BERKELEY 93: A DISTANT STAR CLUSTER NESTLED IN A DUST CLOUD

W. SAURER,[1] R. SEEBERGER,[1] AND R. WEINBERGER[1]
Institut für Astronomie der Leopold–Franzens–Universität Innsbruck, Technikerstr. 25, A-6020 Innsbruck, Austria
Electronic mail: astro@uibk.ac.at

R. ZIENER
Thüringer Landessternwarte Tautenburg, Karl–Schwarzschild–Observatorium, D-07778 Tautenburg, Germany
Electronic mail: vrz@rz.uni-jena.de

Received 1993 July 6; revised 1994 January 19

ABSTRACT

While performing galactic and extragalactic studies near the galactic plane in Cepheus, CCD frames in *B*, *V*, and *R* were taken of the faint ($V \geqslant 16^m$), previously unstudied open star cluster Berkeley 93 (Be 93). Our results indicate that this object is the core of a larger aggregate, is slightly evolved, strongly reddened [$E_{(B-V)} \approx 1.5$], and shows a pronounced variable reddening that is probably due to the location of the cluster inside (near the border) a dust cloud. By far the reddest, and obviously most evolved star is a (variable) carbon star that—because of its reddening and location—appears to be a cluster member. We present arguments in favor of a large distance of more than 5 kpc for Be 93 which possibly belongs to the galactic warp. As an addendum, we present six star concentrations discovered on the POSS or ESO/SERC atlas that might represent hitherto uncatalogued open star clusters of "Berkeley type."

1. INTRODUCTION

The region in and above the galactic plane in the greater neighborhood of $l \approx 100°$ is an area of multiple interest: (i) there is a warp of the Galaxy best visible at $l = 90° - 120°$ that is known for some time in H I but is also evident in the IR (Djorgovski & Sosin 1989) or optical (Miyamoto *et al.* 1988); (ii) at $l = 100° - 110°$, the Perseus spiral arm and an optical arm beyond the Perseus arm rather abruptly seem to begin (Kimeswenger & Weinberger 1989), and (iii) a chain of galaxies, possibly an extension of the Pisces–Perseus supercluster, appears to re(enter) the galactic plane near $l = 90° - 100°$.

We have started to combine galactic and extragalactic research in this interesting area: one of our aims is to better trace the galactic warp, on the one hand by examining the distribution of dust (along the whole dust layer) by optically identifying galaxies in the zone of avoidance and checking their distribution, on the other hand by attempting to discover (stellar) objects that might be members of the warp. The latter (hitherto unsuccessful) attempt led us to a search for distant optically identifiable objects. Berkeley 93=Be 93 ($l = 105\overset{\circ}{.}0$, $b = +7\overset{\circ}{.}4$), a very faint small open cluster with the IAU designation C2154+637 was not studied up to now and appeared promising in this respect.

2. OBSERVATIONS AND REDUCTIONS

The CCD observations have been carried out with the 1.23 m telescope (RC-focus) at the Calar Alto Observatory (Southern Spain) during two photometric nights in November 1990. The CCD detector used was a coated GEC (#10) composed of 410×580 pixels with a pixel size of 22 μm. One pixel corresponds to 0.46 arcsec on the sky so that the total field of the chip covers 3.12×4.45 arcmin.

For Be 93, exposures of 3600, 2700, and 1800 s were obtained in *B*, *V*, and *R*, respectively. To derive the transformation to the standard Johnson *B*, *V* system, images of NGC 7142 and Be 96 were taken. The calibration was done by using brightness data published by Crinklaw & Talbert (1991) for NGC 7142 and delRio (1984) for Be 96. For *R*, three stars (CAS 11, CAS 52, and FS 38) of Neckel & Chini (1980) and Neckel (1978) were used.

The photometric reductions were carried out with a SUN SPARC *I* using the ROMAFOT package implemented in MIDAS. The CCD frames were corrected for constant bias, dark current, and were flatfielded using dome flats. All the frames were obtained at almost the same airmass. Be 93 was observed at airmasses of 1.18, 1.15, and 1.17 in *B*, *V*, and *R*, respectively. The largest difference in airmass between any two frames is 0.18. To keep the effect of different airmasses as small as possible, we have transformed all measurements to the mean airmass of all frames (1.20). By doing this, only small corrections are necessary. For this reason, we used results of former photoelectrical investigations at this site and with this telescope. For an airmass difference of 0.1 we applied corrections of 0.030, 0.018, and 0.008 mag in *B*, *V*, and *R*, respectively. These values turned out to be consistent for NGC 7142 and Be 96. The resulting transformation equations are

$$V = v + 20.15,$$

$$B = b + 19.15 + 0.17(B - V),$$

[1]Visiting Astronomer at the Centro Astronomico Hispano–Aleman, Calar Alto, operated by the Max Planck Institut für Astronomie, Heidelberg, jointly with the Spanish National Commission for Astronomy.

 0004-6256/94/107(6)/2101/7/$0.90

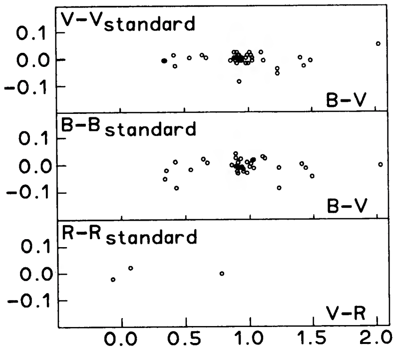

FIG. 1. Magnitudes derived from our transformation equations minus magnitudes taken from the literature for our standard stars vs colors.

$$R=r+20.95-0.40(V-R),$$

valid for an exposure time of 1 s and an airmass of 1.20, where *v*, *b*, and *r* are instrumental magnitudes.

The accuracy of the data is apparent from Fig. 1. A straightforward examination of the scatter in Fig. 1 leads to an error of $\sigma=0.025$ mag for both *B* and *V* for the range covered by our standard stars (instrumental magnitudes on the chip). This corresponds to $16.2\leqslant V\leqslant 20.2$ mag for the *V* and *R* frame and to $15.9\leqslant B\leqslant 19.9$ mag for the *B* frame of Be 93. In *V* and *R*, our program stars are well within this range, whereas in *B*, fainter stars were also measured. However, we estimate the error cannot exceed 0.04 mag.

After reducing the Be 93 frames, we rejected blended stars which are unresolved on the short-wavelength frames containing this star cluster.

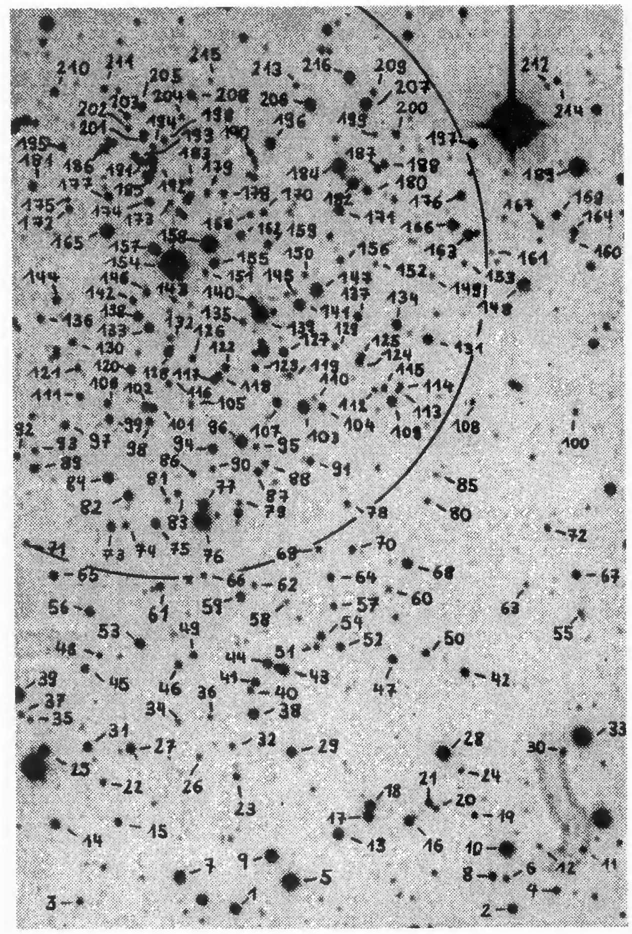

FIG. 2. Identification chart (CCD *R* frame) of Be 93. The stars inside the circle were originally thought to be cluster members, those outside were assumed to be field stars. East is up, north to the left.

3. THE DATA

On a deep *B* plate ($m_{\rm lim}\approx 21$) taken with the Schmidt camera (134 cm free aperture) at the Karl Schwarzschild Observatory in Tautenburg, star counts in and around Be 93 were made. The favorable plate scale (51″ per mm compared to 67″ per mm on the Palomar Observatory Sky Survey, POSS) allowed a better estimation of the extent of the cluster (that later proved to be rather the core of the cluster—see below) and led to an angular diameter of 3′. As cluster center we chose a star that turned out to be the second brightest in *V*, the brightest in *R*, and the reddest of the whole cluster. It is designated as no. 154 in Fig. 2. The coordinates of this star and, therefore, the assumed coordinates of the cluster are

$$\alpha=21^{\rm h}55^{\rm m}28\overset{\rm s}{.}8,\quad \delta=+63°56'24'';\pm 3''(2000).$$

3.1 CCD Photometry

Because of the angular diameter of 3′ that we had determined, we assumed that practically all stars located within a circle of 1′.5 around the red star no. 154 are members of the cluster. The reason for this assumption can easily be understood if one looks at the blue-sensitive POSS print [Fig. 5(a)] or plate of the region around Be 93: there, the cluster seems to be rather isolated, with only few stars in its close vicinity (and the brighter ones being located mainly to the south). Also, the above mentioned star counts on the Tautenburg *B* plate support the impression of isolation. In order to include a number of "field" stars too, we placed the CCD such as to include both most of the "cluster" and an area west of it.

Altogether 63 stars could be measured in *B, V*, and *R* in the cluster region, 130 only in *V* and *R*. The brightnesses of these "cluster stars" together with those outside the cluster area (the "field stars") are listed in Table 1; the former stars are designated by the letter C, the latter bear no designation. All stars of Table 1 are identified in Fig. 2.

In Figs. 3(a) and (b) the color–magnitude diagrams *V* vs $B-V$ and *V* vs $V-R$ for the cluster stars are shown. Three characteristics are immediately evident: (i) the cluster is somewhat evolved; (ii) it is heavily reddened; (iii) the width of the sequence is extremely large, pointing to a pronounced differential reddening. We will discuss these findings below.

Contrary to the *V* vs $B-V$ diagram, the termination of the main sequence appears to be recognizable in the *V* vs $V-R$ diagram, around $V\approx 19^{\rm m}$.

We would now like to address the problem of the fields stars. It might be assumed that in the cluster area, there are

TABLE 1. Photometry of Berkeley 93.

#	R	V	B	V-R	B-V	CL
1	16,87	18,19		1,32		
2	17,46	18,74		1,28		
3	19,07	20,62		1,55		
4	18,47	19,99		1,52		
5	15,20	16,10		0,90		
6	19,24	20,62		1,38		
7	16,51	17,56		1,05		
8	17,98	19,70		1,72		
9	15,94	16,97		1,03		
10	15,34	16,42		1,08		
11	18,86	20,56		1,70		
12	20,13	21,25		1,12		
13	16,89	17,79		0,90		
14	17,24	19,36		2,12		
15	18,57	19,79		1,22		
16	17,11	18,24	19,69	1,13	1,45	
17	16,83	18,06	19,77	1,23	1,71	
18	16,41	18,38	20,18	1,97	1,80	
19	18,97	20,25		1,28		
20	19,73	20,51		0,78		
21	18,39	19,66		1,27		
22	18,92	21,14		2,22		
23	18,93	20,21		1,28		
24	19,47	20,79		1,32		
25	16,27	17,89	19,66	1,62	1,77	
26	20,05	20,92		0,87		
27	17,59	18,71	20,33	1,12	1,62	
28	15,58	16,78	18,25	1,20	1,47	
29	17,29	18,51	19,99	1,22	1,48	
30	18,91	20,74		1,83		
31	18,01	18,84	20,03	0,83	1,19	
32	19,74	21,02		1,28		
33	14,38	15,61		1,23		
34	19,60	20,83		1,23		
35	19,95	21,18		1,23		
36	19,92	21,14		1,22		
37	20,00	20,85		0,85		
38	17,09	18,54	20,07	1,45	1,53	
39	15,65	16,77	18,25	1,12	1,48	
40	19,00	20,32		1,32		
41	18,08	19,30	20,86	1,22	1,56	
42	18,11	19,16	20,37	1,05	1,21	
43	17,16	18,21	19,63	1,05	1,42	
44	17,67	19,05	20,73	1,38	1,68	
45	18,42	19,65		1,23		
46	18,92	20,32		1,40		
47	18,14	19,42		1,28		
48	19,43	20,85		1,42		
49	18,88	20,10		1,22		
50	18,93	20,18		1,25		
51	19,15	20,42		1,27		
52	18,11	19,49	21,37	1,38	1,88	
53	17,38	18,58	20,05	1,20	1,47	
54	18,01	19,24	20,62	1,23	1,38	
55	19,95	20,72		0,77		
56	17,88	18,78		0,90		
57	18,86	20,41		1,55		
58	20,06	21,18		1,12		
59	17,85	18,77	19,86	0,92	1,09	
60	19,13	21,16		2,03		
61	18,47	19,44	20,65	0,97	1,21	
62	19,84	21,04		1,20		
63	19,80	21,25		1,45		
64	18,71	20,13		1,42		
65	17,98	18,98	20,11	1,00	1,13	
66	19,41	20,89		1,48		C
67	17,83	19,41		1,58		
68	16,99	18,12	19,48	1,13	1,36	
69	19,17	20,74		1,57		
70	18,63	20,06	21,43	1,43	1,37	
71	19,88	21,23		1,35		C
72	19,09	20,21		1,12		
73	17,80	19,68		1,88		C
74	19,38	20,88		1,50		C
75	17,66	19,08	20,78	1,42	1,70	C
76	14,70	15,48		0,78		C
77	16,99	18,01		1,02		C
78	19,19	20,91		1,72		C
79	19,51	20,79	21,91	1,28	1,12	C
80	19,16	21,91		2,75		
81	19,94	21,39		1,45		C
82	17,36	18,74	20,47	1,38	1,73	C
83	19,13	20,36		1,23		C
84	17,16	18,18	19,50	1,02	1,32	C
85	19,98	21,55		1,57		
86	19,08	20,56		1,48		C
87	18,23	19,28	20,46	1,05	1,18	C
88	18,83	20,01	20,78	1,18	0,77	C
89	18,49	19,84		1,35		C
90	19,71	21,38		1,67		C
91	18,06	19,53		1,47		C
92	18,99	20,07		1,08		C
93	19,52	20,90		1,38		C
94	17,99	19,04	20,39	1,05	1,35	C
95	19,72	20,79		1,07		C
96	16,15	17,72	19,56	1,57	1,84	C
97	18,20	20,18		1,98		C
98	18,72	19,80		1,08		C
99	18,31	19,39	20,84	1,08	1,45	C
100	19,42	20,79		1,37		
101	18,55	19,55	20,92	1,00	1,37	C
102	17,70	19,32	21,10	1,62	1,78	C
103	16,03	17,60	19,46	1,57	1,86	C
104	18,56	19,58	20,93	1,02	1,35	C
105	19,60	20,97		1,37		C
106	18,83	20,11		1,28		C
107	18,04	19,14	20,61	1,10	1,47	C
108	19,56	21,06		1,50		C
109	17,40	18,75	20,47	1,35	1,72	C
110	19,93	21,40		1,47		C
111	18,86	20,58		1,72		C
112	19,65	21,12		1,47		C
113	19,66	21,23		1,57		C
114	19,13	20,45		1,32		C
115	18,99	19,99		1,00		C
116	19,17	21,24		2,07		C
117	18,64	19,67		1,03		C
118	18,20	19,17		0,97		C
119	19,29	20,49	22,02	1,20	1,53	C
120	17,51	19,21	21,21	1,70	2,00	C
121	19,28	20,98		1,70		C
122	18,20	19,18	20,43	0,98	1,25	C
123	18,91	20,21		1,30		C
124	18,57	19,55		0,98		C
125	18,76	20,29		1,53		C
126	18,61	20,69		2,08		C
127	17,81	18,83	20,18	1,02	1,35	C
128	18,15	19,08	20,35	0,93	1,27	C
129	18,96	20,29		1,33		C
130	18,79	20,17		1,38		C
131	17,30	18,60	20,15	1,30	1,55	C
132	19,27	20,47		1,20		C
133	17,55	18,58	19,94	1,03	1,36	C
134	17,41	18,38	19,68	0,97	1,30	C
135	19,26	20,48		1,22		C
136	18,93	20,38		1,45		C
137	18,13	19,08	20,35	0,95	1,27	C
138	17,60	18,63	19,84	1,03	1,21	C
139	14,68	16,41	18,43	1,73	2,02	C
140	17,11	18,19	19,44	1,08	1,25	C
141	16,71	17,88	19,29	1,17	1,41	C
142	18,88	19,85	21,28	0,97	1,43	C
143	19,28	20,76		1,48		C
144	18,48	19,55	21,08	1,07	1,53	C
145	20,20	21,08		0,88		C
146	18,97	20,14		1,17		C
147	15,91	17,09	18,62	1,18	1,53	C
148	15,64	17,31		1,67		
149	19,77	21,25		1,48		C
150	19,78	21,03		1,25		C
151	19,59	21,11		1,52		C
152	19,95	21,18		1,23		C
153	19,61	20,96		1,35		C
154	11,56	15,73	19,53	4,17	3,80	C
155	17,31	18,34	19,59	1,03	1,25	C
156	18,64	19,76	21,13	1,12	1,37	C
157	16,72	17,74	19,19	1,02	1,45	C
158	14,63	16,25	18,31	1,62	2,06	C
159	18,30	19,50	21,00	1,20	1,50	C
160	19,63	21,03		1,40		
161	19,45	21,02		1,57		
162	18,33	19,55	21,33	1,22	1,78	C
163	17,01	18,51	20,17	1,50	1,66	C
164	18,24	19,26		1,02		
165	15,96	17,19	18,56	1,23	1,37	C
166	17,21	18,24	19,60	1,03	1,36	C
167	18,48	19,95		1,47		
168	18,98	20,85		1,87		C
169	17,88	18,88	20,11	1,00	1,23	
170	18,84	20,26		1,42		C
171	17,19	18,39	19,83	1,20	1,44	C
172	18,90	20,52		1,62		C
173	19,35	21,05		1,70		C
174	17,65	18,78	20,22	1,13	1,44	C
175	19,88	21,13		1,25		C
176	17,82	19,30	21,19	1,48	1,89	C
177	18,29	19,41	20,68	1,12	1,27	C
178	18,97	20,57		1,60		C
179	18,96	20,94		1,98		C
180	18,07	18,94	20,33	0,87	1,39	C
181	18,18	19,43	21,10	1,25	1,67	C
182	16,28	17,86	19,77	1,58	1,91	C
183	19,45	20,90		1,45		C
184	15,07	16,87	18,90	1,80	2,03	C
185	16,85	17,95	19,25	1,10	1,30	C
186	19,69	21,69		2,00		C
187	18,63	19,83	21,04	1,20	1,21	C
188	18,39	19,49	20,84	1,10	1,35	C
189	14,64	15,72		1,08		
190	19,26	20,38		1,12		C
191	18,34	19,29	20,66	0,95	1,37	C
192	16,47	18,04	19,88	1,57	1,84	C
193	18,54	19,57	20,65	1,03	1,08	C
194	19,63	20,65		1,02		C
195	18,56	20,08		1,52		C
196	16,47	18,25	20,29	1,78	2,04	C
197	17,85	19,13	21,10	1,28	1,97	
198	19,10	20,73		1,63		C
199	19,79	21,17		1,38		C
200	18,25	19,97		1,72		C
201	18,13	19,06	20,48	0,93	1,42	C
202	19,43	20,80		1,37		C
203	18,70	19,82		1,12		C
204	19,44	20,97		1,53		C
205	18,37	19,65	21,39	1,28	1,74	C
206	16,30	17,72	19,34	1,42	1,62	C
207	16,55	17,75	19,33	1,20	1,58	C
208	17,99	19,14	20,59	1,15	1,45	C
209	19,18	20,56		1,38		C
210	18,50	19,28	20,92	0,78	1,64	C
211	18,96	20,23		1,27		C
212	19,64	20,84		1,20		
213	19,18	20,68		1,50		C
214	18,67	19,89		1,22		
215	20,22	21,47		1,25		C
216	16,39	17,56	18,98	1,17	1,42	C

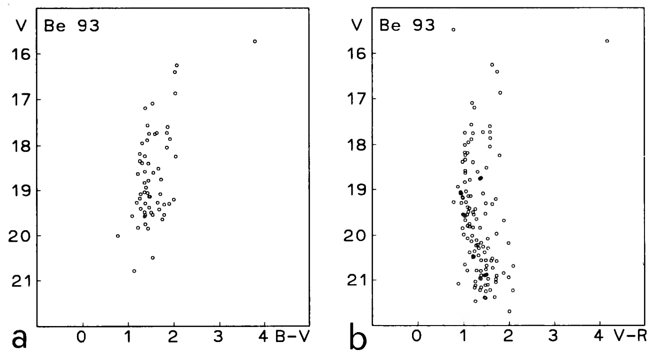

FIG. 3. Color–magnitude diagrams for the stars designated as C (=originally assumed cluster members) in Table 1.

only a few of them (see above). Interestingly, Figs. 3(a) and (b) do not show even one star that can be classified as a foreground star because of its small interstellar obscuration. The presence of intrinsically very red stars or reddened background field stars cannot, however, be excluded.

A difference between the stars contained in the cluster region and the field star region should be obvious via the color–magnitude diagrams, of course. These diagrams, however, caused a surprise. There is no difference discernible, at least at first glance [Figs. 4(a) and (b)]. Obviously, the cluster could be regarded as the "core" of a cluster, which is much larger than previously assumed and includes the field stars west of it as well; this assumption will now be discussed along with the obscuration of Be 93.

3.2 *Interstellar Obscuration*

Unfortunately, we are not able to give a reliable estimate of the interstellar extinction (a determination of the reddening in the $B-V$ vs $V-R$ diagram is rather unpracticable), but from Figs. 3(a) and (b) one might infer that $E(B-V) \approx 1.5$ mag is a somewhat plausible value (see also below). Besides, the stars previously denoted as field stars have a slightly smaller reddening (almost 0.1 mag in $B-V$ and $V-R$).

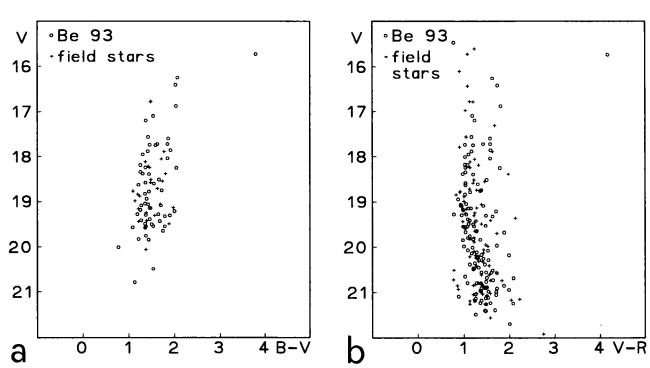

FIG. 4. Color–magnitude diagrams for the stars within the circle in Fig. 2 (+), and outside the circle (O).

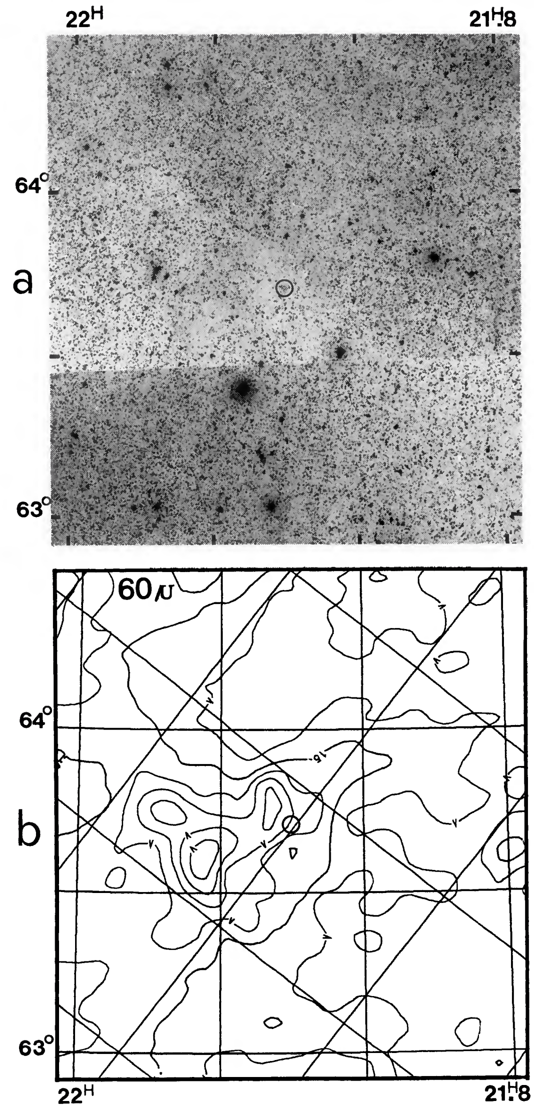

FIG. 5. (a) The region around Be 93 (circle), reproduced from the blue-sensitive POSS prints 1165 and 594. (b) Contour plot at 60 μm (*IRAS*) of the same region as in (a).

The large width of the sequence cannot be explained by photometric errors and/or a prominent double star population alone. In our opinion, the main reason for this finding is the location of the cluster within a dust cloud, and the differential reddening is a measure of how deep the stars reside within the cloud.

An inspection of the POSS and of *IRAS* contour plots may solve the problem: a comparison of the E (red-sensitive) and O (blue-sensitive) POSS prints shows that, on the latter, Be 93 appears to be partly surrounded by an inconspicuous dust cloud, which is most prominent to the east of it, and there is a second prominent part about 10′ to 15′ to the southeast [Fig. 5(a)]. Clearly, no statement can be made, from this comparison alone, about whether the cluster lies behind, in front, or within this dust cloud. Within 0°5, in the north as well as in the south of Be 93, beyond the discernible borders of the cloud, very faint, moderately reddened galaxies were found by us; this means that not far from the cluster, there is no noticeable interstellar extinction along several kpc and the dust cloud appears to be a more or less isolated object.

In Fig. 5(b), an *IRAS* 60 μm contour plot is presented, showing exactly the same region as in Fig. 5(a). In this contour plot, we can clearly recognize the dust cloud and find, that Be 93 (shown as a circle) appears to be located at (or projected against) the western border of this dust cloud.

Taking the results together, namely the large foreground extinction of roughly 1.5 mag, the high differential reddening, the presence of a (distant) dust cloud that is inconspicuous in the optical but well discernible in the infrared—where the cluster is located near its border—and the slightly smaller extinction for the former "field stars" that are even closer to the border, we arrive at the following conclusion: Be 93 is, literally, "nestled" in a dust cloud and is the densest part of a larger aggregate of stars which have originally eaten their way into the dust cloud.

We could not detect any sign of emission or reflection nebulosities in or near the cluster; this finding might be due to the great distance of the aggregate and/or, more plausible, due to the lack of hot cluster members.

Could the dust cloud, with its embedded cluster, be about as close as other dust clouds in this longitude/latitude region, particularly NGC 7129 that is 1 kpc away? We searched for stars with known spectral types and luminosities within 1° of Be 93 for this purpose. Two were found: VV Cep, having $E(B-V)=0.40$ mag, 1.1 kpc distant, and HD 208185, with $E(B-V)=0.37$ mag, 0.55 kpc distant. These data argue for a much larger distance of Be 93.

3.3 The Red Star No. 154

The reddest star of the cluster ($B-V=3.80$ mag, $V-R=4.17$ mag) obviously is the most evolved one. The $B-V$ value must, however, be regarded with some caution; due to the influence of a bad row on the CCD, there might be an uncertainty in the B brightness of about 0.1 mag.

Fortunately, we had an objective prism plate at our disposal that permitted a tentative classification. The plate was taken with the 4° prism of the Kiso 105 cm Schmidt telescope. A combination of hypersensitized Kodak IN emulsion and a Schott RG695 filter covers the wavelength range of 6900–8800 Å.

By comparison with spectra shown in Nassau & Velghe (1964) and Maehara & Soyano (1986), we found that the star appears to be a cool carbon star; C4–C6 is our best guess. Later, we found that this object is contained in Stephenson's (1973) Catalogue of Cool Carbon Stars; there, however, no further information is given except an obviously very inaccurate position.

The star is within the error ellipse of the very faint source *IRAS* 21540+6341, with limits given, except for 12 μm, where a flux of 0.40 Jy is listed.

According to our classification and the presence in Stephenson's catalog, we may assume that the carbon star no. 154 is of middle type, say C5.

TABLE 2. V data on star No. 154.

Plate No.	HJD	V(mag)
5927	2445464.5334	14.61
5932	2445466.5070	14.98
6245	2446650.4424	15.39
6246	2446650.4605	15.38
6252	2446650.4799	15.37

A C5 carbon star has $(B-V)_0=2.34$ mag and $M_V=-2.5$ mag (Seitter & Duerbeck 1982). Consequently, $E(B-V)\approx 1.5$ mag, which is in agreement with the rough extinction estimate discussed above. Taking $A_V=4.5$ mag, we then arrive at a distance of the star to be 5.6 kpc, which would place this star cluster well in the optical spiral arm (Kimeswenger & Weinberger 1989) beyond the Perseus arm. At this distance, its galactic latitude of $b=+7\overset{\circ}{.}37$ corresponds to $z=0.7$ kpc. Perhaps, this cluster therefore belongs to the galactic warp!

A star this late might perhaps be variable. We checked this by using five V plates taken with the Tautenburg Schmidt camera. Indeed, the star is clearly variable, as can be seen from Table 2. The type of variability cannot, however, be derived from these few data.

3.4 Conclusions

By taking the above distance of 5.6 kpc, $A_V=4.5$ mag, and $V=19^{\rm m}$ as the termination of the main sequence, the corresponding earliest spectral type on the main sequence would be A0. The cluster might therefore be $\approx 10^8$ yr old.

In this connection, one is tempted to ask why the dust cloud has not already been dispersed or whether there are yet more objects, possibly deeper embedded. In the *IRAS* PSC, one can indeed find a few faint sources sources in the vicinity of Be 93, and the two prominent peaks that can be seen in Fig. 5 east and southeast of Be 93 have counterparts in the *IRAS* Small Scale Structure Catalog. In any case, near-infrared images would be quite useful to find out whether a large number of stars in the cloud, particularly in the part just mentioned, escaped our attention.

We can thus summarize: The faint cluster Be 93 is the optically most prominent part of a distant open star aggregate located within a dust cloud, is roughly 10^8 yr old, and harbors a variable carbon star. It might belong to the galactic warp.

This work was supported in part by the "Fonds zur Förderung der wissenschaftlichen Forschung" (Project No. P6345) and by the "Forschungsförderungsbeiträge 1987, 1988, und 1989 der Universität Innsbruck." W. S. wishes to thank the local government (Tiroler Landesregierung) for financial support. We would also like to thank Dr. F. Börngen for his help regarding the Tautenburg Schmidt plates.

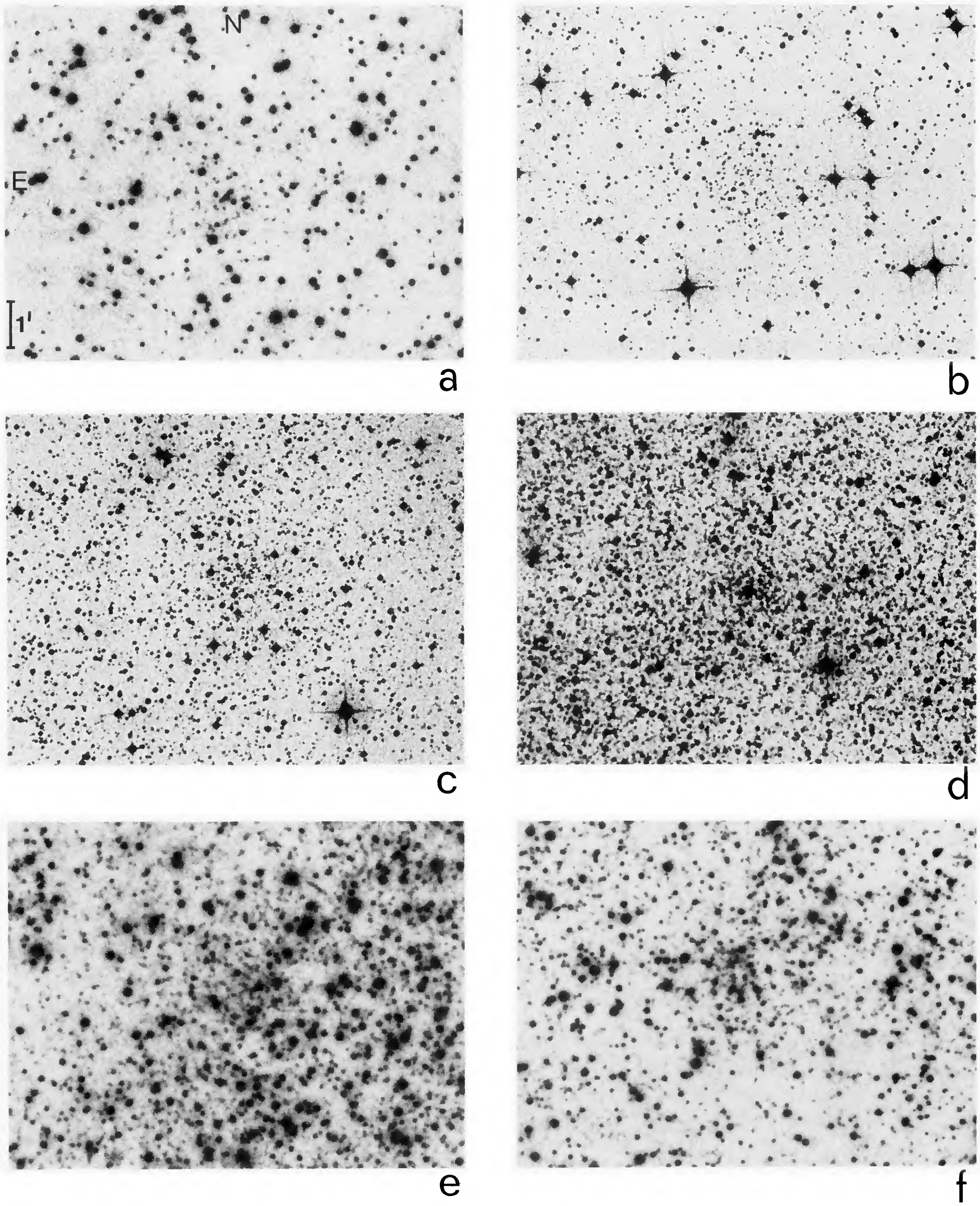

FIG. 6. Finding charts for the open star cluster candidates, reproduced from the POSS or the ESO/SERC atlas and arranged according to increasing R.A.

APPENDIX

The well-known "Berkeley clusters" are the result of a systematic search on the Palomar Observatory Sky Survey (POSS) by Setteducati & Weaver (1962). Most of these clusters are made up of stars of faint apparent magnitude, making them well suited for photometric studies by CCDs. A wealth of various data has already been collected on these often distant aggregates.

During several years of examining photographic atlases like POSS prints or the ESO/SERC film copies for a variety of purposes, we came across several star concentrations that reminded us of star clusters of the Berkeley type. A few of our earliest findings are published by Pfleiderer *et al.* (1977). In this context—on the basis of our profound knowledge of the POSS—we would like to underline that Setteducati & Weaver (1962) had inspected the POSS very carefully and overlooked only a few cluster candidates.

Here we would like to present six hitherto uncatalogued open star cluster candidates. Their (2000) coordinates are: $07^{\rm h}20^{\rm m}\!.9$, $+01°48'$; $08^{\rm h}25^{\rm m}\!.5$, $-39°38'$; $10^{\rm h}41^{\rm m}\!.5$, $-55°18'$; $12^{\rm h}14^{\rm m}\!.1$, $-63°36'$; $19^{\rm h}39^{\rm m}\!.6$, $+25°39'$; $19^{\rm h}51^{\rm m}\!.0$, $+32°15'$. Finding charts are shown in Figs. 6(a)–6(f).

REFERENCES

Crinklaw, G., & Talbert, F. D. 1991, PASP, 103, 536
delRio, G. 1984, A&AS, 56, 289
Djorgovski, S., & Sosin, C. 1989, ApJ, 341, L13
Götz, W. 1990, Die offenen Sternhaufen unserer Galaxis, Verl. Deutsch, Thun, Frankfurt/Main
Kimeswenger, S., & Weinberger, R. 1989, A&A, 209, 51
Lynga, G. 1983, Catalogue of Open Cluster Data, Strasbourg Data Center
Maehara, H., & Soyano, T. 1986, Ann. Tokyo Astron. Obs., 2nd Ser., Vol. 21, No. 3
Miyamoto, M., Yoshizawa, M., & Suzuki, S. 1988, A&A, 194, 107
Nassau, J. J., & Velghe, A. G. 1964, ApJ, 139, 190
Neckel, Th., 1978, private communication
Neckel, Th., & Chini, R. 1980, A&AS, 39, 411
Pfleiderer, J., Weinberger, R., & Mross, R. 1977, Star Cluster Symposium, Budapest, 39
Seitter, W. C., & Duerbeck, H. W. 1982, in LANDOLT-BÖRNSTEIN, Vol. 2, subvol. b, 269
Setteducati, A. F., & Weaver, M. F. 1962, Newly Found Stellar Clusters (University of California, Berkeley)
Stephenson, C. B. 1989, A General Catalog of Cool Carbon Stars, 2nd edition, (Warner & Swasey Obs., Case Western Reserve University), Vol. 3, No. 2