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A Study of Faint Young Open Clusters as Tracers of Spiral Features in our Galaxy
Paper 3: Collinder 97 (OCl 506)

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Abstract. Photoelectric and photographic photometry of twenty-nine stars was done in the field of the open cluster Collinder 97 ≡ OCl 506. Of these stars, a total of twenty-four have been found to be possible members. There is apparently no interstellar extinction in the direction of this cluster which is in the constellation of Monoceros: its $E(B-V)=0.0$ mag. This cluster is situated at a distance of 0.63 ± 0.01 kpc, which is well within the local arm of our Galaxy. The age of this cluster is in the range of 1×10^8 to 5.9×10^8 yr, which puts it in an older age group. Thus, it cannot be specifically considered as a spiral-arm tracer in the study of our Galaxy.

Key words: star clusters, open—star clusters, individual—stars, photometry

1. Introduction

A study of faint young open clusters was initiated by the late Professor M. K. V. Bappu with the main aim of utilising them as tracers of spiral features in our Galaxy. A new technique was developed for a rapid selection of the young clusters from among the not-well-studied fainter ones (Babu 1983). Among the clusters selected, the first to be studied was OCl 585 (Babu 1985). Hereafter, these two works will be referred to as Paper 1 and Paper 2 respectively, the present one being the third in this series.

In Paper 1, the observations of two not-well-studied open clusters, picked from the catalogue given by Alter, Balazs & Ruprecht (1970), were also included. In one of them, namely OCl 506, approximate spectral types could be obtained for a total of thirteen stars, using the modified objective-grating technique. These are reproduced in Table 1 for the convenience of the reader. Since the earliest spectral class among the observed ones was of B5 type and since there is an uncertainty inherent in this technique of fixing the spectral subclasses, this cluster was then roughly classified as a marginally young cluster. In view of this, OCl 506 was selected for further photometric work.

This group of stars (Collinder 97 ≡ Cr 97 ≡ OCl 506 ≡ C 0628+059; $l=205°.37$; $b=-1°.76$) was first listed as a cluster by Collinder (1931), who estimated its distance to be 610 pc. He also gave its angular diameter as 22.5 arcmin with just nine stars in it. He pointed out that this cluster has stars of spectral types B0 and A0 in addition to being a fairly bright cluster ($m_{tot}=5.3$ mag). It has been classified in the Trumpler system as IV 3 p by Ruprecht (1966), where IV indicates that this is not a well-bound cluster, but is passing gradually into the environs, appearing more like a star-field condensation.

The numeral 3 implies that this cluster is composed of bright and faint stars, while the letter p shows that this is a poor cluster with less than 50 stars in it. The finding chart is given in Fig. 1, where it may be noted that some of the stars in the field are so bright that they have even been included in SAO and BD charts. Thus, it is rather surprising that so far no work has been done on them from the cluster point of view.

In this paper, the results of the photometric observations of OCl 506 are presented, based on which it is found that this open cluster is a little too old to be categorised into the young group and thereby concluded that it is not specifically suitable for use as a spiral-arm tracer.

2. Observations and reductions

The photoelectric observations of seventeen stars in the field of this cluster were obtained using a standard *UBV* photometer mounted on the 61-cm telescope at the Siding Spring Observatory of the Australian National University. A dry-ice-cooled

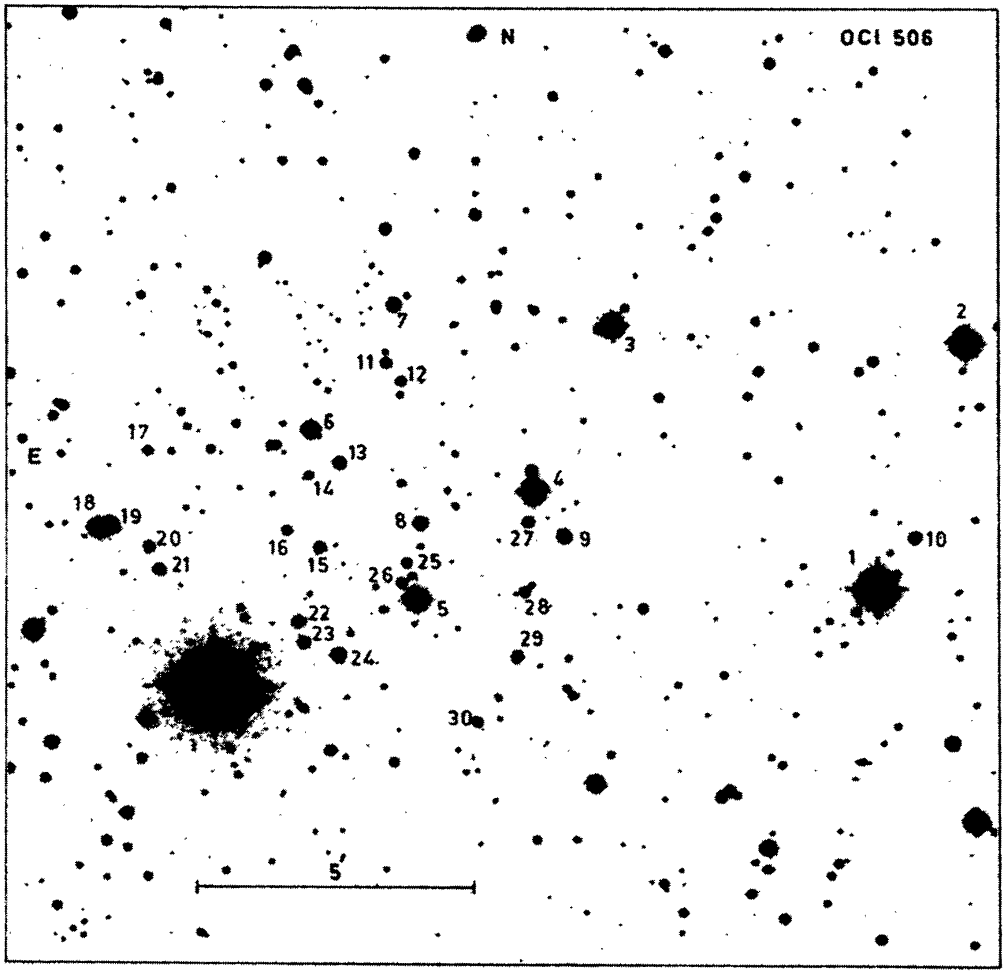

Figure 1. Finding chart for the field of OCl 506, reproduced from the Palomar Observatory Sky Survey (POSS) charts. The identification numbers of the earlier work (Babu 1983) and some extensions introduced in the present work are marked in the chart.

photomultiplier was used along with an on-line computer to collect the data. The instrumental magnitudes, corrected for atmospheric extinction, were standardised with the help of the photometric sequences taken from the work of Landolt (1973). These values are given in Table 1 as V, $(B-V)$ and $(U-B)$. While retaining the same numbers for the stars as in the earlier work (Babu 1983), the numbering has been extended to several more stars in this paper. They are marked in Fig. 1.

The UBV photography of this cluster was done using the 102-cm telescope at Kavalur Observatory. The plate and filter combinations are given in Table 2 along with the exposure times. From these plates, the photographic magnitudes in B and V were obtained on an arbitrary scale for a total of twenty-nine stars, using the PDS microdensitometer in conjunction with the computational facilities available at the Mount Stromlo Observatory in Australia. Unfortunately, the U photograph was affected by poor sky conditions. However, since a sufficient number of stars were observed photoelectrically in U, no further attempt was made to obtain the photographic U magnitudes. The stars common to the photoelectric and photographic

Table 1. The observational data for individual stars in the open cluster OCl 506.

	Star No.	Sp. type*	V	$(B-V)$	$(U-B)$	Membership
Photoelectric photometry:						
1	(SAO 113979)	B8	8.40	−0.02	0.05	m
2	(SAO 113977)	A0	8.71	0.33	0.01	m
3	(SAO 113987)	K0	8.69	0.99	0.66	m
4	(BD+5° 1274)	B5	9.76	−0.05	−0.23	m
5	(BD+5° 1276)	F5	9.57	0.64	0.27	m
8		A0	12.72	0.38	−0.03	m
9		F0	12.26	0.39	0.04	m
10		K5	12.87	0.85	0.35	—
13		F0	12.73	0.49	0.05	m
14			15.24	0.85	0.78	m
15			14.22	0.73	0.27	m
22			14.10	0.67	0.21	m
23			12.67	1.62	—	—
24			12.62	0.51	0.14	m
25			14.51	0.62	0.05	m
27			13.91	0.74	0.34	m
30			13.81	0.80	0.57	—
Photographic photometry:						
6		B8	10.81	0.15	—	m
7		A0	12.27	0.32	—	m
11		F5	13.34	0.64	—	m
12		G0?	13.63	0.60	—	m
16			13.97	0.65	—	m
17			14.24	1.17	—	—
18			11.84	0.30	—	m
19			12.14	0.45	—	m
20			13.81	0.61	—	m
21			13.71	0.48	—	m
26			14.80	0.67	—	m
28			13.98	0.81	—	—

* From Paper 1.

Table 2. Journal of observations.

Band	Plate	Filter	Exposure time
U	IIa-O	UG 2	35 min
B	103a-O	GG 13	20 min
V	IIa-D	GG 11	40 min

observations were used for standardizing the photographic *B*, *V* magnitudes of the remaining twelve stars. These magnitudes and colours are also listed in Table 1.

3. Reddening

The colour-colour diagram of the stars in this field, with $(B-V)$ against $(U-B)$, is given in Fig. 2. In this diagram, the sequence of all the observed stars appears to follow the unreddened curve given by Schmidt-Kaler (1982), indicating that there is no extinction

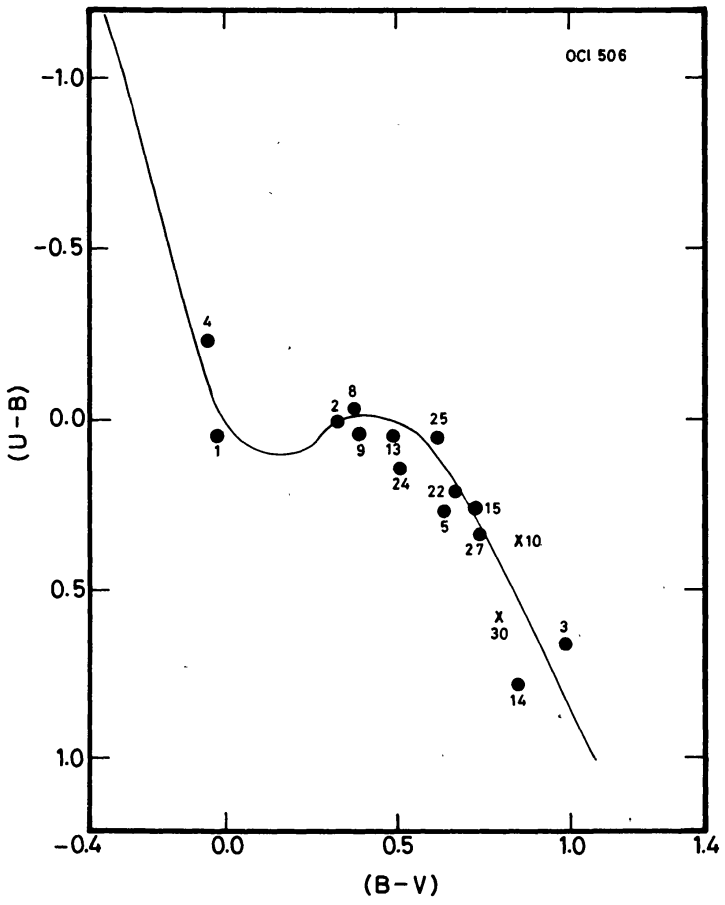

Figure 2. The $(B-V)$ versus $(U-B)$ diagram of the stars in the field of OCl 506. The filled circles and crosses denote the members and nonmembers respectively. The solid curve is the unreddened main sequence (MS) taken from Schmidt-Kaler (1982). The identification numbers of the stars (*cf.* Fig. 1) are also indicated.

due to interstellar medium between the cluster and the observer. Thus,

$$E(B-V)=0.0 \qquad \text{and} \qquad E(U-B)=0.0.$$

That is, the observed magnitudes and colours need no further correction by way of interstellar reddening.

4. Membership

The membership of the individual stars in this cluster has been determined with the help of the photometric criteria given by Vogt & Moffat (1972). In this method, the stars of the clear sequence found in the colour-colour diagram are identified on the two colour-magnitude diagrams as well (Figs 3 and 4). The diagram of $(B-V)$ versus V (Fig. 3), includes also the data of the photographic photometry on twelve stars. This exercise indicates that a total of twenty-four stars are members, the remaining five (stars 10, 17, 23, 28 and 30) nonmembers. Stars 3 and 5 appear to be belonging to the red-giant branch, whereas stars 1 and 2 show some evolved nature. All the members are denoted by 'm' in Table 1.

5. Distance

In order to determine the distance of this cluster using the present photometric data, the two colour-magnitude diagrams (Figs 3 and 4) have been fitted with the zero-age-main-

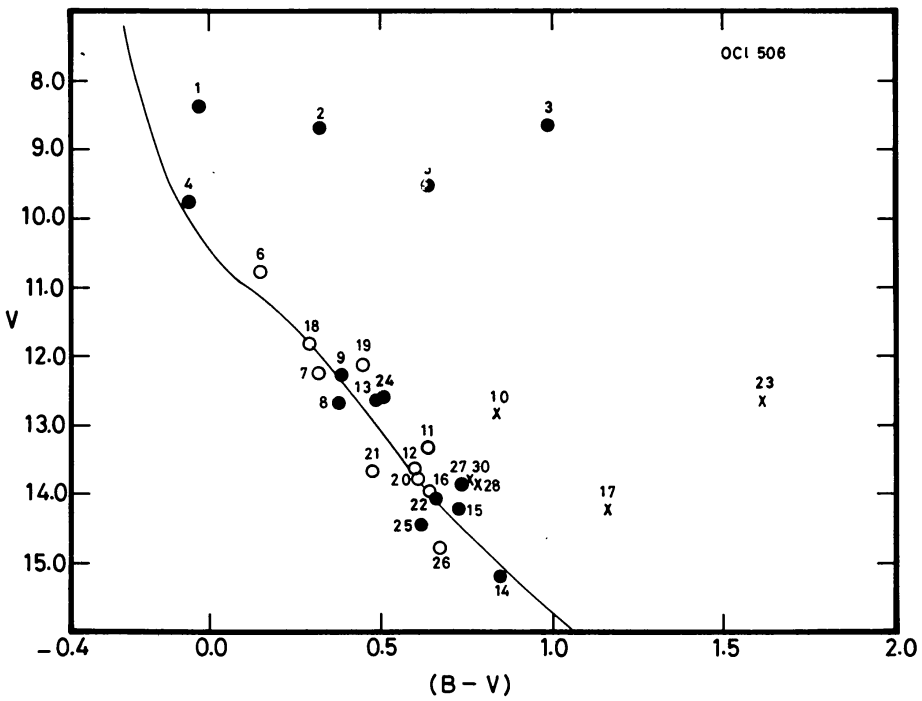

Figure 3. The $(B-V)$ versus V magnitude diagram of the stars in the field of OCl 506. The solid curve represents the zero-age-main sequence (ZAMS) (*cf.* Schmidt-Kaler 1982), which is shifted to match with the observations. The unfilled circles indicate the photographically observed members, the rest of the symbols being the same as in Fig. 2.

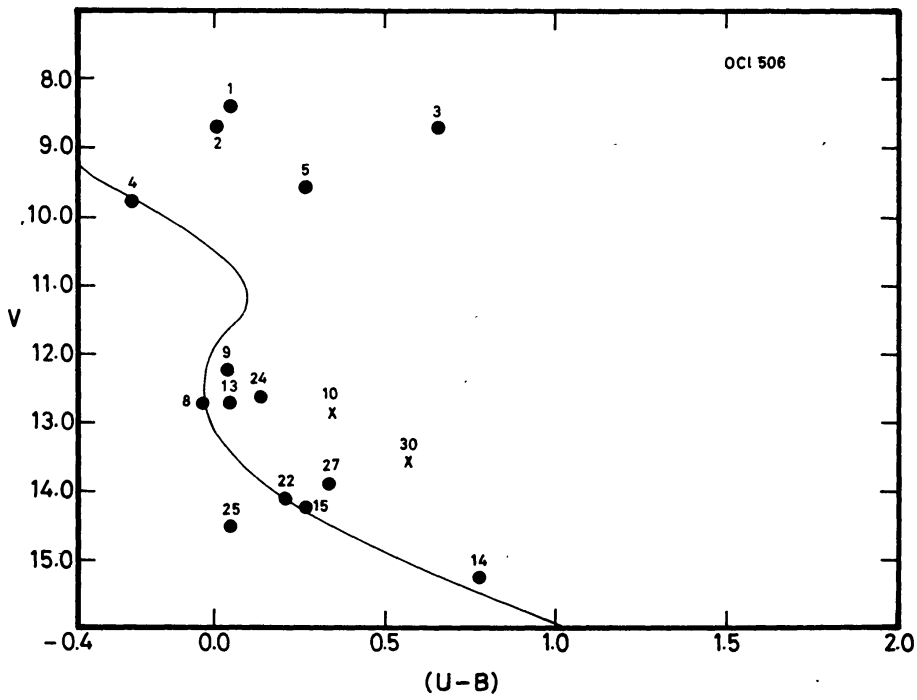

Figure 4. The $(U-B)$ versus V magnitude diagram of the stars in the field of OCl 506. The solid curve represents the ZAMS (*cf.* Schmidt-Kaler 1982) which is shifted to match with the observations. The symbols are the same as in Fig. 2.

sequence (ZAMS) given by Schmidt-Kaler (1982). They yielded the distance moduli of 8.95 mag and 9.05 mag from the long and short wavelength colour-magnitude diagrams respectively, giving an average of 9.0 mag. Then, based on the expression $\log D = 0.2\,(V-M)+1$, the distance D has been found to be

$$D = 0.63 \pm 0.01 \text{ kpc},$$

where $(V-M)$ is the distance modulus.

6. Age of the cluster

The HR-diagram of this cluster, shown in Fig. 5, is plotted for the true distance modulus of 9.0 mag. When the ZAMS (Schmidt-Kaler 1982) and the post-main sequence isochrones (Barbaro, Dallaporta & Fabris 1969) are superimposed on this diagram, the cluster stars clearly indicate an age range from a little later than 1.25×10^8 to about 5.90×10^8 yr. Further, star 4, being the bluest on the MS with $(B-V) = -0.05$ gives the age as 1×10^8 yr. Thus, the total dispersion in the age of this cluster appears to be from 1×10^8 to 5.9×10^8 yr.

7. Conclusions

The very fact that this cluster needs no corrections for the interstellar extinction (*cf.* Section 3) indicates that it is a nearby system. Its bright total magnitude and the

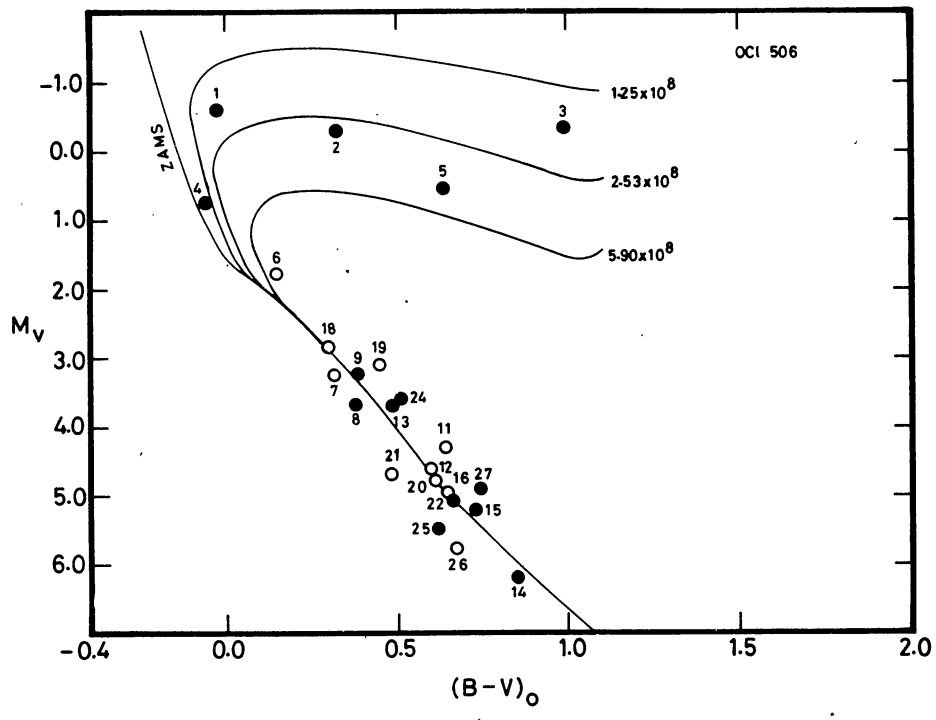

Figure 5. The HR-diagram of the open cluster OCl 506. The ZAMS is the same as in Fig. 3, but drawn for the true distance modulus. The post-MS isochrones are from Barbaro, Dallaporta & Fabris (1969), with the ages indicated alongside. The symbols are the same as in Figs 2–4.

large angular diameter (*cf.* Section 1) render support to this inference. In fact, the earlier estimation of distance by Collinder (1931) is very close to the value of 0.63 ± 0.01 kpc determined in the present work.

The age of this cluster is found to be in the range of 1×10^8 to 5.9×10^8 yr, which puts it in an older age group. Thus, it cannot be specifically considered as a spiral-arm tracer in the study of our Galaxy, in spite of the fact that its location is sufficiently inside the local Cygnus-Orion arm.

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