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VARIABLE STARS IN THE GLOBULAR CLUSTER MESSIER 19

CHRISTINE COUTTS CLEMENT and HELEN SAWYER HOGG
David Dunlap Observatory, University of Toronto, Richmond Hill, Ontario L4C 4Y6, Canada
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ABSTRACT

Periods have been determined for seven of the eight variables in and around the globular cluster M19. Four of these are Population II cepheids with periods from 2.4 to 16.9 days and three are RR Lyrae variables. All of the cepheids and two of the RR Lyrae stars may be members. The only galactic globular clusters known to have more cepheids within their boundaries are ω Centauri and Messier 14.

I. INTRODUCTION

Messier 19 (NGC 6273, R.A. $16^h59^m.5$, Dec. −26°12′, 1950) is a moderately loose globular cluster of concentration class VIII. It lies in a very rich star field in the direction of the galactic center. Harris, Racine, and de Roux (1976) have determined a distance of 10 ± 1.5 kpc and note that the cluster lies about 2 kpc from the galactic center itself. Morgan (1959) classified its integrated spectrum as IV, indicating a moderate metal content. The most striking feature of the cluster is its ellipticity; it is the most elliptical of globular clusters according to Sawyer (1943). Harris *et al.* made the suggestion that a thin absorbing lane on the east side of the cluster may cause the unusual shape. Support for this idea comes from Rosino (1977) who reports that visual inspection of infrared plates he has taken of the cluster reveals little ellipticity. The color–magnitude diagram of Harris *et al.* (1976) shows in general outline, but almost lost in scatter, a giant branch and a well-populated blue horizontal branch. The scatter is attributed to a combination of differential reddening and contamination from the abundant field stars. In their search for UV bright stars in globular clusters, Zinn, Newell, and Gibson (1972) detected six in this cluster.

The first search for variable stars in NGC 6273 was made by one of us (Sawyer 1943), who published identifications of six variables. Four of these were near the cluster center (V1–V4) and two at some distance from it (F1 and F2). Another variable, now numbered V5, was discovered by Coutts, Sawyer Hogg, and Thompson (1975). Still another was found by Samus (1976), who published its identification chart.

For the sake of continuity for investigators working in the field of this cluster, the variables lying with the tidal radius of 14.8 arcmin given by Peterson (1976) are now numbered as follows: F1 becomes V6 and Samus' variable V7, even though it proves to be a field star. F2, well outside the tidal radius, is now omitted from the cluster list.

II. OBSERVATIONAL MATERIAL

Our investigation is based on photographs taken with three telescopes. Sawyer (1943) took 12 plates with the Steward Observatory 36-in. telescope in 1939. The cluster is too far south for the David Dunlap 74-in. reflector, but it can be reached with the 19-in. reflector at the same observatory. Accordingly, a series of 79 photographs were taken with that telescope during the years 1948–1955 with the help of many assistants as listed by Coutts Clement and Sawyer Hogg (1977). Beginning in 1972, a series of 77 photographs has been taken by one of us (C. C. C.) in Chile with the University of Toronto 24-in. telescope at the Las Campanas Observatory. Because of their excellent quality and spacing in time, these last are the mainstay of our period determinations. Our study covers variables V1–V7; F2 is outside the field of the 24-in. plates. Figure 1 identifies variables V1–V5. The measurements for these variables and V7 were made with a Cuffey iris astrophotometer. For V6, estimates were made by eye.

The 36- and 19-in. observations are on the photographic system (m_{pg}). We have used Sawyer's (1943) sequence for the reduction of plates on this system. Photographic magnitudes from the Arizona plates for variables V1–V4 and F1 and F2 were published by Sawyer (1943). Table I now gives the magnitudes on these plates for the new variables, V5 and V7. Table II gives the magnitudes from the 19-in. photographs for those variables which can be effectively studied on these plates of smaller scale and brighter limiting magnitude, namely variables V1, V2, V5, and V7.

The magnitudes from the 24-in. plates are on the *B* system (103a-O emulsion + GG385 filter). Our comparison stars for the *B* plates, identified by and with magnitudes given by Harris *et al.* (1976), are as follows: ZNG 5, 18, 27, 32, 63, 98, 188, 246, 251, 257, 270, 272, 273, 274, 343, and 442. Table III gives the *B* magnitudes determined from the 24-in. photographs for all the variables in the cluster. Measures of magnitudes for variables V3 and V4 are probably a little too bright because of their proximity to the cluster center. The Julian dates given in all the tables are heliocentric.

III. RESULTS

Our work places NGC 6273 in the small group of clusters which have more Population II cepheids than

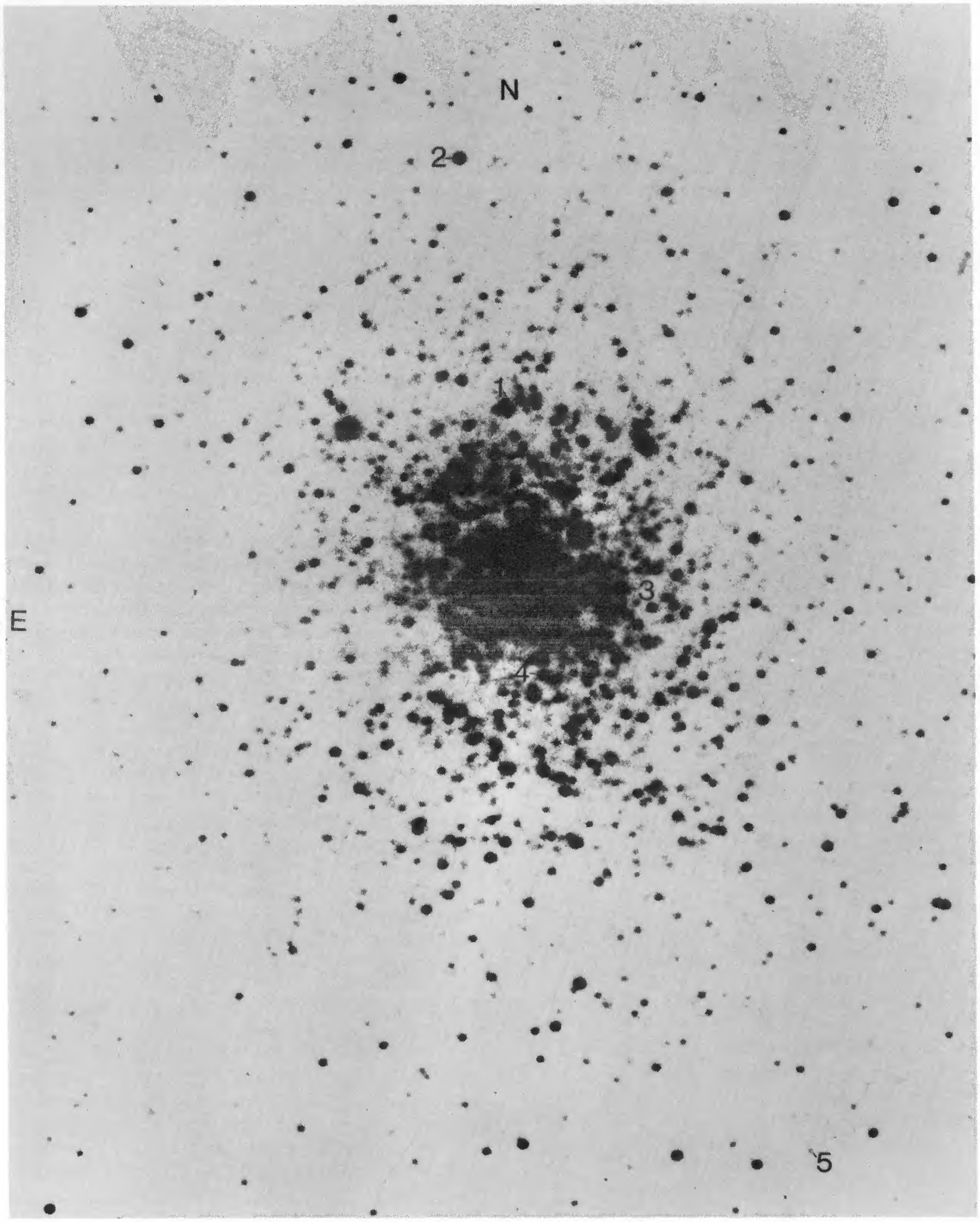

FIG. 1. *B* plate of M19, taken with the 24-in. telescope in Chile on 6 May 1975 at U.T. 7:16. Variables V1–V5 are identified. The scale of the print is 1.80 arcsec mm^{-1}.

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TABLE III

Observations from the U of T 24-inch at Las Campanas, Chile (B)

J.D. ⊙	V1	V2	V3	V4	V5	V6	V7
2441446.856	14.47	13.87	13.81	14.87	15.46	16.2	14.34
49.779	13.65	14.07	13.33	15.22	16.75	16.2	14.42
50.608	13.50	14.58	13.53	15.54	16.64	16.3	14.69
.751	13.33	14.54	13.24	15.20	16.89	15.6	14.47
51.664	13.56	14.88	13.44	14.90	16.67	16.3	14.71
52.648	13.65	14.96	13.54	15.71	16.70	16.1	14.74
53.687	13.58	14.70	13.50	14.54	16.75	15.5	14.51
.809	13.51	14.64	13.56	14.66	16.86	16.1	14.67
54.641	13.60	14.42	13.69	15.36	16.53	16.3	14.49
.732	13.51	14.48	13.36	15.32	16.80	16.4	14.62
.893	13.39	14.44	13.34	15.32	16.86	15.7	14.51
55.649	13.69	14.15	13.93	15.32	16.48	16.4	14.39
.759	13.73	14.07	13.71	14.27	16.78	16.4	14.73
.890	13.71	13.97	13.91	14.30	16.64	16.5	14.34
56.633	13.71	13.60	13.97	14.82	16.35	15.2	14.47
.758	13.71	13.54	13.89	14.90	16.89	16.0	14.77
.830	13.81	13.61	13.95	15.06	16.95	16.0	14.62
503.502	13.61	13.75	13.73	15.44	16.70	15.8	14.62
.695	13.61	13.79	13.71	15.50	15.61	16.2	14.74
06.546	13.73	14.37	14.17	15.08	16.98	15.8	14.47
.734	13.77	14.42	14.18	15.04	15.54	16.3	14.37
07.543	13.85	14.75	14.35	14.88	-	15.3	14.61
.606	13.83	14.72	14.30	14.85	16.92	15.3	14.76
08.505	14.09	14.94	14.20	15.59	16.86	16.2	14.59
.700	14.03	14.98	14.48	15.42	16.86	16.3	14.32
09.631	14.11	14.82	14.05	14.40	16.75	16.0	14.70
10.626	14.50	14.60	14.29	15.28	16.78	15.5	14.42
.729	14.50	14.52	14.24	15.46	16.95	16.0	14.62
11.698	14.54	14.24	13.95	14.21	16.83	15.4	14.65
12.556	14.50	13.81	13.71	14.68	16.80	16.1	14.62
.772	14.66	13.67	13.83	15.00	16.35	16.3	14.72
15.643	14.15	13.65	13.48	15.08	16.80	16.3	14.67
16.604	13.67	13.81	12.86	13.53	16.78	15.9	14.67
60.568	14.22	13.81	14.17	14.45	16.15	16.2	14.55
61.513	14.11	13.93	13.54	14.75	15.48	15.2	14.44
62.489	13.97	14.17	12.85	14.42	16.07	16.3	14.47
.596	13.99	14.11	13.10	14.70	15.97	16.4	14.72
63.621	14.42	14.48	13.51	14.44	16.20	16.4	14.74
68.531	13.37	14.20	12.99	14.21	16.89	16.3	14.64
71.641	13.48	13.41	13.77	15.32	15.54	15.3	14.69
72.571	13.39	13.71	13.81	14.03	16.95	16.2	14.65
842.628	13.33	13.69	13.87	13.79	16.43	15.7	14.37
43.737	13.31	13.95	13.71	14.77	16.55	16.2	14.77
2222.723	14.42	13.65	13.39	14.32	16.80	16.2	14.26
26.607	14.09	14.09	13.93	15.00	16.35	15.6	14.47
27.621	13.48	14.20	13.41	14.11	16.40	16.2	14.32
28.554	13.16	14.64	13.51	15.04	15.68	15.8	14.51
537.640	13.22	13.99	13.07	15.10	16.95	16.3	14.74
.704	13.58	14.26	13.36	15.32	16.95	16.5	14.76
.749	13.24	14.01	13.11	14.90	16.83	16.4	14.51
.815	13.16	14.05	13.07	14.87	16.92	16.4	14.37
.870	13.22	13.99	13.04	14.90	16.83	15.1	14.66
.906	13.33	14.02	13.16	14.97	16.11	15.5	14.75
38.627	13.46	14.26	13.30	14.13	16.73	15.5	14.70
.691	13.56	14.35	13.37	14.35	16.80	16.1	14.74
.758	13.51	14.24	13.37	14.30	16.86	16.3	14.44
.808	13.51	14.35	13.35	14.32	16.86	16.4	-
.863	13.50	14.37	13.37	14.45	16.92	16.4	14.69
.912	13.51	14.37	13.44	14.52	16.35	16.4	14.72
39.623	13.50	14.68	13.39	14.84	16.61	15.5	14.78
.702	13.65	14.68	13.61	15.10	16.70	15.6	14.65
.752	13.56	14.66	13.48	15.15	16.95	15.8	14.39
.833	13.66	14.75	13.53	15.16	16.83	16.0	14.67
89.686	13.01	13.36	13.06	13.67	15.61	16.1	14.65
.748	13.24	13.44	13.24	13.69	16.09	16.1	14.72
90.628	13.67	13.69	13.67	14.88	16.86?	15.1	14.49
.693	13.73	13.79	13.81	14.94	15.50	15.6	14.72
91.689	13.67	13.77	13.53	13.67	15.50	16.5	14.78
92.555	14.11	13.79	14.07	14.62	16.73	16.0	14.29
.663	13.99	13.77	13.81	14.54	16.80	16.1	14.74
.745	14.05	13.75	13.73	14.44	15.71	16.4	14.61
93.549	14.24	13.73	13.71	15.17	16.88	16.1	14.51
94.543	14.45	13.91	13.73	14.21	16.83	16.3	14.39
923.710	12.82	14.72	13.20	14.42	16.98	16.3	14.55
35.812	14.25	14.77	13.02	14.75	16.75	15.9	14.70
3278.622	13.11	14.60	13.69	14.58	16.35	16.3	14.76
80.601	13.44	13.65	13.75	14.72	16.09	16.0	14.57

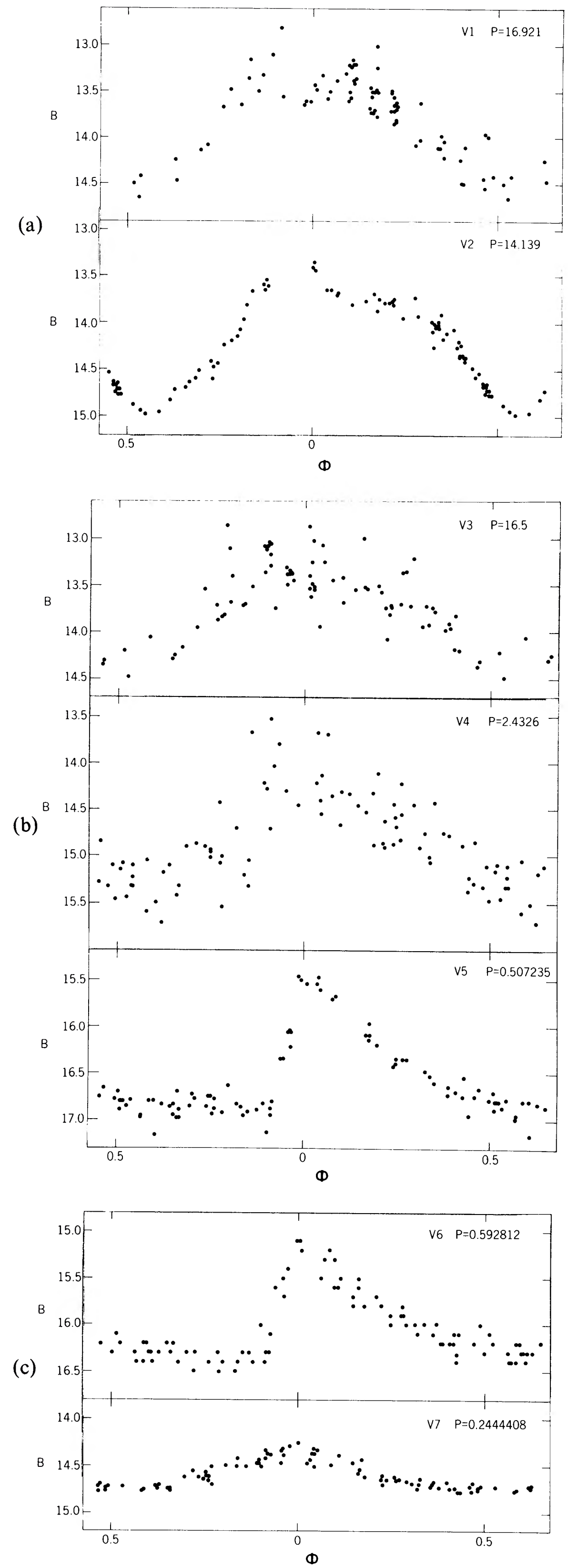

FIG. 2. Light curves for the variables from the Las Campanas 24 in. observations: (a) V1 and V2; (b) V3–V5; (c) V6 and V7.

TABLE IV. Elements of seven variable stars in NGC 6273.

Variable	x (arcsec)	y (arcsec)	B_{max}	B_{min}	Period (days)	Epoch 2400000 +
1	+4	+48	13.15	14.55	16.92	42586.769
2	+14	+123	13.35	14.95	14.139	42589.680
3	−28	−6	13.0	14.4	16.5	42588.968
4	−4	−33	14.0	15.5	2.4326	42589.596
5	−77	−178	15.45	16.95	0.507235	42590.672
6	+347	+421	15.1	16.5	0.592812	42590.624
7	−375	+153	14.3	14.75	0.2444408	42590.599

numbers of globular cluster cepheids as a function of luminosity and has attempted to explain the distribution on the basis of theoretical models. He found that the models predict relatively too few variables spread over too large a range in luminosity in the brighter group (with periods longer than 6 days). The periods for the Population II cepheids now determined in M19 increase Gingold's problem. He suggests that mass loss on the asymptotic branch could explain the discrepancy.

Because of the observational difficulties from northern hemisphere observatories, variables in many of the globular clusters in the group around the galactic center have not been studied thoroughly enough for period determination. It is important to learn whether others in this group are as rich in Population II cepheids as NGC 6273 has been found to be.

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