J.D. 2430573.532
$a \sin i$ 4.44 $\pm$ .06 $\times$ 10^6km.
Mass function 0.0050 $\odot$
Probable error of a single plate $\pm$ 0.78 km./sec.

[1] *Pub. D.D.O.*, v. 1, no. 16, 1945.

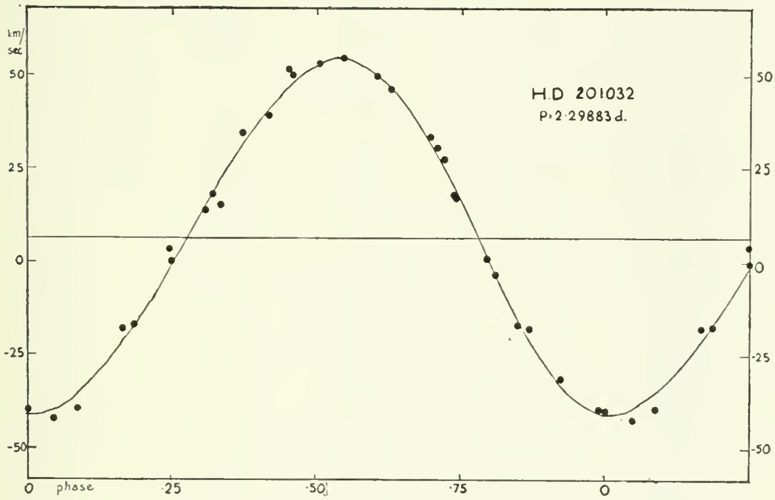
TABLE V

J.D.	V_o km./sec.	Phase from final T	V_c km./sec.	V_o—V_c km./sec.
243 0574.662	−66.0	1.110	−66.0	+0.0
0624.534	−73.0	24.592	−72.9	−0.1
0951.593	−48.6	8.581	−48.2	−0.4
0996.508	−68.0	0.816	−67.5	−0.5
1614.790	−47.6	12.028	−49.9	+2.3
1628.718	−70.5	25.956	−70.9	+0.4
1629.765	−68.5	0.613	−67.8	−0.7
1633.749	−54.1	4.597	−53.6	−0.5
1640.752	−50.9	11.600	−49.5	−1.4
1647.707	−62.0	18.555	−62.2	+0.2
1653.665	−72.7	24.513	−72.9	+0.2
1656.597	−64.4	1.055	−66.2	+1.8
1660.614	−52.7	5.027	−52.4	−0.3
1666.599	−48.8	11.057	−49.0	+0.2
1667.672	−50.8	12.130	−50.0	−0.8
1669.616	−52.0	14.074	−52.7	+0.7
1670.598	−55.8	15.056	−54.5	−1.3
1671.585	−57.2	16.043	−56.4	−0.8
1672.646	−60.1	17.104	−58.7	−1.4
1676.635	−67.2	21.093	−68.4	+1.2
1678.568	−73.3	23.026	−72.2	−1.1
1679.603	−74.0	24.061	−73.0	−1.0
1683.665	−64.5	1.733	−63.6	−0.9
1684.638	−59.8	2.706	−59.8	−0.0
1687.553	−49.3	5.625	−51.2	+1.9
1688.653	−50.4	12.619	−50.6	+0.2
1690.662	−48.5	8.730	−48.2	−0.3
1691.565	−47.0	9.633	−48.2	+1.2
1694.551	−50.4	12.619	−49.4	−1.0
1695.544	−52.6	13.612	−52.0	−0.6
1702.609	−64.5	20.677	−67.6	+3.1
1704.590	−71.4	22.658	−71.7	+0.3
1705.572	−74.1	23.640	−72.8	−1.3
1707.556	−72.8	25.624	−71.6	−1.2
1710.546	−61.2	2.224	−61.7	+0.5
1711.605	−58.7	3.283	−57.7	−1.0
1728.567	−66.7	20.245	−66.5	−0.2
2028.727	−56.9	3.725	−56.2	−0.7
2083.555	−49.9	5.773	−50.9	+1.0

THE ORBIT OF SPECTROSCOPIC BINARY H.D. 201032

By R. W. Tanner

THE star H.D. 201032, $\alpha 21^h 02^m.0$, $\delta + 62°59'$ (1900), vis. mag. 7.26, type A5, was found to have a variable radial velocity on five plates secured here in 1940-41.[1] These plates were taken with the $12\frac{1}{2}$-inch camera, giving a dispersion of about 66 A./mm. at $H\gamma$.



Eight more observations with the 25-inch camera, giving 33 A./mm. in 1945-46 suggested a short period, and the velocity curve was filled in by a run of 25-inch camera plates in September and October, 1947. The orbit is based on 29 plates, including the five $12\frac{1}{2}$-inch plates, as given in Table VI.

About fifteen or twenty lines were measured on each plate, the error of measurement being from one to two km./sec., judged from the internal agreement of the measures.

The period best assembling the observations is 2.29883 days. The observations cover more than 1100 revolutions, and the error in the period is estimated at ± .00005 days. Several check plates eliminate any possibility of an alternative period.

The orbit is nearly circular, and preliminary elements chosen were T_0 = J.D. 2431708.9, K = 49 km./sec., γ = 6 km./sec. A least-squares solution by Sterne's method made rather large changes in

[1]*Pub. D.D.O.*, v. 1, no. 13, 1942.

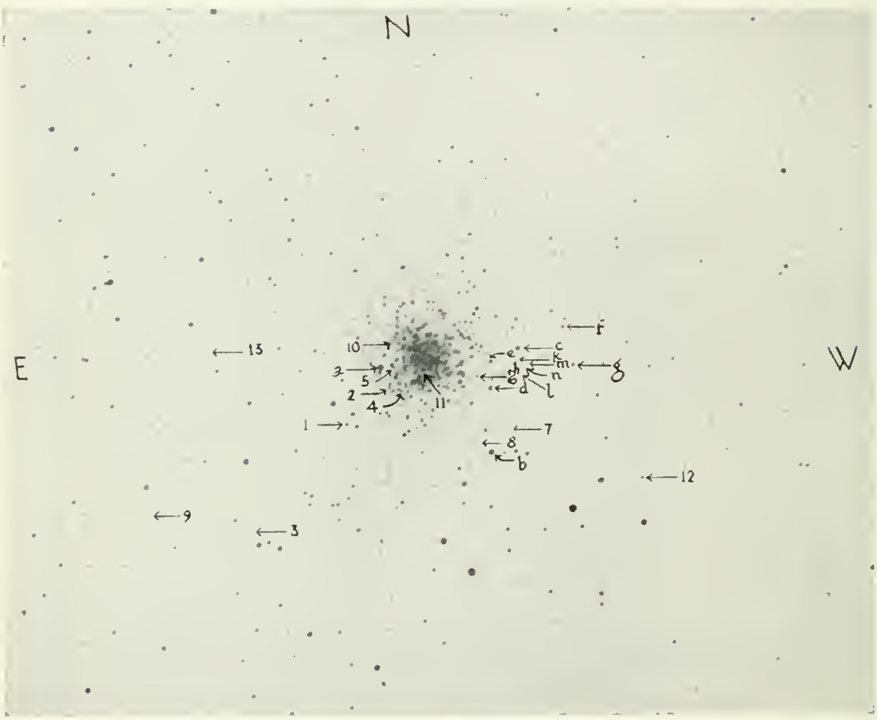
TABLE VI

J.D.	V_o km./sec.	Phase from T_o	V_c km./sec.	V_o-V_c km./sec.
2429858.729	+30.9	.178	+29.0	+1.9
9947.469	+13.7	.781	+14.6	−0.9
2430239.749	+51.5	.923	+47.0	+4.5
0287.558	+ 3.7	.721	− 1.7	+5.4
0324.510	+17.8	.795	+18.4	−0.6
1707.657	−39.4	.478	−40.7	+1.3
2012.816	+17.0	.213	+18.2	−1.2
2013.847	−17.0	.662	−16.6	−0.4
2015.825	−42.5	.526	−39.2	−3.3
2025.865	+39.2	.891	+41.3	−2.1
2033.790	−18.3	.338	−20.8	+2.4
2035.788	+17.7	.207	+20.4	−2.7
2118.510	+27.2	.191	+25.2	+2.0
2432.662	+34.4	.848	+31.8	+2.6
2434.680	− 0.1	.726	− 0.3	+0.2
2435.695	+33.4	.167	+32.1	+1.3
2436.610	−39.3	.565	−35.1	−4.2
2436.785	−18.1	.642	−21.3	+3.2
2437.782	+49.8	.075	+51.0	−1.2
2438.665	−38.9	.459	−40.2	+1.3
2441.771	+15.1	.811	+22.5	−7.4
2444.740	+46.2	.102	+47.0	−0.8
2446.648	+49.9	.932	+48.3	+1.6
2446.749	+52.8	.976	+53.1	−0.3
2453.749	+54.3	.021	+54.6	−0.3
2454.601	−31.2	.392	−32.6	+1.4
2456.642	− 4.4	.279	− 3.5	−0.9
2456.731	−17.1	.318	−15.3	−1.8
2463.506	+ 0.9	.265	+ 1.1	−0.2

the elements, necessitating a second solution with preliminary elements: T_o = J.D. 2431708.88, K = 47.65 km./sec., γ = 6.52 km./sec. The final elements with their mean errors are:

P 2.29883 ± .00005 days
K 47.68 ± .81 km./sec.
γ +6.59 ± .54 km./sec.
e 0.047 ± .016
ω 81° ± 19°
T_o J.D. 2431708.879 ± .005; T J.D. 2431709.396
$a \sin i$ 1.50 × 10^6 km.
Mass function 0.026 ☉
Mean error single plate ± 2.84 km./sec.

PLATE XXXIII



The globular cluster NGC 6333, Messier 9, with variables and comparison stars marked. The edge of an obscuring cloud is responsible for the scarcity of stars in the south-west corner of the region. Enlarged from D.D.O. plate 7959, 1942 July 12, exp. 16 m. Scale 1 mm. = 9″.3.

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PERIODS OF VARIABLE STARS IN THE GLOBULAR CLUSTER MESSIER 9

BY

HELEN B. SAWYER

1951
TORONTO, CANADA

PERIODS OF VARIABLE STARS IN THE GLOBULAR CLUSTER MESSIER 9

By Helen B. Sawyer

(With Plate XXXIII)

The globular cluster Messier 9, NGC 6333, is one of the brighter globular clusters, but it is situated in a region of considerable obscuration in Ophiuchus. Discovered by Messier in 1764, the cluster has been relatively little studied, doubtless due to its considerable southern declination. Its right ascension is 17h 16m, and declination $-18° 28'$ (1950). At galactic longitude 333° and latitude $+9°$, the cluster, with apparent magnitude 8.92 is one of the brightest of the numerous group situated around the galactic centre. With an absolute magnitude of -7.78[1] this cluster ranks among the more luminous globular clusters, which causes the stars to be crowded together in the central region on a photographic plate.

Messier 9 was among those clusters which Bailey[2] suggested should be searched for variables, at about the same time that Shapley[3] announced one variable in it in 1916. No further work has been done on variables in the cluster since that time, except that contained in a progress report by the writer[4] at the Columbus meeting of the American Astronomical Society in 1947.

The writer began work on this object in 1939 with the 36-inch Steward Observatory telescope, through the kindness of Dr. E. F. Carpenter and the National Academy of Sciences. This is the fifth[5] in a series of papers on southern globular clusters, resulting from that visit. During a six-week interval of that year 14 plates were taken on this cluster. In subsequent seasons, the 74-inch David Dunlap reflector has been used to continue the programme. Unfortunately the southern declination of this object prevents photographing it over an interval greater than 2.7 hours on any one night. Further, our seeing conditions deteriorate noticeably when such a low object is far off the meridian. However, 89 plates have been obtained with the 74-inch, making 103 plates now available for study.

In addition to the variable found by Shapley, twelve new variables have been found by the writer. Thirty pairs of plates were blinked in this investigation. A sequence was set up in the cluster from six sequence plates exposed on both the cluster and a standard sequence. One plate with the 36-inch telescope was exposed for 20 minutes on Kapteyn Area 134, and five with the 74-inch were exposed on Area 133 with exposure times ranging from 6 to 12 minutes. However, because of the great zenith distance involved, with uncertainties in atmospheric absorption, the magnitudes cannot have a high weight.

Table I lists the comparison stars with their positions and magnitudes. The positions were measured with a reseau, with the centre of the cluster corresponding to the one used by Shapley. Table II contains the observations of the variables, the means from two measures, except for No. 11. This variable is located right in the heart of the cluster. A number of plates taken under exceptional seeing conditions show its variability beyond question, but it is futile to attempt to estimate it on most plates.

TABLE I

Positions and Magnitudes of Comparison Stars

Star	x″	y″	Mag.
a	+ 50	− 4	13.3
b	− 89	− 108	13.6
c	− 120	+ 21	14.1
d	− 87	− 27	14.7
e	− 86	+ 4	15.1
f	− 174	+ 49	15.4
g	− 187	+ 2	15.9
h	− 104	− 7	16.2
k	− 119	+ 7	16.6
l	− 125	− 9	16.9
m	− 129	+ 1	17.2
n	− 127	− 4	17.7

Apparently no spectacular bright variables, with periods of weeks or months, exist in this cluster. All the variables found appear to be typical RR Lyrae stars with the exception of No. 8. This star, though of the same mean brightness and range as the cluster type variables, seems to have a very small range for any given year, and a different level of brightness for different years. The writer cannot suggest a period for it or even, as yet, classify the type of variation.

TABLE II. MEASURES OF VARIABLE STARS IN NGC 6333

Plate	Julian Day	Var. 1	Var. 2	Var. 3	Var. 4	Var. 5	Var. 6	Var. 7	Var. 8	Var. 9	Var. 10	Var. 12	Var. 13
4252	29408.951	16.8	15.85	– –	– –	– –	16.2	– –	16.2	16.2	– –	15.8	– –
4267	09.927	– –	15.85	16.8	16.8	– –	16.1	16.9	– –	16.4	– –	16.6	– –
4278	11.946	16.75	15.8	16.7	16.8	– –	16.4	16.8	16.2	16.65	– –	15.9	– –
4298	24.884	16.6	15.6	16.1	16.7	– –	16.35	16.5	16.2	16.55	– –	16.4	– –
4311	25.876	16.8	15.75	16.85	16.05	– –	16.4	16.75	16.2	16.7	– –	16.65	– –
4326	27.886	15.65	15.85	15.8	16.0	– –	16.35	16.55	16.35	16.2	– –	15.75	– –
4367	31.861	16.75	15.55	16.85	16.3	– –	16.45	16.7	16.35	16.4	– –	15.9	– –
4374	32.883	16.75	15.85	16.8	16.8	– –	15.85	16.7	– –	16.65	– –	16.3	– –
4397	34.860	16.7	16.15	16.75	16.8	16.2	16.4	15.95	16.3	16.4	– –	16.3	– –
4411	35.870	16.65	15.75	16.65	– –	16.0	15.6	16.75	16.3	16.7	– –	15.75	– –
4421	36.854	16.2	15.4	16.6	16.8	16.7	16.5	16.5	16.25	16.6	– –	16.65	– –
4436	37.858	15.8	15.8	16.7	16.2	– –	16.25	16.75	16.4	16.5	– –	16.6	– –
5975	843.644	16.85	16.0	16.8	16.85	16.7	15.75	16.75	16.1	16.35	16.3	16.2	[16.9
7860	30519.750	15.95	16.2	16.55	16.8	16.7	16.25	16.5	16.55	16.3	16.6	16.6	16.9
7874	20.749	16.8	16.0	16.55	15.9	16.5	16.0	16.85	16.65	16.45	16.5	16.6	[16.8
7875	.764	16.75	16.1	16.55	16.0	16.3	15.8	16.7	16.6	16.75	16.7	16.6	[16.8
7924	49.674	16.05	16.05	16.0	16.3	16.6	16.55	16.7	16.6	16.05	16.9	15.85	17.8
7939	50.707	15.7	15.95	16.75	16.95	16.3	16.3	16.85	16.55	16.3	16.9	16.45	17.5
7956	53.653	15.6	16.2	16.7	16.1	16.2	16.05	16.5	16.6	16.4	16.4	15.9	17.6
7959	.688	15.7	16.05	16.8	16.1	16.3	16.15	16.7	16.65	16.7	16.6	15.95	17.6
7976	54.694	16.75	16.05	16.75	16.75	16.5	16.45	16.75	16.6	16.75	16.5	16.65	16.8
7993	55.689	16.7	15.65	15.75	16.25	16.7	16.6	16.7	16.6	16.75	16.5	16.65	16.8
7996	.733	16.75	15.8	16.05	16.15	16.5	16.6	16.8	16.55	16.45	16.7	16.75	17.0
8013	56.671	16.0	16.25	16.7	16.85	16.4	16.05	16.1	16.6	16.55	16.8	16.35	16.8
8019	.732	16.2	16.2	16.8	16.85	16.5	16.1	16.35	16.55	16.2	16.8	16.35	17.1
8116	86.584	16.15	15.9	16.0	16.0	– –	16.45	16.8	16.7	16.45	16.6	16.7	[16.9
8118	.616	16.1	15.95	16.2	16.05	16.3	16.6	16.85	16.45	16.45	16.6	16.85	[16.8
8818	880.773	16.75	15.9	16.0	16.8	16.7	16.15	16.85	– –	16.15	16.4	15.95	[17.3
8850	84.759	16.35	15.85	16.6	16.2	16.5	16.2	16.15	– –	16.3	16.6	15.95	– –

TABLE II—*Continued*

Plate	Julian Day	Var. 1	Var. 2	Var. 3	Var. 4	Var. 5	Var. 6	Var. 7	Var. 8	Var. 9	Var. 10	Var. 12	Var. 13
8896	30899.690	16.7	16.05	16.4	16.85	16.4	16.45	17.0	16.6	16.6	16.2	16.1	17.4
8901	.735	16.85	16.2	16.35	16.8	16.4	16.6	16.7	16.65	16.2	16.4	16.4	16.9
8904	.774	16.65	16.25	16.45	16.9	16.5	16.4	16.15	16.7	16.2	16.8	16.4	16.8
8921	900.692	16.9	15.8	16.85	15.9	16.4	15.85	16.8	16.65	16.4	16.4	15.85	16.9
8927	.772	16.85	15.95	15.85	16.15	16.5	16.15	16.95	16.85	16.25	16.8	15.9	17.2
9004	32.632	15.65	15.65	16.85	16.7	16.5	16.95	16.65	16.55	16.65	16.3	16.45	[17.1
9007	.669 •	15.85	15.9	16.75	16.8	16.5	16.75	16.8	16.55	16.25	16.4	16.2	[17.4
9024	33.615	16.7	15.95	16.5	15.8	16.1	15.95	16.95	16.65	16.55	16.4	16.8	[17.6
9028	.664	16.9	16.15	16.65	16.1	16.4	16.5	16.8	16.9	16.25	16.3	16.7	[17.4
9032	.704	16.75	16.25	16.75	16.45	16.6	16.65	16.05	16.7	16.05	16.6	16.8	17.3
10102	1257.712	15.7	15.9	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
10103	.728	15.7	15.9	16.7	[16.6	16.2	– –	16.7	– –	16.35	– –	16.7	16.8
10112	58.705	16.8	15.75	16.35	16.55	16.5	15.8	16.3	16.7	16.35	16.7	15.95	16.8
10113	.710	16.85	15.7	16.4	16.55	16.4	15.9	16.4	16.75	16.35	16.7	15.95	16.9
10116	.744	16.65	15.7	16.55	16.7	16.5	15.95	16.55	16.75	16.7	16.8	16.05	16.9
10118	.763	16.85	15.8	16.55	16.6	16.4	16.3	16.6	16.75	16.65	16.5	16.0	[16.9
10133	59.712	16.8	16.0	16.25	16.8	16.3	16.6	17.0	16.7	16.5	16.5	16.1	[16.9
10135	.749	16.85	16.05	15.8	16.8	16.4	16.75	17.0	16.8	16.6	16.5	16.0	[16.9
10138	.788	16.9	15.95	15.95	16.6	16.4	16.25	16.9	– –	16.65	16.3	16.05	[16.9
12046	969.776	16.9	15.65	16.7	16.7	16.1	15.75	16.9	– –	16.6	16.2	– –	16.9
12050	.803	16.8	15.8	16.8	16.8	16.3	15.7	16.8	16.3	16.4	16.4	16.85	16.8
12119	76.741	16.7	15.8	16.45	16.3	16.4	16.65	17.0	16.3	16.35	16.5	16.05	[17.1
12123	.783	16.85	15.85	16.6	15.9	16.5	16.3	16.95	16.5	16.4	16.5	15.9	[16.9
12144	77.756	16.4	16.3	15.9	16.85	16.1	16.05	16.75	16.3	16.65	16.9	16.9	17.5
12262	99.726	16.5	16.0	16.3	16.25	16.1	16.5	[16.6	– –	16.5	– –	15.95	– –
12281	2000.703	16.75	16.1	16.45	16.85	16.5	16.15	16.95	16.5	16.5	16.7	16.5	[17.2
12284	.735	16.7	16.0	15.75	16.85	16.6	15.75	17.0	16.6	16.65	16.9	16.6	[17.2
12327	04.688	16.5	16.3	16.7	16.8	16.2	16.6	16.4	16.3	16.1	16.4	16.75	17.5
12329	.715	16.7	16.15	16.7	16.7	16.3	16.6	16.5	16.25	16.05	16.5	16.65	17.8
12344	05.690	15.7	16.1	15.95	16.05	16.6	16.1	16.95	16.25	16.0	16.5	16.75	17.7
12348	.743	16.0	16.2	16.35	16.35	16.4	16.3	16.85	16.3	16.05	16.6	16.8	17.4
12365	06.682	16.7	16.35	16.75	16.8	16.3	16.8	16.8	16.5	16.1	16.5	16.25	17.7
12368	.728	16.7	15.6	16.75	16.8	16.6	16.7	16.85	16.5	16.2	16.7	16.4	16.7

Table II—*Continued*

Plate	Julian Day	Var. 1	Var. 2	Var. 3	Var. 4	Var. 5	Var. 6	Var. 7	Var. 8	Var. 9	Var. 10	Var. 12	Var. 13
13406	32354.754	15.6	15.9	16.65	16.1	16.6	16.6	16.4	16.25	16.45	16.7	15.9	17.0
13427	55.714	16.7	16.3	16.45	16.85	16.3	15.75	16.85	16.35	16.65	16.7	16.95	17.1
13430	.742	16.75	16.2	16.75	16.9	16.3	15.75	16.9	16.45	16.6	16.8	16.85	17.4
13450	56.719	16.3	15.65	15.7	16.25	16.7	16.85	16.75	16.4	16.4	16.7	16.75	17.2
13452	.735	16.55	15.8	15.75	16.1	16.7	16.75	16.8	16.35	16.15	16.6	16.7	17.4
13466	57.731	15.6	16.15	16.65	16.8	16.3	16.65	16.75	16.35	16.05	16.5	16.05	17.4
13469	.765	15.8	16.15	16.7	16.75	16.5	16.6	16.1	16.1	16.05	16.4	16.1	17.7
13490	60.689	15.8	16.15	16.5	16.8	– –	16.25	16.8	16.1	16.1	16.2	16.65	17.4
13494	.740	16.3	16.0	16.6	16.3	16.2	16.2	16.9	16.3	16.15	16.6	16.8	17.8
14511	733.653	16.75	15.7	16.7	16.7	16.5	16.65	16.2	16.15	16.10	16.6	16.9	[17.4
14513	.685	16.8	15.8	16.8	16.85	16.5	16.45	16.5	16.25	16.15	16.7	16.9	17.4
14518	.725	15.65	16.05	16.7	16.85	16.4	15.7	16.4	16.3	16.05	16.7	16.8	16.8
14522	.764	15.75	15.9	16.65	16.8	16.2	15.9	16.6	16.05	16.1	16.6	16.6	16.8
14535	34.647	16.75	16.4	16.25	16.4	16.7	16.45	16.95	16.1	16.1	16.5	16.45	17.3
14538	.678	16.6	16.35	16.3	16.05	16.6	16.5	16.9	16.15	16.0	16.6	16.4	16.8
14543	.736	16.85	16.5	16.55	16.05	16.6	16.75	16.85	16.05	16.25	16.5	16.8	16.9
14581	40.643	16.8	16.1	16.1	16.9	16.4	16.7	16.65	16.1	16.6	16.7	16.1	17.7
14585	.688	16.85	16.25	16.25	16.55	16.6	16.5 ·	16.75	16.2	16.5	16.8	15.9	17.6
14590	.746	15.8	16.1	16.45	16.05	16.8	16.6	16.7	16.1	16.35	16.7	15.85	17.7
14605	41.642	16.75	16.2	16.6	16 85	16.4	15.75	16.95	16.1	16.45	16.7	16.85	17.8
14611	.731	16.7	15.65	16.15	16.75	16.1	16.0	16.5	16.05	16.35	16.7	16.75	17.5
14625	42.625	16.2	16.05	16.7	16.8	16.8	16.8	16.8	16.1	16.7	16.8	16.7	17.7
14631	.685	16.4	16.25	16.7	16.85	16.6	16.65	16.75	16.1	16.35	16.9	16.75	17.8
14634	.735	16.4	16.25	16.55	16.05	16.3	16.75	16.8	16.05	16.05	16.8	16.5	17.8
14753	70.588	16.8	16.2	16.65	16.8	16.4	16.75	16.8	16.15	16.15	16.7	16.15	17.8
14763	.683	15.8	15.65	16.8	16.85	16.7	16.65	16.0	16.1	16.7	16.4	16.45	16.7
16026	3068.761	15.75	16.1	16.15	16.75	16.7	16.05	16.75	16.4	16.5	16.5	16.75	17.0
16029	.785	15.7	16.1	16.15	16.8	16.7	16.05	16.8	16.15	16.6	16.3	16.75	17.2
16055	69.749	16.8	15.75	16.7	16.25	16.4	16.55	17.2	16.45	16.5	16.5	16.8	17.2
16060	.790	16.8	15.7	16.8	16.35	16.4	16.7	16.55	16.5	16.6	16.6	16.7	17.3
16179	95.685	16.0	15.9	16.85	– –	16.6	16.35	16.1	16.25	16.5	16.3	16.7	17.2
16183	.749	15.8	15.95	16.85	16.7	– –	16.5	16.65	16.05	16.3	– –	16.2	– –

Because of the limited hour angle of the plates, considerable difficulty was experienced in determining the periods. The method worked out by R. W. Tanner[6] for detecting spurious periods in spectroscopic binaries has proved of great value in the investigation of periods in this cluster. From the known fact that the phase residuals, $\Delta\varphi$, of a spurious period will be related to the deviation, α, of the time of the observation from the meridian or ideal time, Tanner shows that by making use of the statistical relation between $\Delta\varphi$ and α one could weed out the spurious periods and confirm true periods. When the period obtained is the true one, a plot of $\Delta\varphi$ against α shows points scattered along the x-axis (α-axis), but if the period is a false one then a definite slope of the points is obtained, accentuated by the observations at the larger hour angles. From the amount of slope the true period may be determined. Once a preliminary period was obtained for a variable in Messier 9, according to Tanner's method phase residuals from a mean light curve were plotted against the hour angle of the observations. In the case of four variables this method showed that an alternative period was the correct one.

The elements of all the variables, with the exception of Nos. 8 and 11, are contained in Table III. The ranges given for the variables are from the 74-inch plates where nearby stars are better separated from the variables. The periods determined range in length from 0.24 day to 0.67 day. Of the eleven periods, seven are over half a day, and four are definitely less than a half day. This is the type of cluster with a double maximum in period frequency, with periods around two-thirds of a day and one-third of a day, and no periods around one-half day. Judged from its magnitude and position, No. 13 is almost certainly a field variable, and is not regarded as a cluster member. This happens to be the faintest variable for which the writer has ever determined a period.

The light curves of the variables are represented in figures 1 and 2. In three cases where the Arizona plates give systematically brighter magnitudes, these have been indicated by open circles.

Several of the variables are among the brightest stars at maximum, reaching magnitude 15.6. The mean magnitude of the 25 brightest stars is 15.50, with the 6th brightest at 14.9 and the 30th at 15.8. These values have been determined with the same sequence as used for the variables, but they agree remarkably well with the determination made by Shapley[7] years earlier, when a different sequence was used and an independent selection of bright stars made. Then the values obtained were 15.61, 15.08, and 15.88 respectively. There appears to be only a tenth of a magnitude difference between the two sets of values, a rather remarkable result when the brightest stars and the sequence were selected and measured quite independently each time.

The mean median magnitude of 9 RR Lyrae stars which are cluster members is 16.39, which value we may take as the modulus of the cluster. Excluded from this mean are variables No. 2, an obvious double star; No. 8, of unknown type; No. 11 in centre of cluster; and No. 13 undoubtedly a field star. The modulus of 16.61

TABLE III

ELEMENTS OF THE VARIABLE STARS IN NGC 6333

Var. No.	x″	y″	Magnitudes Max.	Min.	Mean	Epoch Julian Day	Period in Days
1	+ 91	− 76	15.6	16.9	16.25	29427.886	0.585727
2	+ 40	− 31	15.6	16.4	16.0	29436.854	0.628191
3	+ 207	− 210	15.7	16.85	16.27	32000.735	0.605397
4	+ 23	− 35	15.8	16.95	16.37	30520.749	0.670076
5	+ 34	− 7	16.0	16.8	16.4	29435.870	0.274708
6	− 70	− 14	15.7	16.95	16.32	29435.870	0.607795
7	− 111	− 80	15.95	17.2	16.57	29434.860	0.628456
8	− 73	− 99	16.05	16.9	16.47	– –	– –
9	+ 334	− 191	16.0	16.75	16.37	30933.704	0.322990
10	+ 37	+ 26	16.2	16.9	16.55	30553.653	0.242322
11	− 4	− 7	15.7	16.8	16.25	– –	– –
12	− 275	− 136	15.85	16.95	16.40	29408.951	0.571784
13	+ 259	+ 11	16.7	17.8	17.25	30554.694	0.47985

REMARKS TO TABLE III AND FIGURES 1 AND 2

1. The variable announced by Shapley in 1916.
2. A double star, south and west component varies; the invariable component is about magnitude 16.3.
5. Very difficult to estimate; in a chain of stars which merge under poor seeing. Where really clear cut estimates are made on good plates, scatter on curve is less than with all observations grouped together.
8. Type of variation unknown.
9. This variable is farthest from sequence, which increases scatter in the light curve.
10. Arizona measures are on too small a scale to be used; this is the most difficult variable in the cluster for period determination.
11. Too close to centre for period determination.
12. A faint nearby star may be responsible for the systematically brighter Arizona magnitudes.
13. Probably not a member of the cluster.

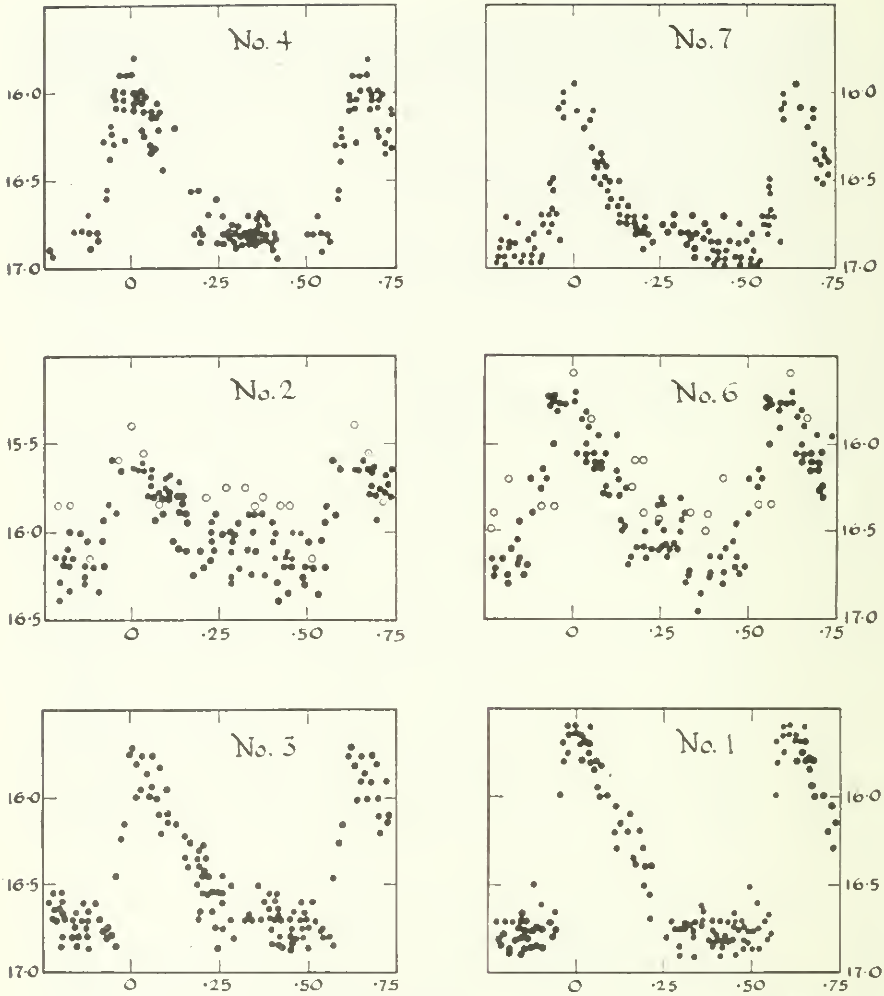

FIG. 1.—Light curves of the longer period cluster type variables in NGC 6333, with periods from 0.67 to 0.58 day. Open circles indicate systematically brighter observations from Arizona plates.

previously determined by Shapley and Sawyer[8] is therefore slightly reduced because the magnitude difference of 0.89 between the 25 brightest stars and the variables is less than was assumed when the variables were unknown.

The cluster is located on the edge of a heavy obscuring cloud, which on the 74-inch plates cuts off most of the stars beyond the

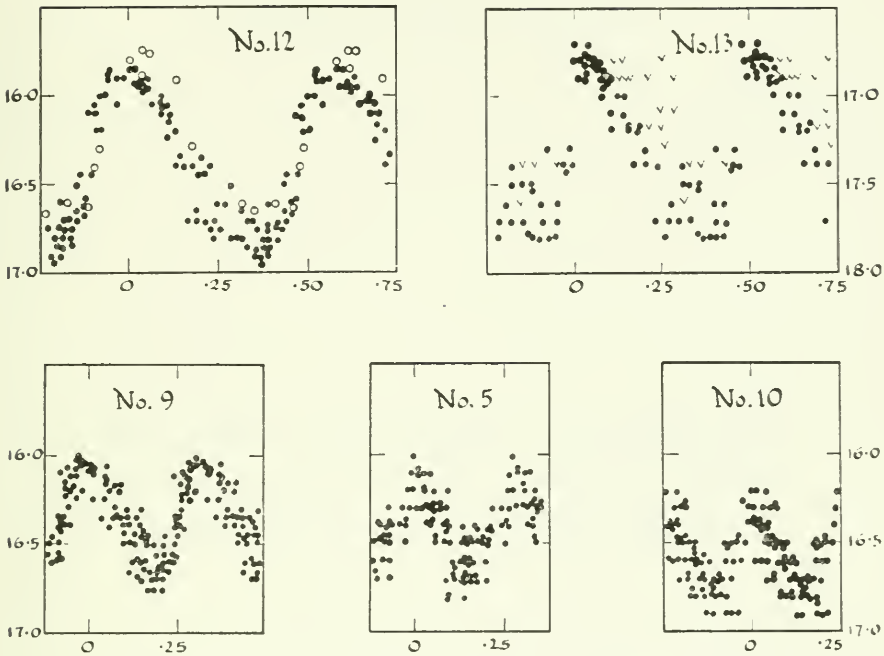

FIG. 2.—Light curves of variables in NGC 6333 with periods from 0.57 to 0.24 day. The faint variable No. 13 is probably not a cluster member.

cluster limits to the south-west, as shown in Plate XXXIII. Because of this and the high colour excess of the cluster,[9] + 0.24, the writer will not attempt to convert this modulus into linear distance. Probably the true correction, when applied, will make this one of the nearer globular clusters.

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THE RADIAL VELOCITIES AND SPECTRAL FEATURES OF TWENTY-ONE Be STARS WITH LARGE ROTATIONAL TERMS

BY

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THE RADIAL VELOCITIES AND SPECTRAL FEATURES OF TWENTY-ONE Be STARS WITH LARGE ROTATIONAL TERMS

By John F. Heard

Presented here are the radial velocities of twenty-one Be stars with galactic longitudes such that the effect of galactic rotation on radial velocity is large. This programme came about in the following way. About 15 years ago it was believed that the emission line stars were intrinsically brighter than those lacking emission lines[1]. To test this hypothesis the writer in 1938 chose from the Mount Wilson Catalogue of Be- and Ae-type stars[1] a group of 84 stars of spectral types B3e to B5e for which velocities had been measured, and attempted to solve for the distances and absolute magnitudes by analysing the velocities for galactic rotation effects. The results were of little value because the stars were relatively bright and accordingly nearby, and because many of them were of such galactic longitudes as to have small rotational terms. To bolster this list of stars, then, those stars were chosen from the Mount Wilson Catalogue which are accessible at this Observatory, which are between the spectral classes B3e and B5e, and which lie within 14° of the galactic longitudes 10°, 100°, 190° and 280°. Radial velocity observation of these stars was commenced in 1938. Before the observations had been completed, R. E. Wilson published an investigation of the mean absolute magnitudes of O- and B-type stars[2] in which he used proper motion data as well as radial velocity data, and demonstrated that the emission stars were no brighter than stars of corresponding spectral class which lacked emission lines. Seyfert and Popper had reached a similar conclusion with respect to c-stars[3] at about the same time in the course of a study of new radial velocity measures of faint B-type stars. In this way the original intention of the programme undertaken here was anticipated, and so the observation of these stars was deferred in favour of other programmes. Now the observations have been completed, and the results are presented with a brief discussion of how they support the conclusions of others already referred to.

The spectra of most of these stars have very poor lines for velocity measures, and so at least five plates were taken for each

TABLE I

MWC	H.D.	α (1900)	δ (1900)	Vis. Mag.	Type M.W.	Velocity km./sec.	P.E.	Plates	Lines	ē	Inter-stellar Vel.	Remarks
		h m	° ′									
10	6343	00 59.4	+ 65 26	7.1	B5eβ	− 7.8	1.9	7	6-9	6.2		Ca^+ stellar
13	9105	01 24.6	+ 62 51	7.5	B5s(e)	(− 33.4) var.	—	6	5-11	3.7		Ca^+ stellar
23	12302	01 55.6	+ 59 12	8.2	B3e	+ 5.7	3.6	7	6-11	11.3	+ 2.3	See note
29	13661	02 08.1	+ 54 04	8.6	B(3)ne	− 50.5	7.1	6	5-6	11.4	− 12.1	
49	15472	02 24.4	+ 70 30	8.0	B4ne	(− 62.1) var.	—	6	4-8	10.7	− 17.6	
63	20017	03 07.9	+ 48 19	7.9	Bne	− 28.4	6.7	5	3-6	11.8	− 6.7	
76	23982	03 44.3	+ 63 11	8.1	B3e	− 13.2	3.6	6	5-7	9.9	− 0.6	
79	24560	03 49.3	+ 44 38	7.8	B(3)ne	− 10.4	2.1	6	5-8	7.2	− 1.9	
82	26420	04 05.7	+ 41 52	7.6	B3neα	+ 2.8	3.4	6	2-6	15.2	+ 20.8	
83	26906	04 10.1	+ 45 58	8.6	B(3)ne	− 14.1	8.3	5	2-5	14.7	− 1.2	
114	37115	05 31.0	− 5 41	8.2	B5ne	+ 36.7	5.4	5	4-7	10.1		
139	44637	06 17.7	+ 15 09	7.7	B3e	(+ 20.0) var.	—	8	2-7	10.4	+ 4.0	
159	50209	06 47.1	− 0 10	8.3	B(5)ne	− 11.7	7.1	5	2-5	10.7		
164	52721	06 57.2	− 11 09	6.6	B3e	+ 9.3	7.2	6	2-6	13.0		
188	65079	07 51.9	+ 3 14	7.7	B3ne	+ 2.6	5.2	7	3-7	14.3		
189	65176	07 52.4	− 1 20	8.1	B(5)ne	+ 96.1	10.2	6	2-4	12.9		poss. var. vel.
307	174886	18 47.7	− 10 21	8.1	B3e	+ 4.4	2.2	6	3-6	5.5		
312	180398	19 11.3	+ 12 56	7.7	B(3)ne	(− 32.7) var.	—	7	2-6	10.6		
320		19 41.3	+ 5 44	8.5	B5ne	− 27.0	7.1	6	2-6	12.0		
383	209296	21 57.2	+ 56 14	8.1	B(5)e	− 31.7	6.4	7	3-7	10.2		Ca^+ stellar
402	223501	23 45.0	+ 61 39	8.2	B3e	− 37.5	6.2	7	3-8	7.9	− 7.2	

star. Most of these were taken with dispersion of 66 A. /mm. at Hγ, the rest with 33 A. /mm. dispersion. The observations were all in the periods 1938-40 and 1946-50, and all the stars are represented by plates in both intervals. Thus any long-period velocity variations or spectrum variations may have been detected.

THE RADIAL VELOCITIES

The radial velocity data are presented in Table I. MWC refers to Mount Wilson Catalogue of Be and Ae stars. P.E. is the probable error of the mean velocity calculated by Peters' formula; ē is the average of the probable errors of the plates calculated from agreement of the lines. The interstellar velocities are listed only for stars in the spectra of which the K-line was distinct and sharp on several plates. For some other stars the interstellar nature of the K-line may have been missed because of weakness of the exposures in the violet region.

Four of the stars are regarded as having variable velocities, and an additional one as possibly having variable velocity. The separate velocity measures of the four variable-velocity stars are listed in Table II.

TABLE II

Star	J.D. 24....	Vel. km./sec.	Star	J.D. 24....	Vel. km./sec.
M.W. 13	29130.875	− 34.1	M.W. 139	29319.583	+ 97.9
H.D. 9105	29166.762	− 27.5	H.D. 44637	29582.929	+ 14.2
	29170.717	− 32.6		29675.620	+ 74.6
	29185.764	− 12.6		32101.939	− 31.7
	29278.476	− 56.9		32977.559	− 38.7
	29907.760	− 39.1		33378.575	+ 7.8
				33381.551	+ 15.4
M.W. 49	29199.753	− 8.8		33385.542	+ 20.0
H.D. 15472	29214.678	− 116.5			
	29625.581	− 165.0	M.W. 312	29447.717	− 78.6
	29912.747	− 39.6	H.D. 180398	29494.623	− 96.6
	32068.901	− 18.5		29851.632	− 64.0
	32077.875	− 24.0		29862.603	+ 12.2
				32001.769	− 14.4
				32473.511	+ 9.8
				32817.571	+ 3.0

The Analysis of the Rotational Terms

To analyse this group of velocities and thus to determine the mean absolute magnitude, the following procedure was used. For each star the term sin $(l - l_0) \cos^2 b$ was computed, using the value $l_0 = 325°$ for the longitude of the galactic centre and the values of the galactic coordinates, l and b, as listed in the Mount Wilson Catalogue. The measured radial velocities were corrected for solar motion by means of the graphical method of Pearce and Hill.[4] Calling this reduced velocity ρ', equations were written of the form

$$\bar{r}A.\sin 2(l - l_0) \cos^2 b + K = \rho',$$

where r is the mean distance of the group of stars, A is the rotational term at unit distance and K is the residual constant which is usually included in these solutions.

One star in Table I, M.W. 63, is classified by Mount Wilson as Bne; it was excluded from the solution. This left 20 equations of the form given above, representing stars of fairly homogeneous apparent magnitude and spectral type. The solution of these equations gave

$$\bar{r}A = 15.0 \pm 4.4,$$
$$K = 0.0 \pm 3.8.$$

Accepting R. E. Wilson's value of the constant of rotation, $A = 17.7$ km./sec. per kiloparsec[5], we have

$$\bar{r} = 850 \text{ pscs.},$$

and from this we get the value of the mean absolute magnitude uncorrected for galactic absorption,

$$\bar{M}' = -1.65 \pm 0.6.$$

If we correct this for absorption by Wilson's method[2] of allowing 0.65 mags. per kiloparsec for stars within 10° of the galactic equator and no absorption for stars at higher galactic latitude, we get

$$\Delta M = -0.44,$$

whence the corrected value of the mean absolute magnitude is

$$\bar{M} = -2.1.$$

This value of mean absolute magnitude is probably a little too bright owing to the tacit assumption that the mean value of log r

is the same as the logarithm of the mean value of r, a point which has been discussed by Greenstein[6]. However, Greenstein has estimated that this error will be not more than one or two tenths of a magnitude for stars as distant as these. If we make a small correction for this effect we have

$$\bar{M} = -2.0.$$

The mean spectral type of these 20 stars is B3.8e. Absolute magnitude -2.0 is normal for main sequence stars of this type. This supports the conclusions of R. E. Wilson and Seyfert and Popper, referred to earlier, that the presence of emission lines is not an indication of abnormal luminosity.

The fact that the K-term turns out to be zero may be taken as an indication that this group of stars is not subject to any systematic atmospheric expansion or subsidence.

Spectral Features

Most, if not all, Be stars are believed to be subject to variations in their spectra, especially as regards strength and character of the emission lines. For this reason brief descriptions of the emission features in the spectra of these stars and any suspected changes are recorded in the following list.

M.W. 10 Single emission at Hβ and Hγ; no change 1938-46.

M.W. 13 Sharp absorption lines; no emission at Hβ; no change 1938-46.

M.W. 23 Hβ emission is sometimes single, sometimes a close double. Hγ emission usually appears as an emission border on the violet side of a sharp absorption line. Other hydrogen lines are sharp absorption. The helium lines are broad, vary in intensity and sometimes have faint emission borders. There is a marked disparity in the velocities from hydrogen and helium absorption lines; the mean velocity of the five plates from hydrogen lines is $+34$ km./sec., from helium lines -45 km./sec. This star will be studied further.

M.W. 29 Hβ has strong, close, double emission on broad absorption, and there are traces of similar emission structure, much weaker, at the other hydrogen lines. There have been no marked changes between 1939 and 1947.

M.W. 49 Hβ has weak double emission in which there are probably changes in relative intensity. Other hydrogen lines show traces of emission.

M.W. 63 Emission at $H\beta$ in 1938-40 indicated only by weakening of the absorption line; stronger double emission at $H\beta$ and $H\gamma$ in 1946-1950.

M.W. 76 Emission at $H\beta$ in 1939-40 very weak; stronger double emission at $H\beta$ and some emission at $H\gamma$ in 1946-48.

M.W. 79 No evidence of emission lines at $H\beta$ etc. in 1938-40 or 1946-49.

M.W. 82 No evidence of emission lines at $H\beta$ etc. in 1938-40 or 1946-50.

M.W. 83 Strong double emission at $H\beta$, much weaker at $H\gamma$; no change 1939-49.

M.W. 114 Strong emission (probably double) at $H\beta$, much weaker at $H\gamma$; emission stronger in 1938 than in 1939 and subsequently.

M.W. 139 Fairly strong narrow emission at $H\beta$, much weaker at $H\gamma$; probably no change 1939-50.

M.W. 159 Weak narrow emission at $H\beta$ and $H\gamma$; probably stronger in 1949 than in 1939.

M.W. 164 Narrow emission at $H\beta$, $H\gamma$, $H\delta$ in 1939, weaker in 1949 and barely detectable in 1950.

M.W. 188 Narrow, moderately strong emission at $H\beta$, very weak at $H\gamma$. Some faint emission at helium lines. No marked change between 1939 and 1949-50.

M.W. 189 No distinct emission at $H\beta$ etc., but hydrogen absorption lines extremely weak. No change 1940 to 1949-50.

M.W. 307 Narrow emission at $H\beta$ and $H\gamma$, stronger in 1946-47 than in 1939-40.

M.W. 312 Faint emission at $H\beta$ and $H\gamma$. In 1947-50 the larger dispersion shows these double with equal intensity; on earlier plates of 1939-40 and 1946 doubling is not certain and emission is probably weaker.

M.W. 320 Double emission at $H\beta$ and $H\gamma$. Red component stronger than violet in 1946, 1947, equal in 1948, weaker in 1950. Emission character uncertain on earlier plates.

M.W. 383 No emission at $H\beta$ etc. in 1938-40 or 1946.

M.W. 402 Double emission at $H\beta$ and $H\gamma$ which is clearly resolved only on larger dispersion plates of 1946-50; there are changes of relative intensity of the two components in this period.

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[6]*Nat. Acad. Sci. Proc.*, vol. 26, p. 259, 1940.

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THE ORBITS OF THREE SPECTROSCOPIC BINARIES, H.D. 164898, H.D. 208835 and H.D. 40372

BY

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THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 164898

By Ruth J. Northcott

The star H.D. 164898, $\alpha(1900)$ 17^h $58^m.3$, $\delta(1900)$ $+45° 21'$, vis. mag. 7.44, Harvard type B9, was discovered to be a spectroscopic binary with a range of about 100 km./sec. from seven plates taken at this observatory during 1936 and 1937.[1] Observation to determine the orbit was started in 1945 and by June 1948 fifty-two plates had been obtained with the one-prism spectrograph. The early plates and the last five plates were taken with a dispersion of 66 A./mm. at Hγ, the rest with a dispersion of 33 A./mm. at Hγ. The lines are of good quality; on the average 16 lines were measured on the higher dispersion spectra, with a probable error of less than two km./sec., judged from the internal agreement of the measures.

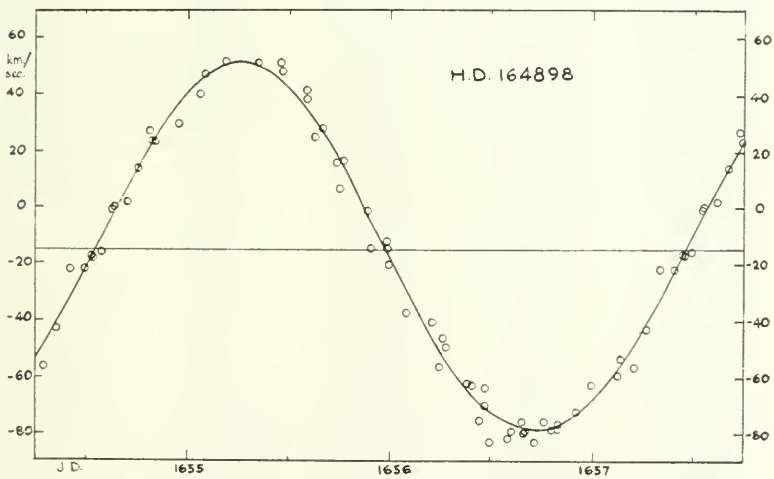

Figure 1

The observations cover about 1500 revolutions, so that the period was not included in the least-squares solution; the error in the period is estimated at ± 0.00005 day. The observations were studied by R. W. Tanner's[2] method to eliminate the possibility of a fictitious period. Table I gives the data from the plates.

TABLE I

Radial-velocity Observations of H.D. 164898

J.D. 242–243	V_o km./sec.	Phase from final T	V_c km./sec.	V_o–V_c km./sec.
8362.694	+24.9	0.272	+31.4	− 6.5
8380.649	−37.0	0.725	−28.6	− 8.4
8685.805	+29.4	2.519	+36.6	− 7.2
8707.742	−64.0	1.121	−70.8	+ 6.8
8720.662	+26.8	2.373	+20.9	+ 5.9
8727.672	−11.8	0.632	−15.6	+ 3.8
8734.653	−52.7	1.779	−55.8	+ 3.1
1671.676	−78.4	1.444	−78.0	− 0.4
1672.617	+23.4	2.385	+22.5	+ 0.9
1687.596	+52.0	2.779	+51.2	+ 0.8
1694.593	−62.1	1.025	−63.4	+ 1.3
1695.617	−21.7	2.049	−22.6	+ 0.9
1696.590	+48.2	0.105	+45.3	+ 2.9
1701.667	+02.0	2.265	+07.2	− 5.2
1702.554	+38.6	0.235	+35.1	+ 3.5
1704.629	+14.1	2.310	+13.1	+ 1.0
1705.549	+28.1	0.313	+26.8	+ 1.3
1706.538	−79.6	1.302	−78.2	− 1.4
1708.531	+15.8	0.378	+19.0	− 3.2
1715.549	−72.0	1.563	−73.2	+ 1.2
1719.524	+40.2	2.620	+44.7	− 4.5
1720.526	−20.0	0.706	−26.1	+ 6.1
1736.500	−17.6	2.095	−16.3	− 1.3
1962.835	−45.2	0.907	−51.6	+ 6.4
1975.794	−00.1	2.200	−01.7	+ 1.6
1980.786	−83.3	1.358	−78.7	− 4.6
2008.697	+51.5	0.100	+45.8	+ 5.7
2015.673	−80.0	1.242	−76.7	− 3.3
2047.681	−69.8	1.163	−73.3	+ 3.5
2056.578	−78.2	1.309	−78.3	+ 0.1
2062.572	−76.3	1.470	−77.1	+ 0.8
2066.662	+47.1	2.643	+46.1	+ 1.0
2067.570	−14.6	0.634	−16.1	+ 1.5
2076.541	−40.1	0.854	−45.4	+ 5.3
2079.521	−49.4	0.917	−52.7	+ 3.3
2081.511	+51.1	2.907	+50.7	+ 0.4
2082.572	−62.7	1.051	−65.7	+ 3.0
2086.516	−17.1	2.078	−18.6	+ 1.5
2089.542	−00.9	2.187	−03.5	+ 2.6
2090.505	+41.8	0.233	+35.3	+ 6.5
2091.562	−75.5	1.290	−78.0	+ 2.5
2096.515	+16.8	0.409	+15.1	+ 1.7
2097.509	−75.9	1.403	−78.5	+ 2.6
2098.499	+23.6	2.393	+23.4	+ 0.2
2100.493	−78.3	1.470	−77.1	− 1.2
2335.827	−00.9	0.532	−01.6	+ 0.7
2362.726	−82.9	1.179	−74.1	− 8.8
2368.605	−81.5	1.224	−76.1	− 5.4
2386.733	−56.3	1.850	−48.1	− 8.2
2391.607	−56.0	0.890	−49.7	− 6.3
2391.807	−75.3	1.090	−68.7	− 6.6
2446.533	+06.6	0.394	+17.0	−10.4
2446.697	−14.4	0.558	−05.3	− 9.1
2663.904	−42.8	1.912	−40.6	− 2.2
2672.885	−15.7	2.142	−09.7	− 6.0
2698.760	−58.8	1.765	−57.3	− 1.5
2704.808	−21.4	1.979	−32.1	+10.7
2727.812	−61.5	1.647	−67.7	+ 6.2

The observations were grouped according to phase into 28 observational equations; weights (1, 2, 3) were assigned according to the number of plates. The preliminary orbit was determined graphically and was circular. The five elements were found using T. E. Stern's[3] method of least-squares solution for small eccentricities. Σpv^2 was reduced from 1766 to 740 by two solutions. The preliminary and final elements are listed in Table II.

The individual observations are plotted in figure 1. The probable error of a single plate is ± 3.6 km./sec.

TABLE II

ORBITAL ELEMENTS OF H.D. 164898

		Preliminary	Final	
Period	P	2.91694 days	2.91694	$\pm$ 0.00005 est.
Eccentricity	e	0	0.0221	$\pm$ 0.004
Angle of periastron	ω		11°.50	$\pm$0°.05
Epoch of mean long.	T_0	J.D. 2431655.57	2431655.554	$\pm$ 0.002
Periastron passage	T		2431655.648	
Velocity of system	γ	−14 km./sec.	−14.93	$\pm$ 0.21
Semi-amplitude	K	66 km./sec.	65.18	$\pm$ 0.32
a sin i			2.614×10^6 km.	
$m_1^3 \sin^3 i/(m_1 + m_2)^2$			0.0838 $\odot$	

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 208835

By T. A. Matthews

The star H.D. 208835, $\alpha(1900)$ 21^h $53^m.9$, $\delta(1900)$ $+46°$ $23'$, vis. mag. 7.39, Harvard type A0, was announced as a spectroscopic binary from six plates taken at this observatory between 1935 and 1938.[1] These plates were taken with the one-prism spectrograph and a dispersion of 66 A./mm. at Hγ. During 1945 and 1950 twenty-six additional plates were obtained with a dispersion of 33 A./mm. at Hγ. The earlier plates were used to determine the period, but were not otherwise used in the solution. The observations were tested for a fictitious period by the method of R. W. Tanner;[2] no related period was indicated. Table III lists the times, phases, observed and computed velocities and residuals for each plate.

The spectrum is of fair quality. An average of eight lines per plate were measured. The helium lines, 4471 and 4026 are unusually

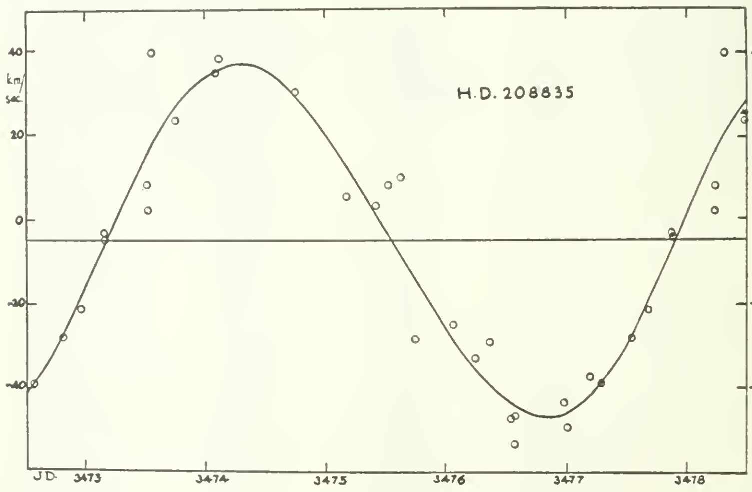

Figure 2

broad and diffuse compared with MgII, 4481, and SiII, 4128, 4130. The quality of the helium lines appears to be somewhat variable. There may possibly be changes in the intensity of this line compared to MgII, 4481. On a few plates the hydrogen lines Hγ and Hδ seem

TABLE III

RADIAL-VELOCITY OBSERVATIONS OF H.D. 208835

J.D. 242–243	V_o km./sec.	Phase from final T	V_c km./sec.	V_o–V_c km./sec.
8042.656	+24.5	2.458	−05.1	+29.6
8403.717	+30.6	0.066	+01.4	+29.2
8844.551	+36.4	1.926	+19.1	+17.3
9119.758	−46.6	3.364	−42.3	−04.3
9144.692	+06.4	4.697	−11.7	+18.1
9175.617	−33.6	2.582	−11.1	−22.5
1701.792	−53.4	3.476	−44.8	−08.6
1708.764	+37.4	1.008	+35.9	+01.5
1745.572	−03.2	0.055	−06.7	+03.5
1747.594	+05.4	2.077	+12.7	−07.3
1749.611	−37.4	4.094	−42.1	+04.7
1763.557	−43.7	3.879	−46.5	+02.8
3468.797	+02.4	0.425	+16.1	−13.7
3470.797	+08.2	2.425	−03.5	+11.7
3471.860	−46.7	3.488	−45.0	−01.7
3478.796	+34.7	0.984	+35.6	−00.9
3484.848	+03.3	2.316	+01.7	+01.6
3485.797	−29.2	3.265	−39.6	+10.4
3487.717	+39.6	0.464	+18.2	+21.4
3489.788	−10.1	2.535	−08.8	−01.3
3490.696	−47.6	3.443	−44.1	−03.5
3491.687	−28.1	4.434	−27.6	−00.5
3491.837	−21.1	4.584	−18.8	−02.3
3496.749	−04.7	0.056	−06.6	+01.9
3499.662	−25.0	2.969	−28.7	+03.7
3499.842	−33.0	3.149	−35.7	+02.7
3500.612	−49.6	3.919	−46.0	−03.6
3500.883	−38.9	4.190	−38.9	00.0
3501.827	+08.3	0.414	+15.5	−07.2
3506.792	+23.7	0.659	+27.1	−03.4
3507.781	+30.0	1.648	+28.9	+01.1
3508.773	−28.5	2.640	−13.9	−14.6

TABLE IV

ORBITAL ELEMENTS OF H.D. 208835

		Preliminary	Final	
Period	P	4.72015 days	4.72015	
Eccentricity	e	0	0.075	± 0.030
Angle of periastron	ω		263°.3	± 25°.2
Epoch of mean long.	T_o	J.D. 2433469.69	2433469.640	± 0.021
Periastron passage	T		J.D. 2433473.092	
Velocity of system	γ	−5.13 km./sec.	−4.9	± 0.97
Semi-amplitude	K	43.85 km./sec.	42.0	± 1.50
a sin i			2.718×10^6 km.	
$m_1^3 \sin^3 i/(m_1 + m_2)^2$			0.0360 ⊙	

to have sharp cores and asymmetrical wings which are sometimes to the red and sometimes to the violet. The changes in the spectrum do not appear to depend on the phase. They have some characteristics of a shell star spectrum.

The preliminary elements were determined graphically and a least-squares solution was made using 16 normal places. Since the eccentricity was found to be small, Sterne's[3] form of least-squares solution for small eccentricities was used. Five elements were included in the solution. The reduction in $\Sigma\ pv^2$ was from 1162 to 920. Table IV lists the preliminary and final elements and their probable errors. Figure 2 shows the individual observations plotted with the final curve. The probable error of a single observation is ± 5.0 km./sec.

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 40372

By Paul-H. Nadeau

The star H.D. 40372, $\alpha(1900)$ 5^h $53^m.2$, $\delta(1900)$ $+01°$ $49'$, vis. mag. 6.06, Harvard type A5, was announced to be a spectroscopic binary from four plates taken at this observatory during 1943 and 1944.[4] During 1946 and 1947 thirty-four plates were obtained from which the orbit was computed. The plates were taken with the one-prism spectrograph, and all but the last six were taken with a dispersion of 33 A./mm. at Hγ; the other plates were taken with a dispersion of 66 A./mm. at Hγ. The information from these plates is listed in Table V. Fictitious values of the period were eliminated by using the method of R. W. Tanner;[2] the period was not included

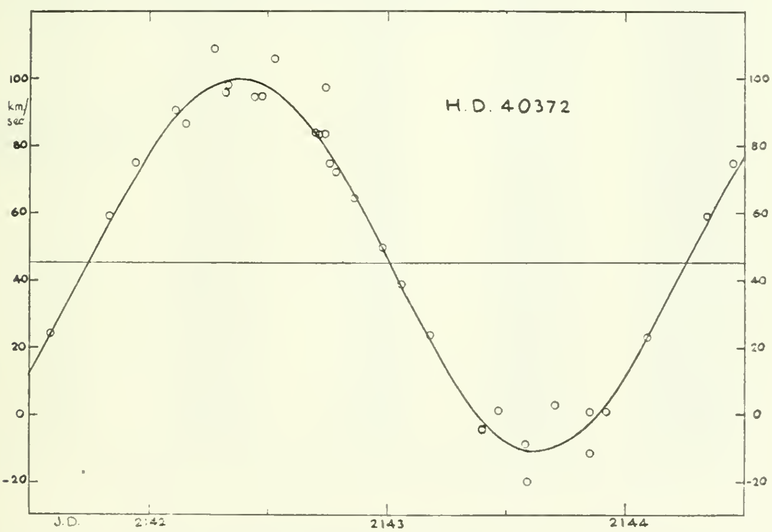

Figure 3

in the least-squares solution. The observations were grouped according to phase into 23 observational equations; weights (1, 2) were assigned according to the number of plates.

The preliminary elements were determined graphically. The value of $\Sigma\, pv^2$ was reduced from 1374 to 1110. The preliminary and final

TABLE V

RADIAL-VELOCITY OBSERVATIONS OF H.D. 40372

J.D. 243	V_o km./sec.	Phase from final T	V_c km./sec.	V_o–V_c km./sec.
0726.697	+ 11.9	2.392	+04.5	+ 7.4
1113.641	− 05.8	0.184	−04.8	− 1.0
1377.861	+101.3	1.318	+99.7	+ 1.6
1427.787	+ 62.5	1.914	+61.0	+ 1.5
1822.717	+ 20.2	2.212	+23.8	− 3.6
1896.510	+ 41.1	2.012	+49.8	− 8.7
2143.814	− 20.0	2.671	−10.9	− 9.1
2144.756	+ 74.8	0.873	+71.6	+ 3.2
2145.762	+ 64.4	1.879	+65.1	− 0.7
2165.732	− 08.9	2.665	−10.8	+ 1.9
2173.751	− 04.4	2.462	−01.3	− 3.1
2174.781	+ 59.0	0.752	+57.5	+ 1.5
2186.692	+ 83.5	1.701	+83.5	0.0
2190.692	− 11.5	0.220	−02.9	− 8.6
2194.667	+ 94.7	1.454	+98.3	− 3.6
2202.667	+108.8	1.233	+98.1	+10.7
2204.658	+ 23.1	0.484	+23.8	− 0.7
2208.661	+ 97.3	1.746	+79.4	+17.9
2212.616	+ 00.7	0.220	−02.4	+ 3.1
2219.641	+ 74.6	1.764	+77.6	− 3.0
2228.560	− 04.3	2.461	−01.2	− 3.1
2230.630	+ 71.9	1.791	+74.9	− 3.0
2233.591	+ 49.8	2.012	+48.9	+ 0.9
2236.544	+ 23.6	2.224	+22.4	+ 1.2
2250.560	+ 01.3	2.537	−06.2	+ 7.5
2252.508	+ 85.6	1.745	+79.5	+ 6.1
2256.540	+ 00.6	0.296	+03.8	− 3.2
2257.544	+ 98.1	1.300	+99.5	− 1.4
2264.523	+ 02.9	0.058	−10.3	+13.2
2265.519	+ 90.8	1.054	+88.5	+ 2.3
2276.531	+ 86.6	1.104	+92.0	− 5.4
2501.659	+106.1	1.511	+96.2	+ 9.9
2501.863	+ 83.5	1.714	+82.4	+ 1.1
2518.601	+ 50.0	2.010	+49.1	+ 0.9
2518.689	+ 38.7	2.097	+38.1	+ 0.6
2520.616	+ 95.7	1.284	+99.3	− 3.6
2520.749	+ 94.4	1.417	+99.1	− 4.7

elements are listed in Table VI. The individual observations are shown in figure 3. The probable error of a single plate is ±4.1 km./sec.

TABLE VI

ORBITAL ELEMENTS OF H.D. 40372

		Preliminary	Final	
Period	P	2.74050 days	2.74050	
Eccentricity	e	0.03	0.018	± 0.022
Angle of periastron	ω	183°	183°.0	± 1°.81
Periastron passage	T	J.D. 2432141.16	2432141.143	± 0.020
Velocity of system	γ	47.0 km./sec.	45.3	± 1.84
Semi-amplitude	K	55.0 km./sec.	55.6	± 1.19
a sin i			2.093×10^6 km.	
$m_1^3 \sin^3 i/(m_1 + m_2)^2$			0.0600 $\odot$	

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