NEW VARIABLE STARS IN THE GLOBULAR CLUSTER NGC 6401*

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Abstract. 115 new variable stars have been detected in a one square degree field centered on the globular cluster NGC 6401. Two of them (No. 157 and 164) seem to belong to the cluster.

1. Introduction

From its first observation in 1784 by Herschel (1786) till now, the globular cluster NGC 6401 ($\alpha = 17^h35^m.53$; $\delta = -23°52'.89$; 1950.0) has not been systematically searched for variable stars, either in the cluster itself or in the surrounding field (Alter *et al.*, 1970; Hogg, 1963).

The importance of interstellar absorption in front of the cluster is perhaps the reason: 3.44 mag. if $A_v = 0.24$ cosec b (Arp, 1965), or 2.69 mag. with $D'_{0.9}$ (Kron and Mayall, 1960).

In 1968 and 1970 we made a large number of photographic observations at the newtonian focus of the 80-cm reflector ($F/6$) at Haute Provence Observatory. The plates are centered on the cluster and cover a field of about one square degree. The comparison between them with the blink microscope of the Lyons Observatory led us to discover 102 new variable stars, one (No. 41) of which seems to belong to the cluster (Terzan and Rutily, 1972). They are the first variables to be discovered in the field of NGC 6401 (Kukarkin, 1971).

Photographic observations (103 aE plates + Ilford 204 filters, $\lambda_{eff} \cong 6400$ Å) have been pursued at the newtonian foci of the 80-cm ($F/6$) and 193-cm ($F/5$) reflectors at Haute Provence Observatory in 1971 and 1972.

In this work, we give the latest results obtained from these new observations.

2. Observations and Measures

The many plates obtained since 1968 have been inter-compared with the blink microscope of the Lyons Observatory. The photometric measures are made with an iris-photometer (accuracy: $\pm$ 0.04 mag.).

The sequence of red magnitudes (m_r) used for this study is the one recently established around the cluster (Terzan and Rutily, 1972). 115 other new variable stars have been detected near NGC 6401. They add to the 102 variables found previously (Terzan and Rutily, 1972) and are numbered from 103 to 217 (Figures 1 and 2).

* Observations made at Haute Provence Observatory (C.N.R.S.)

J. D. Fernie (ed.), Variable Stars in Globular Clusters and in Related Systems, 68–75.

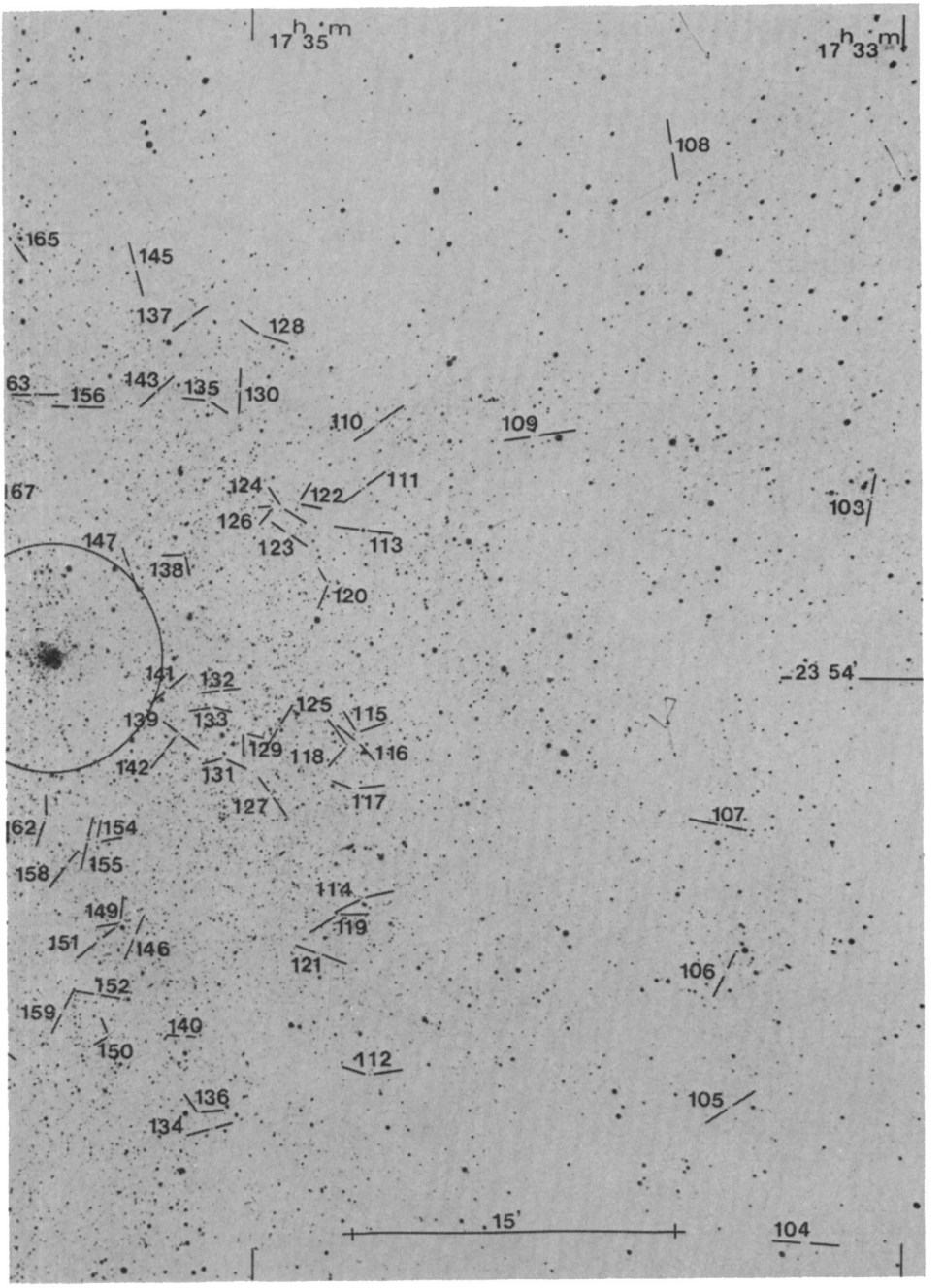

Fig. 1. New variable stars (103–159) detected near the globular cluster NGC 6401.

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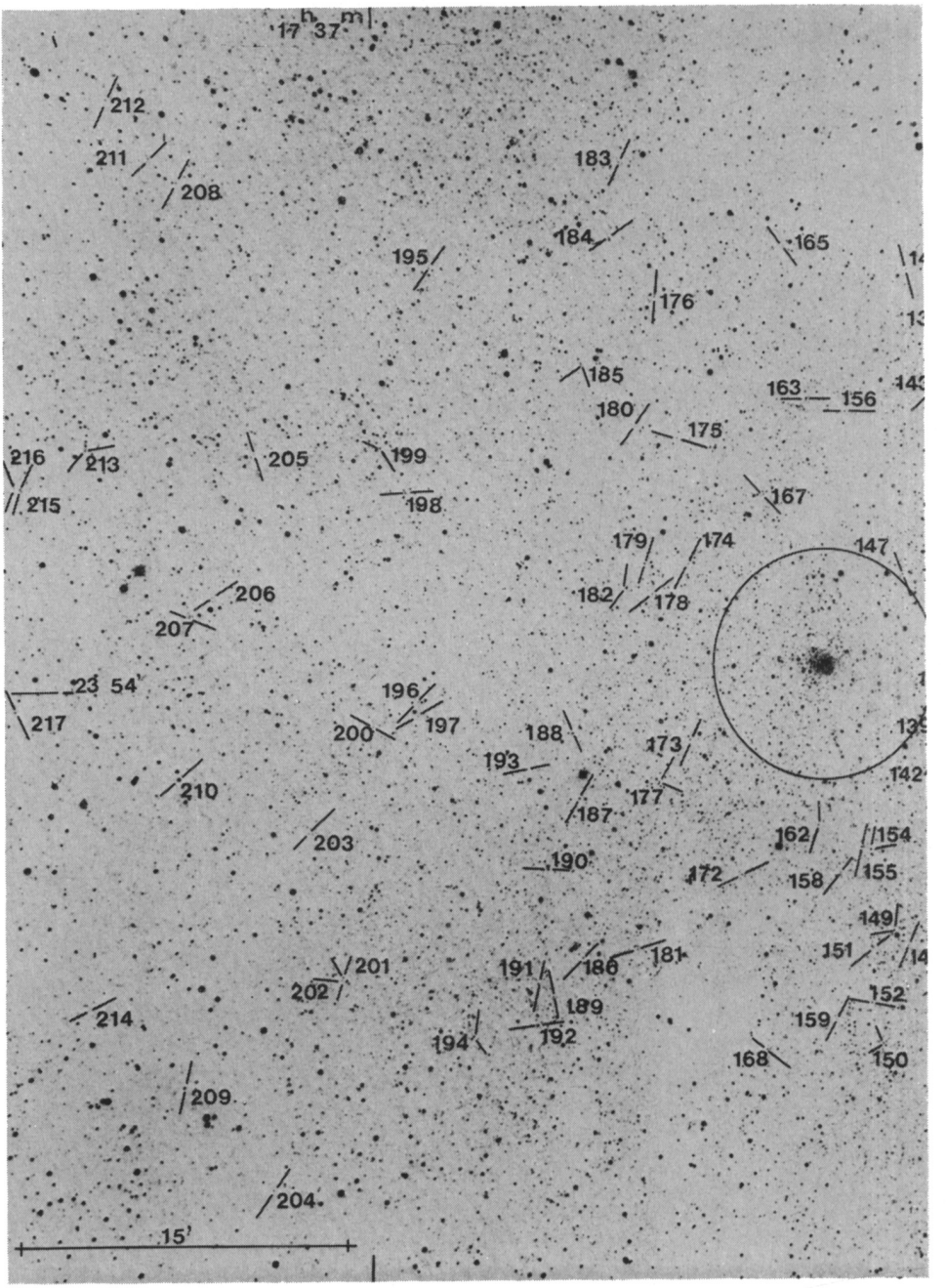

Fig. 2. New variable stars (162–217) detected near NGC 6401.

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Their equatorial coordinates (for the equinox 1950) and their extreme red magnitudes m_1 and m_2 (from the measurement of each variable star on 25 plates) are grouped in the Table I. These m_1 and m_2 do not correspond to $m_{r,\max}$ and $m_{r,\min}$ and it is difficult to find a significant correlation between m_r and $\Delta m_r = m_2 - m_1$.

The location of 15 variable stars situated in a circular area (radius = 5′) centered on the cluster, is given in Figure 3.

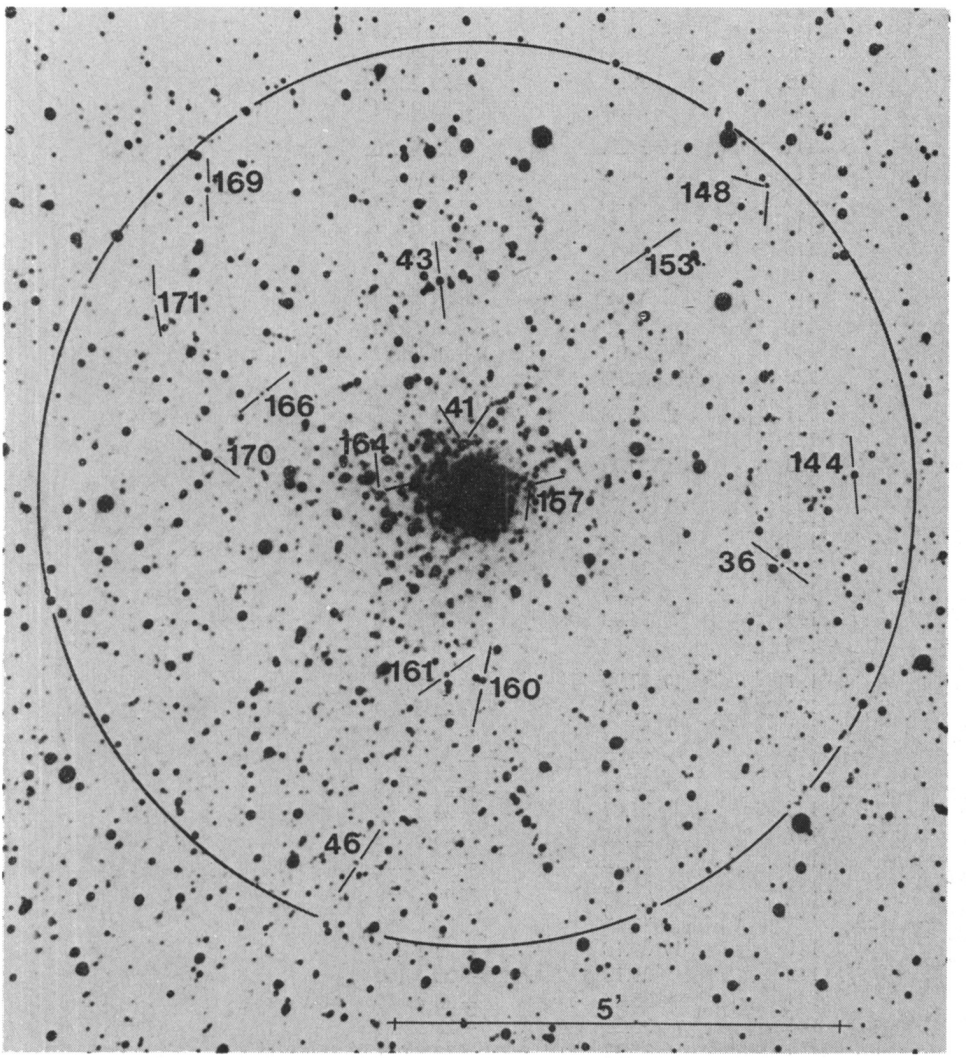

Fig. 3. Identification chart for 15 variable stars situated in a circular area (radius = 5′) centered on NGC 6401.

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TABLE I

Positions and magnitudes of new variable stars

No.	α (1950.0)	δ	m_r	
			m_1	m_2
103	$17^h32^m.88$	−23°45′.85	15.6	16.1
104	33.08	−24 18.81	15.8	>17
105	33.33	−24 12.84	15.9	16.4
106	33.34	−24 06.83	16.1	16.6
107	33.35	−24 00.37	15.2	15.7
108	33.54	−23 30.52	16.1	>17
109	33.98	−23 43.21	16.3	16.9
110	34.49	−23 42.71	15.9	16.8
111	17 34.51	−23 46.10	15.7	16.8
112	34.51	−24 11.30	15.7	17.0
113	34.54	−23 47.37	12.4	13.2
114	34.54	−24 03.51	15.8	16.6
115	34.55	−23 56.26	16.4	>17
116	34.55	−23 56.63	16.5	>17
117	34.56	−23 58.74	15.7	16.5
118	34.59	−23 56.77	15.4	16.0
119	34.62	−24 04.22	15.4	16.1
120	34.65	−23 49.65	16.2	16.8
121	17 34.68	−24 05.96	15.9	17.0
122	34.75	−23 46.16	15.7	16.3
123	34.78	−23 47.50	16.3	17.0
124	34.80	−23 46.33	16.2	>17
125	34.81	−23 55.96	15.9	16.5
126	34.83	−23 46.29	16.5	>17
127	34.83	−23 58.97	15.1	15.7
128	34.87	−23 38.75	16.2	16.7
129	34.93	−23 56.25	16.3	>17
130	34.94	−23 41.23	15.4	16.4
131	17 34.99	−23 57.33	15.8	16.3
132	35.00	−23 54.39	14.6	>17
133	35.02	−23 55.08	16.6	>17
134	35.03	−24 13.68	15.6	16.1
135	35.04	−23 41.64	15.9	16.8
136	35.07	−24 12.94	15.8	16.2
137	35.11	−23 38.06	15.9	>17
138	35.12	−23 48.37	15.0	15.6
139	35.13	−23 56.28	15.7	16.2
140	35.13	−24 09.54	16.2	17.0
141	17 35.18	−23 54.41	16.4	17.0
142	35.18	−23 57.00	15.6	16.1
143	35.22	−23 41.31	16.2	16.8
144	35.25	−23 52.74	15.2	15.6
145	35.28	−23 35.79	15.9	16.7
146	35.29	−24 05.24	16.3	17.0
147	35.30	−23 49.05	14.1	16.1
148	35.32	−23 49.55	16.0	16.5
149	35.33	−24 04.56	15.7	16.1
150	35.37	−24 09.50	15.9	>17

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Table I (Continued)

No.	α (1950.0)	δ	m_r	
			m_1	m_2
151	$17^h35^m.38$	−24°05′.66	16.3	>17
152	35.40	−24 07.71	15.4	15.9
153	35.41	−23 50.26	15.8	16.8
154	35.41	−24 01.04	15.5	16.0
155	35.44	−24 00.92	15.6	16.1
156	35.48	−23 41.94	15.4	16.3
157	35.51	−23 52.82	15.9	16.5
158	35.51	−24 02.03	15.8	16.7
159	35.52	−24 08.45	16.0	>17
160	35.55	−23 54.95	15.5	15.9
161	17 35.58	−23 54.88	15.9	16.4
162	35.58	−23 59.96	15.3	16.1
163	35.61	−23 41.38	15.0	15.8
164	35.63	−23 52.93	15.2	15.9
165	35.68	−23 34.71	16.0	16.7
166	35.72	−23 51.82	16.5	>17
167	35.74	−23 45.56	15.7	>17
168	35.75	−24 09.75	15.4	16.2
169	35.77	−23 49.57	15.7	16.4
170	35.77	−23 52.47	14.2	14.6
171	17 35.81	−23 50.78	17.0	>17
172	35.83	−24 02.08	15.7	16.2
173	35.99	−23 56.22	15.5	16.2
174	36.00	−23 48.53	16.1	17.0
175	36.03	−23 43.06	16.0	17.1
176	36.10	−23 36.89	15.9	16.5
177	36.10	−23 58.03	15.3	16.0
178	36.11	−23 49.86	15.5	16.3
179	36.14	−23 48.51	15.4	16.1
180	36.17	−23 42.52	15.7	>17
181	17 36.17	−24 05.34	15.5	16.5
182	36.20	−23 49.62	16.2	>17
183	36.22	−23 31.02	15.9	16.5
184	36.25	−23 34.32	15.5	16.7
185	36.34	−23 39.86	15.7	>17
186	36.35	−24 05.69	15.8	16.8
187	36.36	−23 58.75	15.1	15.8
188	36.38	−23 55.90	15.2	>17
189	36.44	−24 07.38	15.8	>17
190	36.46	−24 01.81	14.9	16.0
191	17 36.49	−24 06.82	15.5	16.6
192	36.50	−24 08.64	14.7	15.3
193	36.53	−23 57.46	15.9	16.8
194	36.71	−24 09.12	15.1	15.6
195	36.83	−23 35.60	15.1	>17
196	36.88	−23 54.49	16.3	16.8
197	36.88	−23 55.11	16.1	>17
198	36.91	−23 45.37	15.7	16.1
199	36.99	−23 43.43	15.3	15.8
200	37.02	−23 55.56	16.0	16.7

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Table I (Continued)

No.	α (1950.0)	δ	m_r	
			m_1	m_2
201	17h37m13	−24°06′44	15.9	16.5
202	37.13	−24 06.58	16.3	>17
203	37.24	−24 00.18	16.3	16.7
204	37.36	−24 15.70	15.8	16.4
205	37.40	−23 43.65	16.3	16.9
206	37.54	−23 49.86	16.1	16.7
207	37.62	−23 50.74	15.9	16.6
208	37.65	−23 31.78	15.7	16.4
209	37.65	−24 11.19	13.9	14.5
210	37.66	−23 57.38	14.0	>17
211	17 37.73	−23 30.73	15.6	16.4
212	37.87	−23 28.18	15.8	16.4
213	37.95	−23 43.40	15.2	15.9
214	37.95	−24 07.76	16.3	>17
215	38.15	−23 45.04	15.1	15.7
216	38.17	−23 45.01	15.8	16.5
217	38.17	−23 54.74	15.5	16.4

3. Discussion

(1) Each star is considered 'variable' if it is detected with the blink microscope and if it shows a $\Delta m = m_2 - m_1 \geqslant 0.4$ mag. Many other stars in the field are suspected variables ($\Delta m < 0.4$ mag.).

(2) Variable stars No. 41,157 and 164 (Figure 3) seem to belong to the cluster. The study of their periods will give us a better idea as to their membership.

(3) Several of these 217 (102 + 115) variable stars found near NGC 6401 are probably longperiod or irregular variables.

The latest photographic observations dating only from June 1972, the determination of light curves, the calculation of periods, and the discussion of results, will form the subject of another publication.

4. Conclusion

These results show how profitable is the search for variable stars in the field of NGC 6401. But for the detection of variable stars within the cluster itself, it is absolutely necessary to obtain a great many photographic observations with an image tube at the Cassegrain focus of a reflector situated in the Southern Hemisphere.

On the other hand, it would be particularly interesting to proceed to a *UBV* photometric study of the cluster in order to study the $V-(B-V)$ colour-magnitude diagram.

We hope to accomplish this at the European Southern Observatory in April–May 1973.

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References

Alter, G., Ruprecht, J. and Vanýsek, J.: 1970, *Catalogue of Star Clusters and Associations*, Akademiai Kiado, Budapest.
Arp, H. C.: 1965, *Stars and Stellar Systems* **5**, 401.
Herschel, W.: 1786, *Phil. Trans. Roy. Soc. London* **A76**, 457.
Hogg, H. B. S.: 1963, *Publ. David Dunlap Obs.*, No. 12.
Kron, G. E. and Mayall, N. U.: 1960, *Astron. J.* **65**, 581.
Kukarkin, B. V.: 1971, Private communication.
Terzan, A. and Rutily, B.: 1972. *Astron. Astrophys.* **16**, 408.

DISCUSSION

Demarque: What kind of image tube did you use?
Terzan: It will be described in the paper by Terzan, Rutily, and Ounnas on NGC 4590.

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