STUDY OF THE OPEN CLUSTER IC 1805

BY U. C. JOSHI* AND RAM SAGAR†
Uttar Pradesh State Observatory, Manora Peak, Naini Tal, India

(*Received September 28, 1982*)

ABSTRACT

Photoelectric magnitudes and colours in the *UBV* system have been determined for 169 stars in IC 1805. The reddening is variable across the cluster. The distance modulus to the cluster is estimated at $11\overset{m}{.}7$. Star-formation activities are still in progress in the cluster region.

Introduction. The young open cluster IC 1805 ($\alpha = 02^h28\overset{m}{.}9$, $\delta = +61°14\overset{'}{.}0$ (1950); $l^{II} = 134\overset{\circ}{.}74$, $b^{II} = +0\overset{\circ}{.}92$), is one of the largest group of O-stars associated with complexes of gas and dust. Trumpler (1930) has classified this cluster as of type IV3 *mN*, while Ruprecht (1966) has classified it to be of type $III3_p$. The cluster stars are embedded within an emission nebulosity (Westerhout 1958; Akabane *et al.* 1967) and cannot easily be distinguished from the field stars. Relative proper motions of 354 stars in the cluster region were determined by Vasilevskis *et al.* (1965) with a mean error of ±0.16 second of arc per century. He has computed the probability of cluster membership, *p*, for all the stars individually. Sanders (1972) revised these membership probabilities by applying the maximum-likelihood method discussed earlier by him (Sanders 1971). The distribution of these stars on the basis of *p* is shown in Table I. We can, therefore, statistically expect to find 14 cluster members from among those stars for which $p < 50$ per cent and 104 cluster members in the group of stars with $p \geqslant 50$ per cent. From this discussion, it is clear that an overwhelmingly large percentage of the cluster members have their *p* values greater than 50 per cent. We have, therefore, derived the cluster parameters on the basis of the stars with $p \geqslant 50$ per cent. Out of these 141 stars, photoelectric *UBV* magnitudes are available only for 56 stars (Hoag *et al.* 1961; Ishida 1969; Mermilliod 1976), while for most of the remaining stars only photographic *UBV* values are available (Hoag *et al.* 1961; Moffat 1972).

As the photoelectric *UBV* magnitudes are not available for 60 per cent of the cluster members, fresh photoelectric *UBV* photometry of the cluster has been carried out and the cluster parameters based on these observations have been estimated.

Observations and Reductions. The observations were carried out between November 1978 and December 1981 on the 104-cm Sampurnanand reflector of the

*Present address: Physical Research Laboratory, Navrangpura, Ahmedabad-380 009 India.
†Present address: Department of Physics, Kumaun University, Naini Tal-263 002 India.

TABLE I

DISTRIBUTION OF STARS, IN THE REGION OF IC 1805, ACCORDING TO MEMBERSHIP PROBABILITY, p, DETERMINED BY SANDERS (1972)

p (per cent)	Number of stars present in the range of p
0	127
$1 \leqslant p \leqslant 9$	41
$10 \leqslant p \leqslant 19$	15
$20 \leqslant p \leqslant 29$	15
$30 \leqslant p \leqslant 39$	7
$40 \leqslant p \leqslant 49$	8
$50 \leqslant p \leqslant 59$	21
$60 \leqslant p \leqslant 69$	32
$70 \leqslant p \leqslant 79$	46
$80 \leqslant p \leqslant 89$	42
$90 \leqslant p$	0
Total no. of stars.	354

Uttar Pradesh State Observatory. The method of observations and reductions are the same as described elsewhere by us (Sagar and Joshi 1979). For standardizing the instrumental magnitudes and colours, we have used the photoelectric sequence given by Ishida (1969). The stars used for this purpose are marked in Table II. Stars 26 and 103 whose variations are within the errors of our observations ($\pm 0\overset{m}{.}02$ in V, $\pm 0\overset{m}{.}03$ in $(B - V)$ and $\pm 0\overset{m}{.}035$ in $(U - B)$), were used as extinction stars. A minimum of two sets of observations, on different nights, were taken for each star. The average *UBV* values are listed in Table II. A total of 169 stars has been observed in the region of the cluster.

Reddening. The $(U - B)$, $(B - V)$ diagram of IC 1805 is plotted in figure 1. We have fitted the intrinsic zero-age main-sequence (ZAMS) by Mermilliod (1981) on the cluster MS-stars (fig. 1) and found that the colour excess, as obtained by the sliding fit method, varies from $E(B - V)_{min} = 0\overset{m}{.}52$ to $E(B - V)_{max} = 1\overset{m}{.}13$; yielding $\Delta E(B - V)$ $(= E(B - V)_{max} - E(B - V)_{min}) = 0\overset{m}{.}61$, which is indicative of the presence of non-uniform extinction across the cluster (Burki 1975). The mean value of the colour excess, $E(B - V)$ is found to be $0\overset{m}{.}80$. The reddening across the cluster has also been found variable by various other investigators (Johnson *et al.* 1961; Herbig 1962; Vasilevskis *et al.* 1965; Ishida 1969; Moffat 1972). In order to determine the spatial distribution of the colour excess, $E(B - V)$, we have divided the cluster field into areas of 5×5 square

TABLE II

PHOTOELECTRIC *UBV* MAGNITUDES OF STARS IN IC 1805

Star Number	*V* (mag)	(*B* − *V*) (mag)	(*U* − *B*) (mag)	*E*(*B* − *V*) (mag)	*p* (per cent)	Remarks
5	12.98	1.62	1.63	—	42	
7	14.44	0.84	0.16	0.99	73	2
8	13.39	0.78	0.17	0.91	65	2
15	14.14	0.87	0.03	1.07	59	2
18	12.61	0.84	−0.12	1.09	74	2
21	11.29	0.98	−0.07	1.27	67	1
23	11.45	0.84	−0.11	1.12	80	1
26*	12.04	0.67	0.57	0.99	57	3
28	13.49	0.76	0.11	—	41	
29	13.29	0.63	0.24	—	4	
37	13.86	0.85	0.10	1.02	71	
39	13.01	0.89	0.62	1.14	81	3
42	13.45	0.90	−0.05	1.14	54	2
43	12.22	1.60	1.05	1.07	75	3, 4
49*	12.80	1.12	0.02	1.40	62	2
50	12.75	0.59	0.12	0.87	72	3, 4
51	11.32	0.38	−0.35	—	0	
52*	13.27	1.08	0.04	1.34	69	2
53	12.82	0.80	−0.04	1.01	60	2
55	13.82	0.87	0.49	1.07	77	2
56	13.23	0.50	0.15	—	27	
57	13.90	0.86	0.31	0.91	72	3
60	13.93	0.78	0.73	0.88	62	3
62	12.54	0.85	−0.18	1.12	84	2
63	13.33	0.78	0.40	0.91	77	3
68	13.16	0.63	−0.11	0.82	76	2
69	12.34	0.68	−0.24	0.92	75	2
70	8.31	0.79	−0.22	0.99	82	1, 4
71	13.83	0.69	−0.03	—	46	
72	12.38	0.61	−0.33	0.87	77	2, 4
74	11.40	1.93	1.90	0.83	51	1
79	14.32	0.75	—	—	26	
82*	12.50	0.81	−0.14	1.06	79	2
85	13.83	0.69	−0.34	0.98	70	2
86	12.79	0.54	0.37	—	33	
91	13.02	0.55	0.16	0.79	70	3
94	13.91	0.78	−0.10	1.00	52	2
96	13.50	0.56	−0.10	0.72	82	2
99	13.44	0.75	0.60	0.76	83	3
103*	10.56	0.51	−0.42	0.77	78	1
104	8.79	0.57	−0.51	0.90	76	1, 5
105	11.50	0.73	0.48	0.73	67	1
109	13.98	0.79	−0.09	—	3	
110	13.26	0.78	0.36	0.81	53	3
111	11.52	0.49	−0.42	0.75	84	1
112	9.92	0.52	−0.47	0.82	81	1, 5

TABLE II—(*continued*)

Star Number	V (mag)	(B − V) (mag)	(U − B) (mag)	E(B − V) (mag)	p (per cent)	Remarks
113	10.92	0.88	−0.16	1.19	82	1
118	10.30	0.54	−0.50	0.85	83	1, 5
121*	11.59	0.63	−0.30	0.88	63	2
122	13.73	1.05	0.49	—	49	
123	13.88	0.57	0.31	0.79	63	3
124	14.40	0.78	—	0.76	69	3
128	13.40	0.70	−0.29	0.97	80	2
129	14.06	0.67	0.05	0.81	73	2
130	13.26	0.66	−0.14	—	10	
131	12.52	0.97	0.44	0.94	55	3
134	14.07	0.63	0.06	0.76	82	2
136	11.04	0.61	−0.35	0.89	71	1
138	9.58	0.45	−0.60	0.79	76	1, 4, 5
139	13.10	0.53	−0.09	0.68	80	2
142	11.30	0.48	−0.36	—	0	
143	11.40	0.55	−0.51	0.86	83	2
146	13.53	0.56	−0.09	—	21	
147	13.34	0.64	0.04	0.78	71	2
149	11.24	0.48	−0.38	0.70	83	1, 4
152	12.96	0.73	−0.14	0.95	70	2
154	14.07	0.77	—	0.96	71	3
155	14.39	1.32	—	—	29	
156	12.03	0.61	−0.36	0.88	55	2
157	13.48	0.65	−0.26	0.89	68	2, 4
158	12.73	0.98	−0.05	1.24	56	2
159	13.74	0.71	−0.17	—	27	
160	8.11	0.68	−0.40	1.02	57	1, 5
161	10.86	0.46	−0.49	0.73	70	1
162	12.55	0.46	−0.29	0.67	50	2, 4
163	12.20	0.75	−0.25	1.02	79	2
164	13.92	0.77	0.01	0.95	53	2
165	12.77	0.63	−0.22	0.86	73	2
166	11.97	0.53	−0.25	0.75	82	1
167	12.25	0.48	−0.30	0.69	84	2
168	13.72	0.78	0.26	0.96	60	3
169	11.73	0.59	−0.29	0.85	78	1, 4
170*	10.07	0.39	0.26	0.35	69	1
171	13.13	0.60	−0.06	0.76	60	2
172	13.86	0.77	0.03	0.94	80	2
174	11.63	0.49	−0.36	0.75	77	1
175	13.10	0.63	−0.20	0.85	78	2
180	12.90	0.67	−0.22	0.91	67	2
182	13.38	0.62	−0.12	0.81	83	2
183*	11.15	0.60	−0.48	0.88	74	1
185	11.58	0.54	−0.40	—	43	
188	12.68	0.55	−0.29	0.78	72	2
189	13.72	0.72	−0.09	0.93	75	2

TABLE II—(*Continued*)

Star Number	V (mag)	$(B-V)$ (mag)	$(U-B)$ (mag)	$E(B-V)$ (mag)	p (per cent)	Remarks
191	12.96	0.64	−0.26	0.88	66	2
192	8.43	0.42	−0.62	0.76	58	1, 5
195*	13.01	1.45	0.95	0.91	80	3
198	13.17	1.56	1.08	0.92	69	3
199	11.54	1.67	1.44	0.81	83	3
200	13.90	0.68	−0.08	—	15	
204	14.54	0.41	0.50	0.81	54	3
205	13.88	0.65	−0.01	0.81	61	2
207	14.12	0.76	0.15	0.89	78	2
208	12.95	0.59	0.35	0.81	65	3
211	11.03	0.58	−0.37	0.86	83	1, 4
212	13.01	0.58	−0.21	0.79	75	2
213	13.64	0.56	−0.21	0.76	65	2
214	13.70	0.81	0.31	0.81	58	3
215	12.80	2.12	1.70	0.82	75	3, 6
218	13.61	0.54	−0.03	0.67	79	2
220	13.18	0.70	0.13	—	27	
221	11.64	0.40	0.26	0.51	82	1, 4
222	14.09	0.70	—	—	38	
224	13.56	0.74	—	0.91	52	3
225	13.63	0.72	−0.05	0.91	84	2
228	14.02	0.83	—	0.91	61	3
229	13.51	0.65	0.09	0.81	67	3
232	9.39	0.49	−0.50	0.80	76	1, 5
236	13.67	0.54	−0.08	0.69	65	2
238	14.13	0.47	0.54	0.82	56	3
240	13.54	0.30	0.30	0.82	79	3
241	13.71	1.08	0.39	—	22	
244	12.84	0.68	0.30	0.81	64	3
248	12.93	0.63	0.35	0.81	63	3
250	12.66	0.56	−0.34	0.81	70	2
251	14.04	0.67	0.40	0.81	70	3
252	12.76	0.89	0.06	1.09	82	4
253	14.25	0.66	—	—	47	
254	14.23	0.79	0.21	0.81	50	3
255	13.43	0.78	0.18	0.90	80	2
256	13.90	0.65	0.12	0.81	65	3
258	12.98	0.76	−0.17	1.00	82	2
259	11.01	0.60	−0.33	0.86	78	2
260	11.52	0.46	−0.36	0.72	83	1
262	12.20	0.58	−0.28	0.81	82	2
264	12.80	0.56	−0.09	0.72	81	2
265	13.91	0.55	0.19	0.69	67	3
266	13.47	0.61	−0.08	0.78	83	2
267	13.50	0.66	0.38	—	7	
269	13.91	0.70	—	—	26	

TABLE II—(*concluded*)

Star Number	V (mag)	(B − V) (mag)	(U − B) (mag)	E(B − V) (mag)	p (per cent)	Remarks
270	13.70	0.76	0.18	0.81	61	3
272	14.17	1.00	—	—	5	
276	12.88	0.54	−0.28	0.76	79	2
277	12.71	0.60	−0.20	0.81	83	2
278	11.56	0.47	0.28	0.50	80	1
279	13.56	0.64	−0.06	—	35	
280	13.76	0.63	0.47	0.72	82	3
281	14.21	0.60	—	0.72	81	3
283	14.30	0.72	—	0.81	80	3
288	11.12	0.47	−0.42	0.74	78	1
290	11.74	0.57	0.18	0.25	66	1
299	13.84	1.26	0.71	—	40	
301	11.95	0.66	0.14	0.14	70	1
303	11.88	0.67	0.50	—	29	
308	10.93	1.52	1.47	0.57	57	1
310	13.15	0.47	0.42	0.75	81	3
315	12.85	0.49	0.24	0.57	62	3
322	13.51	0.75	—	0.82	80	3
324	14.08	0.86	—	0.82	53	3
330	13.78	0.36	—	0.57	81	3
332	12.98	0.52	−0.30	0.74	81	2
334	14.24	0.56	−0.21	0.75	59	2
336	14.37	0.58	—	—	1	
339	13.42	0.69	0.42	0.75	68	3
341	12.06	0.60	0.23	0.75	74	3
345	13.91	0.68	−0.01	0.84	82	2
346	13.30	0.63	0.33	0.75	77	3
349	14.60	0.89	—	—	24	
350	14.41	0.63	—	0.74	82	3
352	13.01	0.45	0.29	—	14	

Notes

(i) Due to neighbouring bright stars, stars 144 and 177, having the membership probability 73 and 69 per cent respectively, could not be observed.

(ii) Explanation for numbers in remarks column:

1. $E(B - V)$ values are derived on the basis of spectral class.
2. $E(B - V)$ values are derived from the photometric method.
3. $E(B - V)$ values are estimated on the basis of the average $E(B - V)$ value of the nearest stars.
4. *UBV* values determined by us differ from those determined by Ishida (1969) and therefore the stars might be variable.
5. Spectroscopic binaries or variable-radial-velocity stars (Mermilliod, 1976).
6. $(U - B)$ values are taken from Mermilliod's catalogue (1976), as they could not be determined by us.

(iii) Stars with numbers marked * belong to the photoelectric sequence given by Ishida (1969). The adopted reddening value $E(B - V)$ is also given. The star numbers and corresponding membership probability, p, are taken from Sanders (1972).

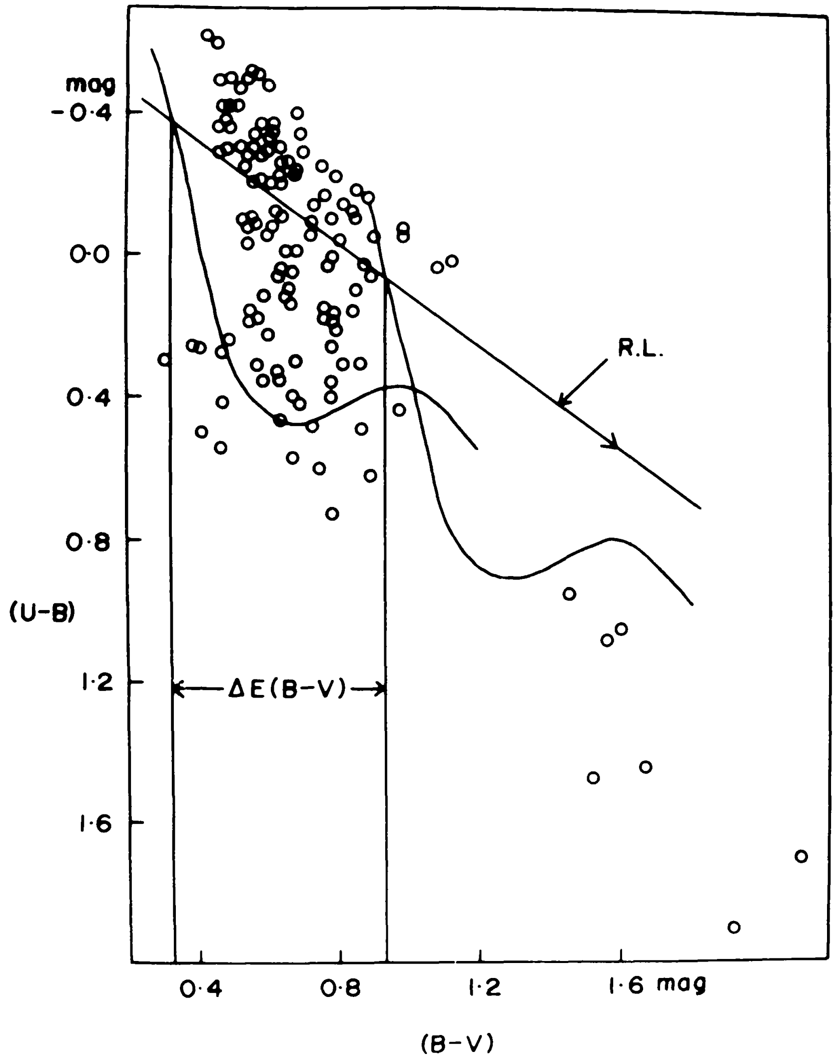

FIG. 1—The $(U-B)$, $(B-V)$ diagram of IC 1805. R.L. is the reddening line. The continuous curves denote the fitted intrinsic ZAMS given by Mermilliod (1981) for the minimum and maximum values of $E(B-V)$. $\Delta E(B-V) = E(B-V)_{max} - E(B-V)_{min}$.

minutes of arc, as indicated in Table III and have determined the reddening across each box, using O and B stars, in the same way as described elsewhere by us (Sagar and Joshi 1978, 1979). Table III shows the variation of reddening across the cluster.

Based on the above considerations the individual stars have been suitably dereddened in the discussions to follow, by applying corrections determined from:

(a) the MKK classification of the stars (cf. Mermilliod 1976), if available;
(b) the photometric method as described earlier by us (Sagar and Joshi 1979), if the spectral classification is not available; and

1983JRASC..77...40J

TABLE III

VARIATION OF REDDENING ACROSS THE CLUSTER IC 1805

$\Delta\delta$	$\Delta\alpha$: 25 to 30	20 to 25	15 to 20	10 to 15	5 to 10	0 to 5	−5 to 0	−10 to −5	−15 to −10	−20 to −15	−25 to −20	−30 to −25
20 to 25				0.81 (1)								
15 to 20				0.81 (6)				0.98 (1)				
10 to 15				0.82 (3)		0.73 (1)	0.76 (2)				1.07 (1)	0.99 (1)
5 to 10					0.81 (1)	0.79 (2)	0.87 (3)	0.88 (3)		1.34 (1)		
0 to 5			0.72 (1)	0.69 (1)	0.72 (2)	0.80 (11)	0.79 (7)	0.91 (2)		1.40 (1)	1.18 (2)	
−5 to 0		0.74 (1)			0.81 (3)	0.96 (9)	0.81 (1)			1.14 (1)		
−10 to −5		0.75 (1)			0.91 (1)		1.16 (1)		1.12 (1)	1.01 (1)		
−15 to −10									0.87 (3)	1.02 (1)	1.09 (1)	
−20 to −15	0.84 (1)				0.89 (1)	0.94 (1)			0.96 (1)			0.91 (1)
−25 to −20				1.09 (1)								

The average value of $E(B - V)$ in areas 5×5 square minutes of arc is indicated in the appropriate boxes along with the number of stars used for the determination of reddening, given in brackets. Coordinates are relative to star number 148, in arc minutes.

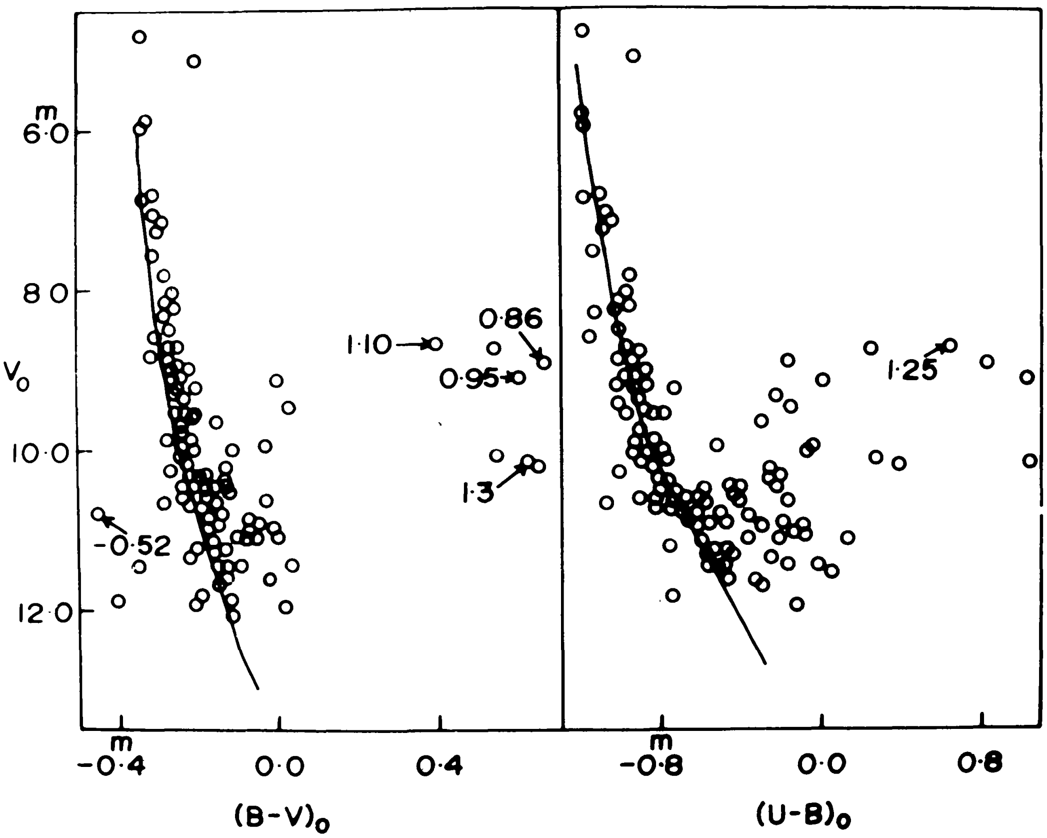

FIG. 2—The V_0, $(B - V)_0$ and V_0, $(U - B)_0$ colour-magnitude diagrams of IC 1805. The solid line represents the ZAMS, taken from Schmidt-Kaler (1965), fitted onto the cluster MS.

(c) the average $E(B - V)$ values of nearest stars, if none of the above two methods are applicable.

The $E(B - V)$ value for each individual star, thus estimated, is listed in Table II. For star numbers 170, 290 and 301 the obtained reddening values are quite low as compared to the average value of the cluster reddening. This shows that these stars could be foreground stars. Consequently, in the subsequent discussions, we have not considered these stars as cluster members.

Distance. We have determined the intrinsic $(B - V)_0$ and $(U - B)_0$ colours and V_0 magnitudes of the cluster stars using their individual values of $E(B - V)$ listed in Table II, in the same way as described earlier by us (Sagar and Joshi 1979). The distance modulus to the cluster IC 1805 has been obtained by fitting the ZAMS given by Schmidt-Kaler (1965) on to the cluster MS in the V_0, $(B - V)_0$ and V_0, $(U - B)_0$ diagrams (figure 2). To avoid the evolutionary effects, only the lower part of the cluster MS has been used in distance estimation. The estimates of the true distance modulus as obtained from the two colour-magnitude diagrams are ($11^{m}.95 \pm 0^{m}.1$) and $11^{m}.85 \pm 0^{m}.1$). The average value of the distance modulus is ($11^{m}.9 \pm 0^{m}.2$) implying that the distance to the cluster is (2.40 ± 0.24) Kpc. The estimate of the distance modulus, determined by various authors, ranges from $11^{m}.0$ to $12^{m}.0$ (Alter *et al.* 1970, Moffat 1972) with a modal value of $11^{m}.6$.

HR diagram of IC 1805. The HR diagram of IC 1805 has been plotted in figure 3 for a true distance modulus of $11^{m}.9$ after applying correction for variable reddening across the cluster as indicated in Table II. From the HR diagram of the cluster the following inferences can be drawn:

1 A well defined cluster MS, extending from $M_V = -6^{m}.0$ to $0^{m}.1$ clearly exists.
2 In the upper part of the cluster sequence, where the member stars have just started evolving off the cluster MS, evolutionary effects are clearly visible.
3 It resembles the HR-diagram of several young clusters, namely NGC 2264 (Sagar and Joshi 1982), NGC 6823 (Sagar and Joshi 1981) and I Ori (Walker 1961).
4 Stars 43, 74, 105, 131, 195, 198, 199, 215, 278 and 308 occupy positions in the HR-diagram well above the MS, while stars 85, 204, 238, 240 and 310 occupy positions well below the MS. These positions are peculiar from the standpoint of stellar evolution, though all these stars have $p > 50$ per cent. Such peculiar stars have also been identified in a few other open clusters (McNamara and Sanders 1976; Sagar and Joshi 1982). The possibility that these stars are field stars cannot be ruled out in the light of the fact that among the stars having $p \geqslant 50$ per cent, the statistically expected number of field stars is 37 (*vide* discussion in *Introduction*). In subsequent discussions we have not considered these stars as cluster members.

Age of the cluster stars. We have estimated the age of the cluster stars, using the theoretical evolutionary tracks for the stars in the pre-main-sequence stage given by Iben (1965). From the fit of the theoretical gravitational isochrones (cf. Sagar 1979) in the HR diagram of the cluster (figure 3), it is found that rather than assigning an unique age to the cluster stars, it would be appropriate to say that most of the pre-main-sequence stars have ages between 0.3–1.2 million years while some other stars are even younger than 0.3 million years. The result that the stars in IC 1805 have an age spread is supported in that there are several indications of star formation still taking place in the cluster region e.g. existence of a compact multiple system (Sharpless 1954, Moffat 1972), presence of emission nebulosity (Akabane *et al.* 1967) and the presence of molecular cloud (Lada *et al.* 1978).

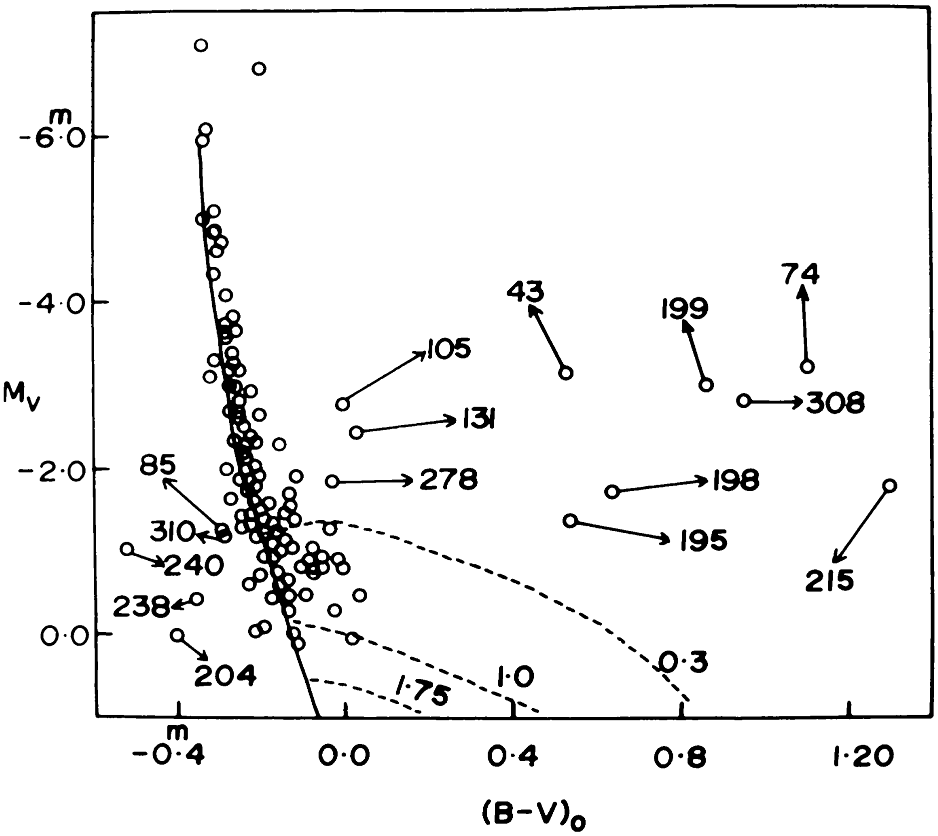

FIG. 3—H-R diagram of IC 1805. The solid curve is the ZAMS, taken from Schmidt-Kaler (1965). Dashed curves are the isochrones by Iben (1965) with the ages (in million years) indicated alongside. Peculiar stars from the standpoint of stellar evolution are indicated.

In the light of the above discussions we conclude that star formation in the cluster region is not coeval and that the processes of star formation are still going on.

Acknowledgement. The authors wish to express their thanks to Dr. S. D. Sinvhal for guidance and helpful discussions.

U. C. Joshi and Ram Sagar,
Uttar Pradesh State Observatory,
Manora Peak,
Naini Tal – 263129,
India.

REFERENCES

Akabane, K., Miyazawa, K., Takahashi, T., Ishizava, Y., and Nakajima, T. 1967, *Tokyo Astron. Bull. No.* **177**, p. 241.

Alter, G., Ruprecht, J., and Vanýsek, V. 1970, *Catalogue of Star Clusters and Associations*, 2nd edition, Akadémiai, Kiadó, Budapest.

Burki, G. 1975, *Astron. Astrophys.* **43**, 37.

Herbig, G. H. 1962, *Astrophys. J.* **135**, 736.

Hoag, A. A., Johnson, H. L., Iriarte, B., Mitchell, R. I., Hallam, K. L., and Sharpless, S. 1961, *Publ. U.S. Naval Obs.* 2nd Series, **17**, Part 7, p. 490.

Iben, I. Jr. 1965, *Astrophys. J.* **141**, 993.

Ishida, K. 1969, *Monthly Notices Roy. Astron. Soc.* **144**, 55.

Johnson, H. L., Hoag, A. A., Iriarte, B., Mitchell, R. I., and Hallam, K. L. 1961, *Lowell Obs. Bull.* **5**, 133.

Lada, C. J., Elmegreen, B. G., Cong, H.-I. and Thaddeus, P. 1978, *Astrophys. J.* **226**, L39.

McNamara, B. J. and Sanders, W. L. 1976, *Astron. Astrophys.* **52**, 53.

Mermilliod, J. C. 1976, *Astron. Astrophys. Suppl.* **24**, 159.

Mermilliod, J. C. 1981, *Astron. Astrophys.* **97**, 235.

Moffat, A. F. J. 1972, *Astron. Astrophys. Suppl.* **7**, 355.

Ruprecht, J. 1966, *Bull. Astron. Inst. Czech.* **17**, 33.

Sagar, R. 1979, *Studies in Star Clusters*, University of Gorakhpur (Ph.D. thesis).

Sagar, R. and Joshi, U. C. 1978, *Monthly Notices Roy. Astron. Soc.* **184**, 467.

Sagar, R. and Joshi, U. C. 1979, *Astrophys. Space Sci.* **66**, 3.

Sagar, R. and Joshi, U. C. 1981, *Astrophys. Space Sci.* **75**, 465.

Sagar, R. and Joshi, U. C. 1982, *Monthly Notices Roy. Astron. Soc.* (in Press)

Sanders, W. L. 1971, *Astron. Astrophys.* **14**, 226.

Sanders, W. L. 1972, *Astron. Astrophys.* **16**, 58.

Schmidt-Kaler, Th. 1965, in H. H. Voigt (ed.) Landolt-Bornstein, *Numerical Data and Functional Relationship in Science and Technology*, Group VI, Vol. I, p. 284.

Sharpless, S. 1954, *Astrophys. J.* **119**, 334.

Trumpler, R. J. 1930, *Lick Obs. Bull.* **14**, 154.

Vasilevskis, S., Sanders, W. L. and van Altena, W. F. 1965, *Astron. J.* **70**, 806.

Walker, M. F. 1961, *Astrophys. J.* **133**, 438.

Westerhout, G. 1958, *Bull. Astron. Inst. Neth.* **14**, 215.