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Study of Old Open Clusters NGC 1605, Czernik 18, NGC 2509

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Abstract. We present the first CCD photometric UBVRI observations of three open clusters NGC 1605 (OCl 406), Czernik 18 (OCl 426) and NGC 2509 (OCl 630) obtained by using the 1.02 m telescope at Vainu Bappu Observatory, Kavalur. While the colour excess E(B-V) for the cluster OCl 426 is found to be 0.43 mag, it is estimated to be 0.14 mag for OCl 406 and 0.15 mag for OCl 630. After correcting for these colour excesses, their distances are found to be 1148 pc (OCl 406), 955 pc (OCl 426), and 912 pc (OCl 630). Further, as the ages of these clusters are found to be in the range of 0.8×10^9 yrs to 8×10^9 yrs, they may be categorised as old open clusters.

Keywords : Open cluster, photometry, distance, age

1. Introduction

The spiral structure of our Galaxy is conveniently studied by means of young objects. The late Prof. M. K. V. Bappu initiated a study of faint young open clusters with the main aim of utilizing them as tracers of Galactic spiral features. Continuing the earlier work carried out by Babu (1983, 1985, 1987) on these lines, three not-well-studied open clusters OCl 406, OCl 426 and OCl 630 are selected from the catalogue given by Alter et al. (1970) as an attempt to explore their suitability in the study of galactic structure.

2. Observations and Reductions

The first CCD photometric observations of three open clusters NGC 1605 (=OCl 406, α_{2000} : $04^h35^m01^s, \delta_{2000}$: $+45°15'$), Czernik 18 (=OCl 426, α_{2000} : $04^h27^m49^s, \delta_{2000}$: $+30°57'$) and NGC 2509 (=OCl 630, α_{2000} : $08^h00^m48^s, \delta_{2000}$: $-19°03'$) were obtained through UBVRI filters by using the 1.02 m telescope at Vainu Bappu Observatory, Kavalur. These clusters have been

chosen from among the selection of a few not-well-studied open clusters as an attempt to explore their suitability in the study of galactic structure.

From each cluster field, about 100 stars were chosen for analysis. These stars were selected from the central region of the frame, covering a field of 5 × 5 arcmin down to m_v = 21.5 mag. The fainter stars were ignored. The raw frames were flat fielded, sky subtracted and corrected for bad pixels. The reduction was done using the IRAF packages. The atmospheric extinction corrections and the instrumental calibration were colour diagrams, were used to get the individual interstellar reddening corrected magnitudes as V, (U-B), (B-V), (V-R), (R-I) and (B-I).

3. Reddening

The (B-V) vs (U-B) diagram of the selected stars in the field of the individual clusters showed a small shift from the unreddened main sequence given by Schmidt-Kaler (1982). By shifting the unreddened curve on to the observed sequence in such a way that the shift is parallel to the reddening line, the colour excesses E(B-V) were obtained as 0.14 mag, 0.43 mag and 0.15 mag for the clusters OCl 406, OCl 426 and OCl 630 respectively. We have also used the (B-V) vs (B-I) diagrams to obtain the values of E(B-V) based on the technique given by Natali et al. (1994). Further, as the scatter in this diagram is found to be negligibly small, the values given in this work can be considered to be more reliable. The respective colour excesses obtained by both the techniques are found to be same.

It may be noticed that in the catalogue of Lynga (1987) the value of E(B-V) for the cluster OCl 406 (NGC 1605) is given as 0.97 which is the transformed value (cf. Steinlin, 1968) from the RGU system tabulated by Becker and Fenkart (1971) as 1.36. In turn, the reference for that is Fang (1970). Fang has used RGU system to study the cluster and only mentions that E(G-R) = 1.35, E(U-G) = 0.95 and gave the earliest spectral type as B3. However, no explanation is given as to how these parameters were obtained. It can also be noted that the number of stars chosen by Fang is much smaller compared to our data. In addition, Barkhatova and Chentsov (1961) using photographic photometry equivalent to BV system, has stated that the colour excess cannot exceed 0.64 mag in the direction of this cluster. Thus, the value given by Fang (1970) appears to be an over estimation as compared to the results obtained by Barkhatova and Chentsov as well as the present work which is carried out using photoelectric photometry.

4. Distances

The distance modulus of each cluster has been estimated by fitting the zero age main sequence (ZAMS) given by Schmidt-Kaler (1982) onto the (B-V) vs V diagram from which their respective distances have been calculated. The distances of the clusters OCl 406, OCl 426 and OCl 630 are found to be 1148±119 pc, 955±115 pc and 912±115 pc respectively.

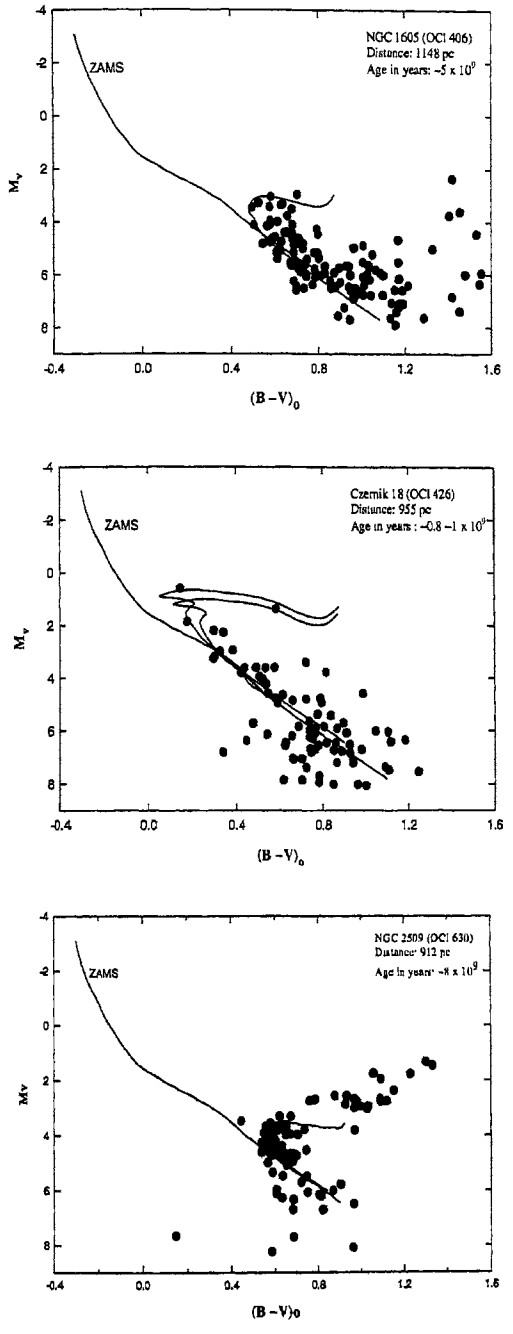

Figure 1. The HR diagram of the old clusters NGC 1605, Czernik 18 and NGC 2509 (OCl 630). The ZAMS is taken from Schmidt-Kaler (1982) and thick curve represnts the isochrones given by Bertelli et.al. (1994)

It may be noted that Barkhatova and Chentsov (1961) had obtained the distance of the cluster OCl 406 as 1480 pc using photographic techniques, while Becker and Fenkart (1971) tabulated the distance as 2720 pc obtained through RGU photometry by Fang (1970). While the distance of this cluster estimated by Barkhatova and Chentsov is quiet close to the value obtained in this paper, the apparently greater distance given by Fang could be the result of using a large colour excess value.

5. Ages

Employing the theoretical isochrones given by Bertelli et al. (1994), the ages of these clusters have been found to be of the order of 109 yrs (Fig.1). Among them, OCl 426 is found to be the 'youngest' with the age between 0.8 to 1×10^9 yrs, while OCl 406 is found to be of age $\sim 5 \times 10^9$ yrs which is as old as M67. However, OCl 630 is found to be the 'oldest', its age being $\sim 8 \times 10^9$ yrs making it younger than NGC 188 but older than M67, both of which are well known old open clusters (Sujatha and Babu, 2003).

In the work done by Fang (1970) the earliest spectral type is mentioned as B3. But there is no indication about which star in the cluster is of the spectral type B3. However, in the present work the smallest (B-V) on the main sequence is 0.44 and most luminous star on the main sequence is $M_v = 3.8$. When these values were compared with that of the cluster age relations given by Allen (2000) the log age in years of the cluster is found to lie between 9 and 10, which is in agreement with our results.

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