NGC 1866 AND THE MAGELLANIC CLOUD VARIABLES

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In both of the Magellanic Clouds are found circular and centrally concentrated groups of stars that have been called, with some scepticism, globular clusters. They are intermingled with the open (galactic) star clusters, some of which are involved in nebulosity, like that of the Pleiades, and others are clear, like Messier 11, and h and χ Persei.

The cluster NGC 1866, near the northern border of the main body of the Large Cloud, and the immediately surrounding field have been studied in some detail, first because of the high apparent brightness of the cluster (photographic magnitude 8) and the suspicion that it may not be a typical globular cluster, and second, to determine the frequency curve of the periods of the Cepheid variable stars around and in the cluster in comparison with the frequency in the denser parts of the Cloud.

Plates suitable for the discovery and study of the variable stars were made with the 24-inch Bruce refractor and the 60-inch Rockefeller reflector at the Boyden Station. No cluster type variables were found, notwithstanding careful search and the adequacy of the plate material. The cluster lies in the outer part of the Large Cloud, which was not systematically surveyed by Miss Leavitt in her early studies or by later surveyors of the Clouds. Before the present study, therefore, only one variable, HV 2886, of irregular type, had been found and two others, HV 12204, HV 12211, had been suspected of variability in the area now surveyed.

The 29 variables now reported are listed in Table I. The magnitude scale and zero point for this field have been adjusted to conform with the magnitude standards used in other parts of the Large Cloud. All magnitudes are subject to revision as soon as current photoelectric studies are completed. The adjustment was made in such a way that the amplitudes would, as elsewhere, approximate one magnitude, and the median magni-

TABLE I. VARIABLES IN REGION OF NGC 1866

HV Number	R.A.	Dec.	Magnitude Max.	Magnitude Min.	Period in Days	Distance from Cluster
12185	5^h 9^m17^s	$-65°29'.4$	14.0	15.15	irregular	$25'.3$
12186	5 9 33	-65 21.5	14.25	15.7	12.24	27.0
12187	5 9 58	-65 55.6	15.1	16.55	3.2867	28.7
12188	5 10 26	-65 53.5	16.0	16.65	2.933966	25.5
12189	5 10 36	-65 48.6	16.0	16.85	3.2460	22.0
12190	5 10 38	-65 33.0	14.0	15.05*	7.18282	17.0
2886	5 10 58	-65 33.1	12.8	14.25	irregular	14.8
12191	5 11 51	-65 20.8	15.55	16.4		16.7
12192	5 11 56	-65 30.1	15.45	16.1		9.5
12193	5 12 11	-65 43.2	15.85	16.75	3.4654	10.3
12194	5 12 12	-65 38.9	15.55	16.5	3.2049	7.5
12195	5 12 21	-65 18.2	15.55	16.5	3.1897	17.3
12196	5 12 23	-65 33.7	15.7	16.65	3.11306	5.6
12197	5 12 54	-65 37.6	16.0	16.75	3.1437	2.9
12198	5 12 59	-65 34.2	15.85	16.65	3.5230	1.6
12199	5 12 59	-65 36.3	16.0	17.05	2.63911	1.2
12200	5 13 16	-65 34.8	16.0	16.75	2.7249	0.8
12201	5 13 17	-65 41.4	15.15	16.5	3.4439	5.9
12202	5 13 19	-65 35.7	16.1	16.65	3.1011	1.2
12203	5 13 21	-65 36.3	15.85	16.65	2.954	1.0
12204**	5 13 38	-65 35.5	14.9	16.25	3.43861	2.2
12205	5 13 47	-65 38.1	15.3	16.5	3.2104	5.2
12206	5 13 58	-65 31.0	15.3	16.9	2.50579	6.7
12207	5 14 59	-65 46.6	15.25	16.25	4.50645	16.3
12208	5 15 35	-65 26.7	15.55	16.75	2.6036	16.3
12209	5 15 36	-65 35.9	15.7	16.75	2.92997	19.4
12210	5 15 36	-65 36.9	15.45	16.4	5.0831	19.4
12211***	5 15 44	-65 47.7	15.85	16.7	2.93996	20.0
12212	5 15 47	-65 27.9	15.45	16.0		15.9

* Secondary minimum not observed for this eclipsing star.
** No. 85 in list of suspected variables; *Ann. Harv. Col. Obs.* **90**, No. 1, 1933.
*** No. 86 in list of suspected variables; *Ann. Harv. Col. Obs.* **90**, No. 1, 1933, position remeasured.

tudes would fall along the well established period-luminosity curve. All with periods, except HV 12190, are Cepheids.

The most significant results of this survey, which covers two-thirds of a square degree centered on the cluster, are (1) the complete absence of cluster-type Cepheids, (2) the discovery that twenty-three of the twenty-nine variables are typical Cepheids, (3) the deduction that only four of the twenty-three periods are longer than 3.5 days, and (4) the anomaly that these classical Cepheids are twenty times as abundant in and near the cluster as in other parts of the surrounding field. We comment on each of these items in turn:

1. The absence of cluster variables in this part of the Large Cloud is in agreement with our searches elsewhere. Occasionally a cluster-type Cepheid has been found on the photographs of the Clouds, but it has properly been assigned to the foreground on the basis of median magnitude. If cluster-type variables of appropriate magnitude had been found in NGC 1866, they would have supported the identification of this object as a globular cluster.

2. The relative abundance of Cepheids, compared with other types of variable stars, is not much different here than elsewhere in the Clouds. The eclipsing variable, HV 12190, does not show rounded maximum, like those in another section of the Cloud, the region of 30 Doradus.[1] As a member of the Cloud, its absolute magnitude would be approximately −3 at maximum; more likely therefore it is a foreground star of absolute magnitude about +1.0, even though eclipsing stars of apparent photographic magnitude 14 and fainter at maximum are elsewhere exceedingly rare in galactic latitude −33°. Similarly the brightest of the two irregular variables (HV 2886) may be a foreground object, although a later study of irregular red variables scattered over the Cloud will report many with absolute magnitudes brighter than −3.0. The small amplitudes of three of the variables have prevented the determination of periods and types.

3. The distribution for the periods in this border region around NGC 1866 is compared in the accompanying figure with the distribution found in two thoroughly investigated fields nearer the geometric and mass center of the Cloud. One is on the axis and the other in the more open area west of 30 Doradus. The contrast is less than that shown in the Small Magel-
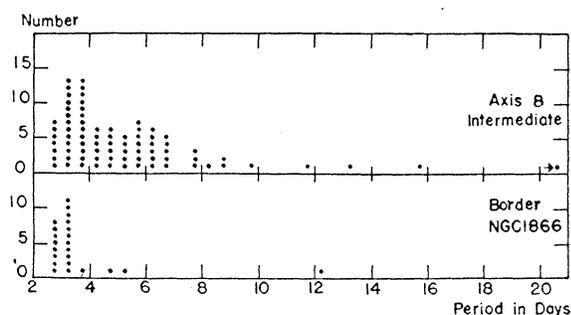

Figure 1. Comparison of period distribution in dense and border regions of the Large Magellanic Cloud.

lanic Cloud; there the length of the most frequent period increases steadily from the Cloud borders, where it is 2.70 days, to the core of the Cloud, where the median is 6.47 days.[2]

The dependence of period length on position in the Cloud remains one of the most puzzling problems of the Magellanic Clouds; it may result from a combination of the effects of uneven chemical abundance, of equipartition of energy, and of a tendency to form the greater Cepheids (high luminosities) where the hypothetical pre-star material was originally most densely accumulated.

4. Classical Cepheids, and other intrinsic variable stars, are notoriously absent from the open clusters of the Milky Way. In the following tabulation, however, we find that the typical Cepheids in and on the borders of the cluster NGC 1866 are twenty or thirty times as abundant as elsewhere. A rough count of the star density in the cluster, on its borders, and in the general field indicates, however, a similar distribution of non-variable stars. That is, we may reasonably assume that the cluster is accumulated from the general population of the Cloud and this general population includes classical Cepheids mingled at random with the other stars of high luminosity. Table II presents the material on star counts in successive rings centered on the cluster. The

TABLE II. FREQUENCY OF STARS IN REGION OF NGC 1866

Ring	Limiting Radii	Comp. Areas	No. of Stars	No. in Unit Area	No. of Vari-ables	No. in Unit Area	% Vari-ables
1	0′ to 4′	1	200:	200:	7	7.0	3.5:
2	4′ to 8′	3	115	38	5	1.7	4.3
3	8 to 12	5	158	32	2	0.4	1.3
4	12 to 16	7	187	27	2	0.3	1.1
5	16 to 20	9	235	26	7	0.8	3.0
6	20 to 24	11	265	24	2	0.2	0.7
7	24 to 28	13	261	20	4	0.3	1.5
Totals and Means for Rings		3–7	1106	26	17	0.4	1.5

slightly greater proportion of variables in the cluster indicated in the last column may only reflect the ease of detecting variation where companion stars are near at hand.

Short exposures with the 60-inch reflector show more irregularities in the internal structure of NGC 1866 than are found in an average globular cluster of the Galactic System. Also Dr. Baade reported in a private communication in 1949 that color observations made with the Pretoria reflector indicate a color distribution of the brighter stars that is more in keeping with that of a Hyades-like open cluster, with its white and red giants equally bright, than with that of the typical globular cluster, where the reddish stars are photographically a magnitude or more brighter than the blue stars.

We conclude that NGC 1866 is probably not a typical globular cluster, notwithstanding its general appearance and its linear dimensions. The other "circular" star clusters of the Cloud are on the average two or three magnitudes fainter. So far they have revealed no cluster-type Cepheids. Their colors, and the variable star population around them, are under further investigation at the Harvard Observatory.

REFERENCES

1. Shapley and Nail, *Proc. Nat. Acad. Sci.* **34**, 178, 1948; Harv. Reprint No. 306.
2. Shapley and McKibben, *Proc. Nat. Acad. Sci.* **26**, 110, 1940; Harv. Reprint No. 192.

Harvard College Observatory,
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PARALLAX AND ORBITAL MOTION OF ALGOL

FROM PHOTOGRAPHS TAKEN WITH THE 24-INCH SPROUL REFRACTOR

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Introduction and summary. Algol $= \beta$ Persei; $3^h 1^m 7$, $+ 40°34'$ (1900) is the well-known eclipsing binary with a period of 2.867 days. The best established of the longer periods is that of 1.873 years, attributed to the unseen component Algol C.[1]

Algol has been on the Sproul astrometric program since 1920. The first parallax series extends from 1920 to 1926. From 1938 on the star was photographed each year. A first astrometric study based on 261 plates taken on 82 nights was made in 1942 by Armstrong Thomas;[2] at that time the phases of the 1.873 orbit were inadequately covered. Since all phases have now been covered, a new solution was undertaken, based on 560 plates with 1972 exposures (total weight 411), taken on 164 nights. The resulting value for the relative parallax is $+.''0408 \pm .''0022$ (p.e.); the photocentric semi-axis major of the 1.873 orbit is found to be small, amounting to $.''0147 \pm .''0028$, the inclination is $63° \pm 16°$. The mass of Algol C is found to be $1.45 \pm .26 \odot$; no conclusive evidence is obtained for the luminosity of Algol C.

Material and measurements. Information about the observations is contained in Table I, also parallax factors in right ascension and declina-

TABLE I. OBSERVING DATA, MEASURED POSITIONS AND RESIDUALS

Epoch	Date	H.A. min.	No. of pl.	exp.	Obs.	P_α	P_δ	x	y	ξ unit .0001 mm	η unit .0001 mm	O—C v_x unit .0001 mm	v_y	p
1920.744	*Sept. 28	−20	1	2	P	+.65	+.46	−.87	+.68	+257	−40	+20	−66	1
.763	Oct. 5	+1	1	2	P	+.56	+.47	−.91	+.63	245	+54	+10	+28	1
.768	Oct. 7	−5	1	1	P	+.53	+.47	−.92	+.62	245	+63	+11	+36	1
21.074	Jan. 27	−4	2	3	Po	−.93	−.17	−1.12	−.21	126	−48	−82	−59	1
.077	Jan. 28	+3	1	2	P	−.93	−.17	−1.11	−.24	204	+5	−4	−6	1
.727	Sept. 22	−57	2	4	P	+.73	+.45	+.57	−.70	+272	−30	+30	−49	1
.735	Sept. 25	−58	2	4	P	+.69	+.46	+.57	−.70	292	+41	+52	+22	1
22.084	Jan. 31	+6	1	2	M	−.94	−.20	+.69	+.55	210	+39	+14	+29	1
.718	Sept. 19	−80	2	4	P	+.76	+.44	−1.05	+.41	231	+80	−7	+53	1
.729	Sept. 23	−37	1	1	M	+.72	+.45	−1.06	+.38	213	+73	−24	+45	1
.737	Sept. 26	−57	2	4	P	+.68	+.46	−1.07	+.36	+236	+24	0	−5	1
23.966	Dec. 19	−8	2	4	P	−.59	+.15	+.65	+.61	186	+20	−13	+2	2
24.017	*Jan. 7	−46	2	4	P	−.80	.00	+.53	+.74	206	+12	+12	−4	2
.763	*Oct. 5	−28	2	3	P	+.56	+.47	−1.14	−.08	236	+42	+3	+14	2
.777	Oct. 10	+10	1	2	Wl	+.49	+.47	−1.13	−.12	176	+41	−56	+14	1