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# VARIABLE STARS IN THE GLOBULAR CLUSTER MESSIER 80

by

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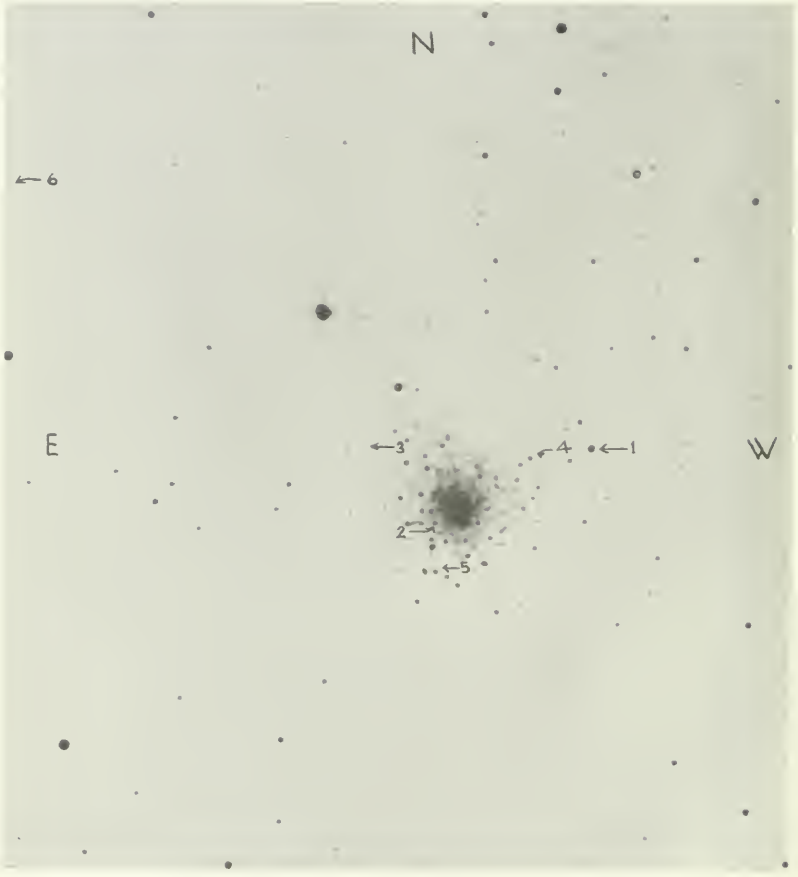
PLATE XXVIII




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

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

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 show-

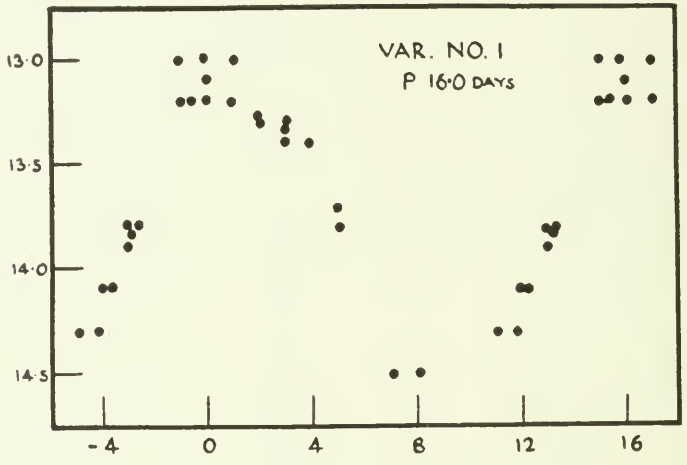



FIGURE 1.

ing 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.

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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Richmond Hill, Ontario,
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