

152 new variable stars in the Large Magellanic Cloud.

(Harvard College Observatory Circular No. 82).

The two Magellanic Clouds have long been objects of careful study, on account of the extraordinary physical conditions which prevail in them. They have not, however, heretofore been known as regions in which variable stars are numerous. The discovery of a large number of variable stars in the Small Magellanic Cloud, as announced in Circular No. 79 (A. N. 3963), led to an examination by Miss Leavitt of the Large Cloud, by the same method, although a detailed examination of the region immediately surrounding NGC. 2070, the Looped Nebula, had already been made, with negative results. Over one hundred variable stars have thus been found. Twenty-one plates, taken with the Bruce 24-inch Telescope and having exposures of from one to five hours, were used. A series of six of these, taken within ten days of each other, has made it possible to derive some inferences as to the periods.

In Table I, a number for reference, the right ascension and declination for 1900, the brightest and faintest magni-

tudes observed on the plates, according to a provisional scale, and the range, are given in the successive columns.

The light of nearly all these variables changes rapidly. Among those obviously having short periods are Nos. 20, 23, 53, 59, 60, 62, 65, 66, 68, 69, 72, 78, 80, 81, 89, 102, 103, 107, 113, 126, 131, 132, 134, 135, 142, 152. Their distribution is remarkable, as they are usually found in groups, of which the most definite is in the collection of faint stars and nebulae which begins near NGC. 1850 and extends in a southeasterly direction toward a point about a degree south of NGC. 2070. These comprise more than half the total number thus far discovered, and appear to be distinguished from the others by their faintness, even at maximum, and their small range of variation. The remaining variables, as a rule, are not found in any of the regions noticeably crowded with stars, though many variables are distributed around the edges of such regions. They show no tendency to be grouped near NGC. 2070.

Table I.
Variable stars in the Large Magellanic Cloud. *)

No.	α 1900	δ 1900	Br.	Ft.	R.	No.	α 1900	δ 1900	Br.	Ft.	R.
1	4 ^h 55 ^m 2	-67° 38'	13.9	14.8	0.9	30	5 ^h 8 ^m 4	-69° 22'	13.9	14.9	1.0
2	4 55.4	-71 4	12.7	14.7	2.0	31	5 8.6	-70 34	13.0	13.8	0.8
3	4 55.8	-70 25	14.3	15.0	0.7	32	5 8.7	-70 47	13.7	14.8	1.1
4	4 57.1	-69 31	13.0	13.7	0.7	33	5 8.8	-68 54	12.2	14.4	2.2
5	4 57.3	-67 31	14.0	14.9	0.9	34	5 9.8	-68 52	13.6	15.0	1.4
6	4 57.5	-68 8	13.8	14.7	0.9	35	5 9.9	-69 2	13.9	15.0	1.1
7	4 58.6	-70 7	12.8	14.5	1.7	36	5 10.4	-67 58	13.8	14.1	0.3
8	4 58.8	-69 36	12.8	14.7	1.9	37	5 10.5	-69 7	14.4	14.9	0.5
9	4 59.2	-67 52	13.9	14.9	1.0	38	5 10.5	-70 34	12.5	13.7	1.2
10	4 59.6	-70 29	13.3	14.8	1.5	39	5 10.6	-68 48	14.3	15.0	0.7
11	5 0.3	-69 36	12.0	14.0	2.0	40	5 11.2	-69 16	13.3	14.6	1.3
12	5 0.5	-68 36	11.7	13.9	2.2	41	5 11.4	-68 14	13.9	14.4	0.5
13	5 1.9	-68 14	11.4	15.5	4.1	42	5 12.5	-69 13	14.1	14.8	0.7
14	5 2.3	-69 3	13.0	14.0	1.0	43	5 13.4	-69 13	14.4	15.0	0.6
15	5 2.9	-66 22	12.8	14.2	1.4	44	5 14.9	-69 19	14.2	14.7	0.5
16	5 2.9	-69 41	13.8	14.9	1.1	45	5 15.0	-67 34	13.5	14.8	1.3
17	5 4.3	-67 24	12.7	14.8	2.1	46	5 15.9	-69 20	14.6	15.0	0.4
18	5 4.3	-69 4	13.1	14.7	1.6	47	5 16.0	-69 11	14.3	15.1	0.8
19	5 4.6	-69 14	14.0	14.6	0.6	48	5 16.1	-70 14	13.9	15.0	1.1
20	5 4.7	-69 10	13.0	15.0	2.0	49	5 16.3	-69 22	14.4	15.0	0.6
21	5 4.8	-68 52	13.8	14.5	0.7	50	5 16.4	-69 10	14.3	14.9	0.6
22	5 6.6	-69 15	13.4	14.9	1.5	51	5 16.6	-69 34	14.2	15.0	0.8
23	5 6.7	-70 42	14.0	15.0	1.0	52	5 17.0	-69 39	14.3	14.9	0.6
24	5 6.8	-68 48	13.7	14.8	1.1	53	5 17.0	-70 42	13.0	14.0	1.0
25	5 7.1	-68 33	14.4	15.0	0.6	54	5 17.2	-69 50	14.7	15.3	0.6
26	5 7.2	-70 56	13.7	15.0	1.3	55	5 17.4	-70 24	14.5	15.1	0.6
27	5 7.3	-68 44	14.3	15.0	0.7	56	5 17.5	-69 26	14.4	15.1	0.7
28	5 7.4	-69 1	13.0	14.7	1.7	57	5 17.9	-70 52	13.6	14.5	0.9
29	5 7.7	-70 10	12.2	13.6	1.4	58	5 18.7	-67 19	12.9	14.0	1.1

*) Auch hier habe ich aus den in Nr. 3963 erörterten Gründen von einer besonderen provisorischen Numerierung abgesehen. Die südlich von -69° 58' gelegenen Sterne gehören zum Sternbilde Mensa, die nördlich gelegenen zum Sternbilde Dorado. Kr.

No.	α 1900	δ 1900	Br.	Ft.	R.
59	5 ^h 19 ^m 3	-68° 20'	14.1	14.7	0.6
60	5 19.4	-70 52	14.4	15.0	0.6
61	5 19.9	-69 42	13.6	14.6	1.0
62	5 20.6	-69 16	14.0	14.9	0.9
63	5 20.6	-68 2	14.2	14.7	0.5
64	5 20.8	-68 10	14.2	14.6	0.4
65	5 20.9	-69 42	14.1	14.9	0.8
66	5 21.3	-70 8	14.3	15.1	0.8
67	5 21.7	-69 9	12.9	14.0	1.1
68	5 21.8	-69 54	13.9	15.0	1.1
69	5 22.8	-69 3	14.2	15.0	0.8
70	5 22.9	-69 28	14.8	15.1	0.3
71	5 22.9	-70 15	14.6	15.2	0.6
72	5 23.0	-69 4	14.4	15.1	0.7
73	5 23.1	-69 44	14.3	15.0	0.7
74	5 23.5	-70 1	14.7	15.4	0.7
75	5 23.6	-69 43	14.2	14.8	0.6
76	5 24.2	-69 59	13.9	14.8	0.9
77	5 24.6	-70 5	14.7	15.2	0.5
78	5 25.1	-68 16	14.9	15.3	0.4
79	5 25.1	-69 54	14.3	14.9	0.6
80	5 25.2	-68 17	14.8	15.2	0.4
81	5 25.4	-69 18	14.1	15.0	0.9
82	5 25.4	-67 44	11.7	12.8	1.1
83	5 25.5	-70 1	14.3	15.0	0.7
84	5 26.0	-67 26	12.8	14.6	1.8
85	5 26.3	-69 49	14.8	15.1	0.3
86	5 26.4	-69 10	13.8	14.8	1.0
87	5 26.8	-69 59	14.3	14.9	0.6
88	5 26.9	-69 56	14.5	15.1	0.6
89	5 27.2	-69 41	13.9	15.0	1.1
90	5 27.2	-69 53	14.8	15.2	0.4
91	5 27.4	-69 48	14.4	14.9	0.5
92	5 27.6	-66 58	13.0	14.1	1.1
93	5 27.7	-67 21	13.8	< 15.5	1.7
94	5 28.0	-69 55	14.3	14.8	0.5
95	5 28.0	-71 16	13.8	< 15.2	1.4
96	5 28.1	-70 24	14.9	15.3	0.4
97	5 28.1	-69 55	14.3	14.8	0.5
98	5 28.1	-68 28	13.8	14.4	0.6
99	5 28.3	-69 48	14.7	15.1	0.4
100	5 28.4	-67 8	13.9	14.7	0.8
101	5 28.4	-69 55	14.2	14.7	0.5
102	5 28.8	-70 5	13.2	14.8	1.6
103	5 29.0	-69 53	14.1	15.0	0.9
104	5 29.5	-69 45	14.4	< 15.5	1.1
105	5 29.5	-69 45	14.8	15.2	0.4

No.	α 1900	δ 1900	Br.	Ft.	R.
106	5 ^h 29 ^m 5	-69° 45'	14.8	< 15.5	0.7
107	5 29.6	-70 2	13.8	15.0	1.2
108	5 29.8	-69 55	14.1	15.1	1.0
109	5 30.2	-67 37	14.4	15.0	0.6
110	5 30.2	-69 50	14.1	14.9	0.8
111	5 30.5	-69 13	13.8	14.1	0.3
112	5 30.6	-70 18	14.7	15.2	0.5
113	5 31.0	-69 31	13.3	14.2	0.9
114	5 31.0	-69 57	14.0	15.0	1.0
115	5 31.2	-67 30	13.1	14.3	1.2
116	5 31.3	-70 9	14.6	15.2	0.6
117	5 31.3	-70 42	14.4	15.1	0.7
118	5 31.4	-70 1	14.1	15.2	1.1
119	5 31.6	-66 34	12.4	14.2	1.8
120	5 31.6	-70 2	14.5	14.8	0.3
121	5 31.6	-70 19	14.4	15.1	0.7
122	5 31.7	-70 0	14.8	15.2	0.4
123	5 32.2	-70 9	14.7	15.1	0.4
124	5 32.7	-70 0	14.7	15.2	0.5
125	5 33.1	-67 59	13.1	14.1	1.0
126	5 33.4	-68 15	13.6	14.8	1.2
127	5 34.3	-67 41	13.7	14.7	1.0
128	5 34.6	-67 53	13.6	14.4	0.8
129	5 34.6	-68 3	14.0	14.8	0.8
130	5 35.5	-67 48	13.6	14.2	0.6
131	5 35.9	-66 46	12.2	13.8	1.6
132	5 36.1	-68 36	12.3	13.4	1.1
133	5 36.2	-67 0	13.8	14.8	1.0
134	5 36.8	-68 53	13.0	14.6	1.6
135	5 38.1	-69 32	13.4	14.8	1.4
136	5 38.6	-68 8	13.9	14.9	1.0
137	5 38.6	-70 19	14.5	15.0	0.5
138	5 38.7	-70 18	14.9	15.2	0.3
139	5 39.0	-70 5	14.4	15.1	0.7
140	5 40.0	-70 22	14.2	15.1	0.9
141	5 40.0	-70 42	14.4	15.2	0.8
142	5 40.3	-67 53	13.2	14.2	1.0
143	5 40.4	-70 23	14.5	15.0	0.5
144	5 40.5	-69 6	14.0	14.5	0.5
145	5 40.7	-70 24	14.6	15.1	0.5
146	5 41.7	-69 21	14.4	14.9	0.5
147	5 43.7	-66 52	14.5	15.0	0.5
148	5 44.0	-70 10	13.9	14.7	0.8
149	5 44.3	-68 43	14.2	14.7	0.5
150	5 45.3	-69 34	14.6	15.1	0.5
151	5 46.3	-69 16	14.4	14.9	0.5
152	5 47.2	-68 12	13.2	14.4	1.2

Remarks.

13. This star has the largest range of any of the variables in Table I. The period is probably long.

15. The preceding star of a pair.

23. The central star of a close cluster of five.

25. A faint star north of and closely following the variable makes it appear nebulous, except on plates in which the definition is good.

30. The preceding star of a close pair.

36. The variation of this star seems to be real, although the observed range is small.

46. Variation well shown, though small.

53. Period apparently extremely short.

61. The northern star of a close pair.

64. Variation well shown, though small.

70. The variation of this star seems to be real, although the observed range is small.

78, 80. These adjacent stars apparently vary alternately. On the plates examined, one is always bright when the other is faint. Period apparently short.

85. The variation of this star, although small, seems to be real, as there are good comparison stars near it.

90. The variation is well shown.

96. The variation is well shown.

104, 105, 106. These three stars are very near together. The periods of all are evidently short. Nos. 105 and 106 were discovered by Mrs. *Fleming* while confirming adjacent variables.

110. This star may be of the Algol type. It is of uniform brightness on nearly all of the plates examined, but is faint on two plates.

The variability of all of these stars, and of those announced as variable in Circulars Nos. 78 (A. N. 3950) and 79 (A. N. 3963), have been confirmed either by Mrs. *Fleming* or by Miss *Leland*. It is probable that the range will be increased when a photometric scale is substituted for that here used. Many of the faint stars in the Large Magellanic Cloud show slight fluctuations in brightness. This renders it probable that many more variables may be discovered from an examination of later plates.

Preparations are being made for determining the precise positions, periods, and light curves of all of these variables. The treatment should be like that of the 128 variables in ω Centauri, discussed in Volume XXXVIII. This will be a large piece of work, and progress will necessarily be slow.

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111. The variation of this star seems to be certain, although the observed range is small.

119. This star is faint on only three plates.

120. This star is certainly variable, although the observed range is small.

122. Variation well shown.

123. Variation well shown.

138. The variation of this star is certainly real, although the observed range is small.

144. This star was observed as slightly variable in the previous examination of the region near NGC. 2070. Additional plates have confirmed the variability with a larger range than was observed at that time.

Two or three assistants should be started on the work at once.

The total number of new variables found in nebulous regions by Miss *Leavitt*, and announced in Circulars Nos. 78 (A. N. 3950), 79 (A. N. 3963), and 82, is at least 277. It is a remarkable illustration of the results to be expected from a systematic study of the Harvard Library of Astronomical Photographs. During 1903, a grant from the Carnegie Institution permitted a corps of eight or more observers to carry on such investigations. Since then this corps has been disbanded, and the means of the Observatory have permitted but one observer to be employed on similar work, with the results here shown.

Edward C. Pickering.

Secular Variation of Precession from Besselian Star Constants.

By Dr. *Herman S. Davis.*

All secular variations for the final catalogue of the new reduction of Piazzini's observations, were computed last fall by the formulae:

$$100 \frac{d^2\alpha}{dt^2} = 2 [9.1640] a b + [6.6337_n] a + [9.6513_n] b + ([7.813146] \sin 2\alpha + 0.003220)$$

$$100 \frac{d^2\delta}{dt^2} = [9.1640] a b' + [6.6337_n] a'$$

The last term of the first equation may be written:

$$([6.8118_n] a' b' + 0.003220)$$

to be analogous in the use of the star constants, but it is preferable not to do so, since one addition of two logarithms for each star was avoided by a small, easily constructed, table of values of this entire term from $+0.0097$ to -0.0033 with limiting values of α , only, as the argument for each of the 130 units.

Astronomers who are accustomed to employing the Besselian star-constants for reduction to mean place, so that they have already at hand the logarithms of the letters involved in the formulae, will readily see the vast saving of time in this computation of the secular variations. It requires no use whatever of trigonometrical tables, and only two additions of logarithms, viz. $(\log a + \log b)$ and $(\log a + \log b')$.

After this the natural numbers of all the terms of both equations may be written immediately, using the star-constants directly as arguments in a four-place antilogarithm table, in which the printed argument has been shifted by an amount equivalent to the mantissa of the coefficient; or, as was done in the Piazzini work, by using tables of 'limiting values', which are very small, quickly constructed, and only four in number since two of them will be identical for α and δ .

Four-place logarithms are sufficiently precise to give the secular variations to four decimals for all terms and all stars, except for the first term in α , when the stars fall within a polar lemniscate limited by $\delta = 90^\circ$ at 6^h and 18^h , and $\delta = 73^\circ$ at 0^h and 12^h . There are only 27 such stars in Piazzini's catalogue.

Inspection of the following constants (which are written