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Mass function of open clusters NGC 1857 and Czernik 25

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Abstract. The first CCD photometric UBVRI observations of the open clusters NGC 1857 (Czernik 20, OCl 427) and Czernik 25 (OCl 493) are presented. The observations were obtained on 28 November 2003 with the 2m Himalayan Chandra Telescope at Hanle using a LN2 cooled 2k × 2k CCD. The colour excess E(B-V) is found to be non-uniform in the line of sight of NGC 1857 ranging between 0.38 and 0.60 mag, while it is 0.69 mag for Cz 25. Further, the clusters NGC 1857 and Cz 25 are estimated to be at a distance of 5.75±0.8 kpc and 4.79±0.5 kpc respectively. As the log (age) of NGC 1857 is estimated to be in the range of 8.00 to 8.25 and that of Cz 25 is 8.45, they may be considered to be of intermediate age.

The luminosity function (LF) and the mass function (MF) for both the clusters have been derived. The MF slopes for the clusters NGC 1857 and Cz 25 are -2.39±0.26 and -2.70±0.25 respectively. These values are in fair agreement with that given by Salpeter. Mass segregation is observed in both the clusters and it could be due to the dynamical evolution of the clusters or the imprint of star formation process or both.

Keywords : Open clusters, photometry, distance, age, luminosity function, mass function and mass segregation

1. Introduction

Open clusters provide basic information for the understanding of star formation and chemical evolutionary processes in the Galaxy. In that context, continuing the earlier work done by us (Sujatha and Babu, 2003a; 2003b; 2004, hereafter referred to as Paper I, Paper II and Paper III respectively), we have obtained the first CCD photometric UBVRI observations of two open

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clusters NGC 1857 and Czernik 25. These clusters are selected from the catalogue given by Alter et al. (1970). The identification charts are shown in Fig.1. A brief description of the clusters is given below.

NGC 1857 (Cz 20, OCl 427: α_{2000} = 05h 20m 06s; δ_{2000} = + 39^{o}20' 39"; l = 168^o.3; b = + 01^o.32): Czernik (1966) catalogued it as a cluster and estimated its angular diameter as 18 arcmin with 325 stars as its members. This cluster has been classified as II 2 r in the Trumpler system of classification by Ruprecht (1966). Photoelectric and photographic photometry in UBV was performed in the field of this cluster by Babu (1989) for 72 stars, of which, a total of 43 have been found to be probable members down to V = 15.75 mag. Babu also gave a variable extinction of E(B-V) between 0.38 and 0.53 mag,with a range in ages from 1.0 $\times$ 10^7 to 7.1 $\times$ 10^7 years at a distance of 4.27±0.14 kpc in the outer Perseus arm.

It may be noted that the coordinates (α_{2000}=05h 20m 06s ; δ_{2000}= + 39^{o}28'00" given by Czernik as well as in WEBDA for Cz 20 do not match with the field of any cluster, while a cluster designated as NGC 1857 (Cuffey, 1937) is found just about 8 minutes of arc away towards south in declination with the coordinates of α_{2000}= 05h 20m 06s ; δ_{2000}= + 39^{o}20'39". So assuming it to be a minor misrepresentation, we considered that both Cz 20 and NGC 1857 are one and the same cluster and proceeded with further studies of this cluster with the designation as NGC 1857.

Further, since an examination of the POSS (Palomar Observatory Sky Survey) charts showed only one cluster in that neighbourhood, Babu (1989) had observed that cluster through visual identification of the field seen at the focal plane of the telescope, with the designation of Czernik 20.

The photographic photometry of NGC 1857 was done earlier by Cuffey (1937) who indicated a distance of 600 pc for the cluster, while Colegrove et al. (1994) used the BVRI photometry on NGC 1857 and obtained log (age) = 8.25±0.3 with E(B-V) = 0.68±0.05 mag.

Czernik 25 (OCl 493; α_{2000}= 06h 13m 06s ; δ_{2000}= + 06^{o}59'00"; l = 202^o.31; b = -05^o.26): This group of stars was first listed as a cluster by Czernik (1966) who mentioned that it is spread over an angular diameter of 7 arcmin with 44 stars as its members. It is classified as II 2 p in the Trumpler system of classification (Ruprecht, 1966). No other data is available in CDS and in WEBDA. The numbering of the stars in this cluster has been introduced for the first time in this work.

2. Observations and reductions

The first CCD UBVRI photometric observations of the two open clusters NGC 1857 and Czernik 25 were carried out on 28 November 2003 by using the 2 meter Himalayan Chandra Telescope at Indian Astronomical Observatory located at Hanle. The observations were obtained with the help of the remote control facilities available at CREST, Hosakote (near Bangalore, India) employing the LN2 cooled 2k $\times$ 2k CCD with the HFOSC (Himalayan Faint Object Spectrograph and Cam-

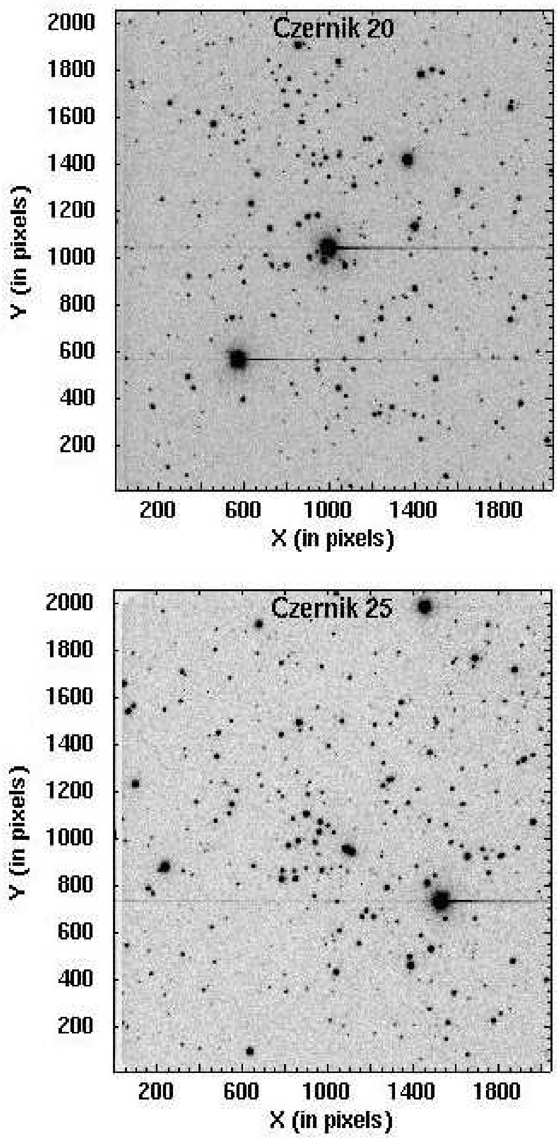

Figure 1. Finding chart for the clusters NGC 1857 (indicated as Czernik 20) and Cz 25. North is towards the bottom and East is towards the right side of the charts.

era) at the Cassegrain focus. The 0.296 arcsec pixel^{-1} plate scale resulted in a field of view of 10.10×10.10 arcmin^2. The well known open cluster M67 was also observed on the same night for calibration of the instrument. The practice of obtaining at least two frames for each filter was followed during the observations. The journal of observations is given in Table 1.

Table 1. Log of observations.

Date	Object	Filter	UT	Airmass	Exp. Time (sec)	Date	Object	Filter	UT	Airmass	Exp. Time (sec)
28 Nov 2003	NGC 1857	U	16 30	1.263	60	28 Nov 2003	Cz 25	U	17 48	1.245	120
		U	16 36	1.245	120			U	17 54	1.227	120
		U	16 41	1.227	120			B	18 04	1.195	20
		B	16 53	1.195	20			B	18 08	1.188	10
		B	16 55	1.188	10			V	18 14	1.179	5
		B	16 59	1.179	5			V	18 19	1.170	2
		V	17 03	1.170	2			R	18 24	1.159	5
		V	17 08	1.159	5			R	18 28	1.152	0.7
		V	17 10	1.152	0.7			R	18 31	1.144	1
		R	17 14	1.144	1			I	18 35	1.132	5
		R	17 20	1.132	5			I	18 39	1.125	0.5
		R	17 23	1.125	0.5						
		I	17 27	1.118	0.5		Cz 25 field	I	21 51	1.537	5
		I	17 31	1.112	1			V	21 56	1.569	20
		I	17 34	1.106	5			B	21 59	1.590	45
	NGC 1857 field	I	18 50	1.113	20		M67	U	-	-	120x2
		V	18 56	1.110	30			B	-	-	15x2
		B	19 00	1.105	60			V	-	-	5x2
								R	-	-	2x2
								I	-	-	2x2

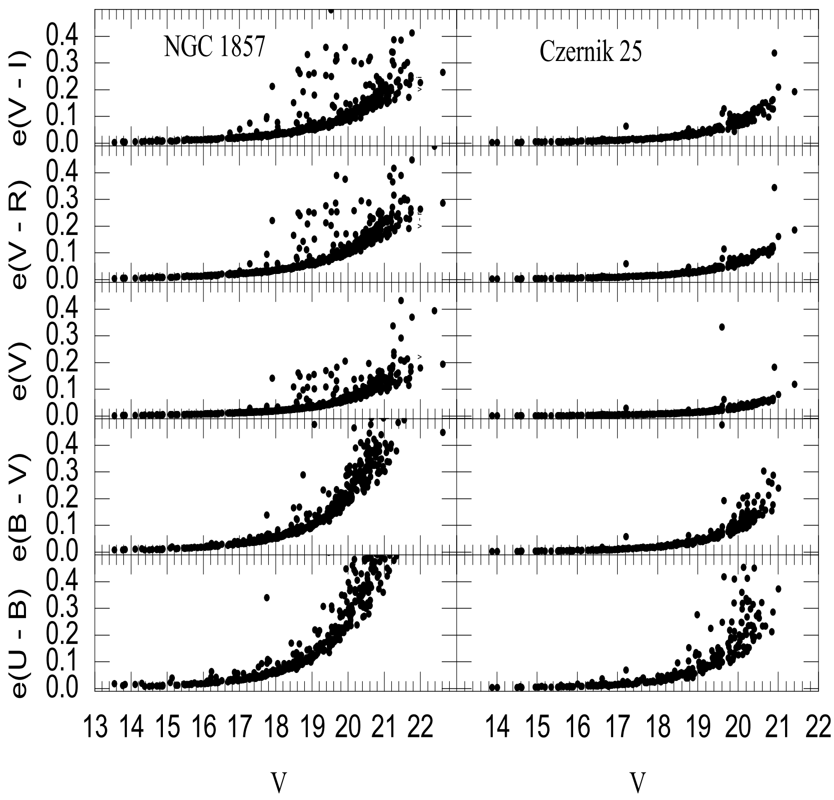

Figure 2. The DAOPHOT errors in the colour indices and V magnitude as function of V.

The individual magnitudes (denoted by lower case u, b, v, r, i) of stars, normalized for 1s of time was obtained by following the usual reduction procedure with the IRAF packages of CCDRED and DAOPHOT using the point spread function (PSF) method (Stetson, 1987). These magnitudes were corrected for the atmospheric extinction to obtain the instrumental magnitudes which are denoted with the subscript 'o'. The instrumental corrections were then applied for obtaining the standard magnitudes and colours (denoted by upper case UBVRI) of the stars in each frame by employing the photometric calibrations drawn from the observations of M67 as given below.

$(B - V) = 0.921 \pm 0.025 (b - v)_o - 0.330 \pm 0.035$
$(V - v_o) = -0.040 \pm 0.003 (B - V) - 0.604 \pm 0.025$
$(U - B) = 1.077 \pm 0.030 (u - b)_o - 2.190 \pm 0.070$
$(V - R) = 0.989 \pm 0.020 (v - r)_o - 0.126 \pm 0.010$
$(V - I) = 0.989 \pm 0.018 (v - i)_o - 0.381 \pm 0.010$
$(B - I) = 0.960 \pm 0.011 (b - i)_o - 0.143 \pm 0.022$

The standard magnitudes and colours of the cluster stars thus derived are given in Table 2. A sample of it is presented here. The entire data will be available only in electronic form at WEBDA open cluster database website at http://obswww.unige.ch/webda/. It can also be obtained from the authors.

The photometric errors in these colour indices along with those in V magnitudes are shown in Fig. 2 as a function of V mag. It may be clearly seen that these errors become large (≥0.1 mag) for stars fainter than V = 19 mag in NGC 1857 and for stars fainter than V=20 mag in Cz 25. However, as expected, the errors in the (U-B) colour index become somewhat higher than the others. Thus the measurements of those stars that are brighter than such magnitudes are considered as more reliable.

3. Completeness factor

To derive the reliable cluster parameters, it is necessary to check for the completeness of the photometric data. Owing to the stellar crowding on the CCD frames, not all stars of a given frame may be detected. Therefore, the completeness of the data was assessed by repeatedly running the ADDSTAR task in the V and I frames of the clusters and the corresponding comparison field regions. About 10% of the number of detected stars were added in each luminosity bin of 1 mag at random positions. Then the photometric routines were run on these images in the same manner as it was done on the original frames and the completeness factor (CF) was estimated as the ratio between the number of artificial stars recovered and the total number of stars added per each bin. For determining the CF and using it for the correction of data incompleteness, a number of methods have been described by various authors (*cf.* Stetson 1987; Mateo, 1988; Sagar and Richtler, 1991; Banks et al, 1995). We have adopted the procedure given by Sagar and Richtler (1991) as this method recovered the actual LF better with a mean error of about 4 percent up to CF > 50% (Mateo, 1988). The CF in V frame is found to be minimum in each magnitude bin as compared to that in I frame and is tabulated in Table 3. Following the procedure described by Sneh Lata (2005), these CF values have been used to correct the apparent magnitude distributions of the stars in the respective frames of the clusters as well as in the corresponding comparison fields.

4. Cluster radial profile

Having obtained the completeness factor, it is now necessary to obtain the knowledge of the radial extent of the cluster. To determine this, one has to know the cluster centre, which is defined as the location of maximum stellar density of the cluster's area. It is found by fitting Gaussian to the profiles of star counts in X and Y pixels as shown in Fig. 3. Using this method the estimated centre is found to be at (966±34, 1048±29) and (1132±54, 1091±55), for NGC 1857 and Cz 25 respectively. The corresponding celestial coordinates for NGC 1857 are RA(2000): 05h 20m 06.3s ; Dec(2000): +39d 20m 31s and for Cz 25 it is at RA(2000): 06h 13m 43.7s ; Dec(2000): +06d 56m 26s. In the case of NGC 1857 the spatial stellar distribution shows a clear central

Table 2. Sample of the standardised UBVRI photometric data for individual stars in the open clusters under study. The V magnitude and colours are in mag.

X (in pixels)	Y (in pixels)	ID	V	(U-B)	(B-V)	(V-R)	(V-I)
NGC 1857							
1058.995	225.828	1	17.405	0.853	1.000	0.645	0.549
935.918	238.354	2	17.483	0.340	0.509	0.338	0.153
720.119	246.176	3	20.980	0.579	1.165	0.732	0.946
731.930	258.943	4	20.636	0.178	1.468	0.953	1.024
945.880	258.107	5	20.416	0.682	0.906	0.110	0.445
1094.062	259.101	6	20.604	0.413	0.957	0.731	0.633
1228.223	260.481	7	18.711	0.519	0.655	0.433	0.291
	*	*	*	*	*	*	*
	*	*	*	*	*	*	*
Cz 25							
987.622	318.820	1	18.552	0.684	1.288	0.685	0.772
770.825	319.873	2	17.023	0.423	1.075	0.613	0.623
866.358	332.644	3	17.640	1.013	1.555	0.854	1.069
693.552	338.424	4	18.011	1.160	1.322	0.737	0.761
999.752	371.947	5	19.508	0.634	1.258	0.706	0.800
759.657	391.166	6	18.690	0.430	1.034	0.591	0.568
774.351	393.832	7	20.045	0.695	1.079	0.622	0.676
	*	*	*	*	*	*	*
	*	*	*	*	*	*	*

Table 3. Completeness analysis results for the cluster data.

V range	Cluster NGC 1857	Field	V range	Cluster Cz 25	Field
14-15	100%	100%	14-15	100%	100%
15-16	100%	100%	15-16	100%	100%
16-17	100%	100%	16-17	100%	100%
17-18	98.5%	99%	17-18	97%	98%
18-19	93.5%	95%	18-19	94%	96%
19-20	82%	83%	19-20	85%	88%
20-21	61%	65%	20-21	61%	60%
21-22	52%	60%	21-22	52%	55%

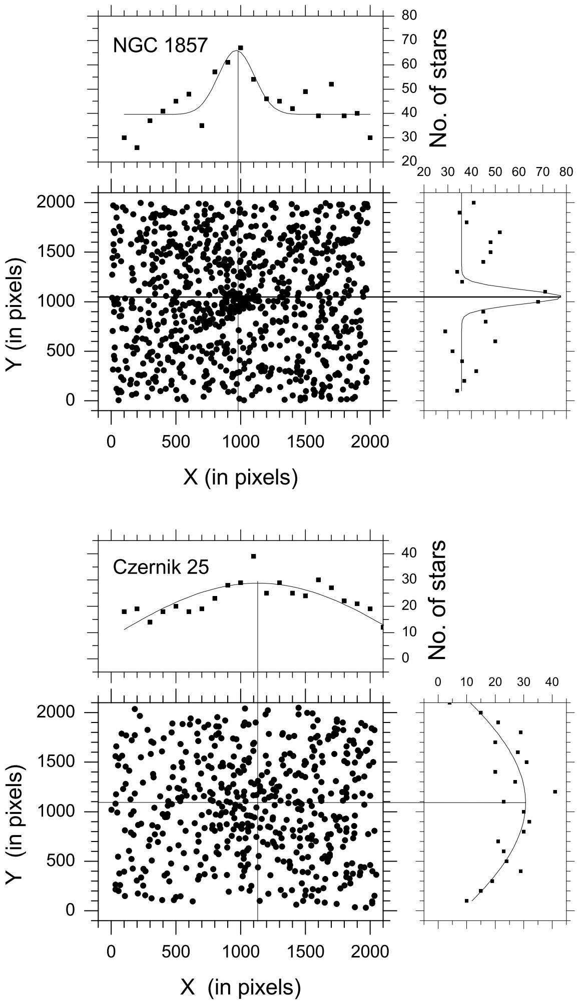

Figure 3. Profiles of stellar counts across NGC 1857 and Cz 25. The Gaussian fits have been applied to the X and Y profiles. The center of symmetry about the peaks of the two profiles is taken to be the position of the cluster center.

concentration of the cluster stars with an elongated morphology (Fig. 3). It may also be noted that the Gaussian distribution in the case of Cz 25 does not appear to merge with the background uniform field density (as in the case of NGC 1857) due to it being a detached poor cluster with little central concentration.

For determining the radial stellar density of stars, we adopted the method of dividing the given cluster area into a number of concentric annuli of 50 pixels wide around the estimated cluster center. Then the number of stars in these annuli are counted and divided by their respective

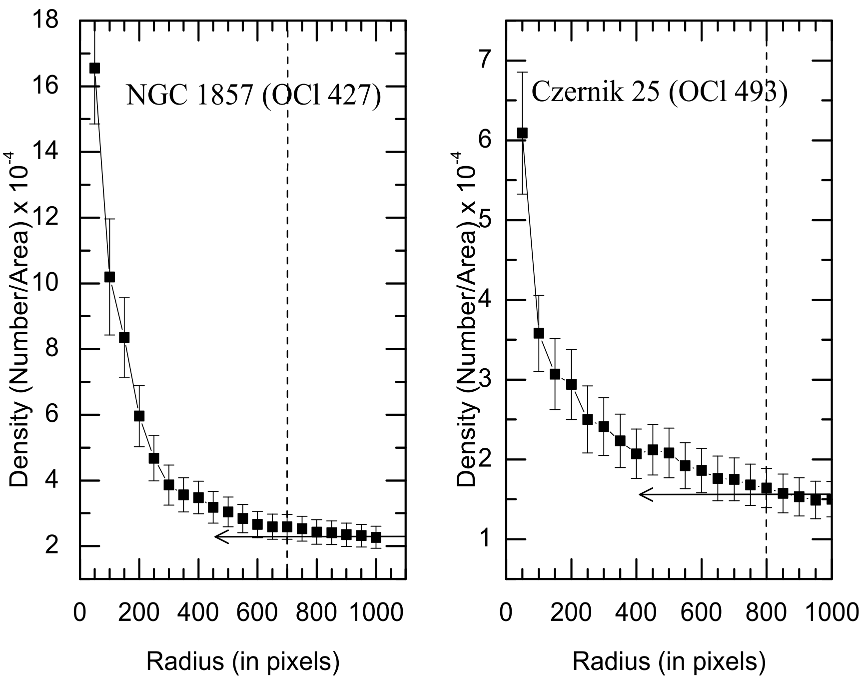

Figure 4. The stellar density profiles for the stars V ≤ 21mag in the region of NGC 1857 and Cz 25 as a function of radius from the adopted centre of the clusters. The arrows indicate the average stellar density of the observed field regions.

areas to obtain the stellar density in each annulus. Using this method it is found that both NGC 1857 and Cz 25 show a clear density gradient confirming the existence of clustering (Fig. 4). The same procedure was carried out for the respective field regions also and the average value of the stellar density is included in the diagram (shown as arrows in Fig. 4). From this figure of the density profiles, we can identify that the cluster radius extends up to 700 pixels (equivalent of 3.5 arcmin of the sky) for NGC 1857 and up to 800 pixels (equivalent of 4 arcmin of the sky) for Cz 25, beyond which it reaches the background field star density. Thus we adopted 3.5 and 4 arcmin respectively as the angular radius for NGC 1857 and Cz 25. The entire analysis for obtaining the various cluster parameters was carried out for the stars lying within this radius on all the CCD frames. The region outside this limit is taken as representative of the galactic field.

5. Interstellar extinction towards the clusters

The (B-V) vs (U-B) diagram of the stars in the respective fields of both the clusters showed a noticeable shift from the unreddened main sequence (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 $E(B-V)_{min}$ and $E(B-V)_{max}$ were found to be 0.38 and 0.60 mag for NGC 1857

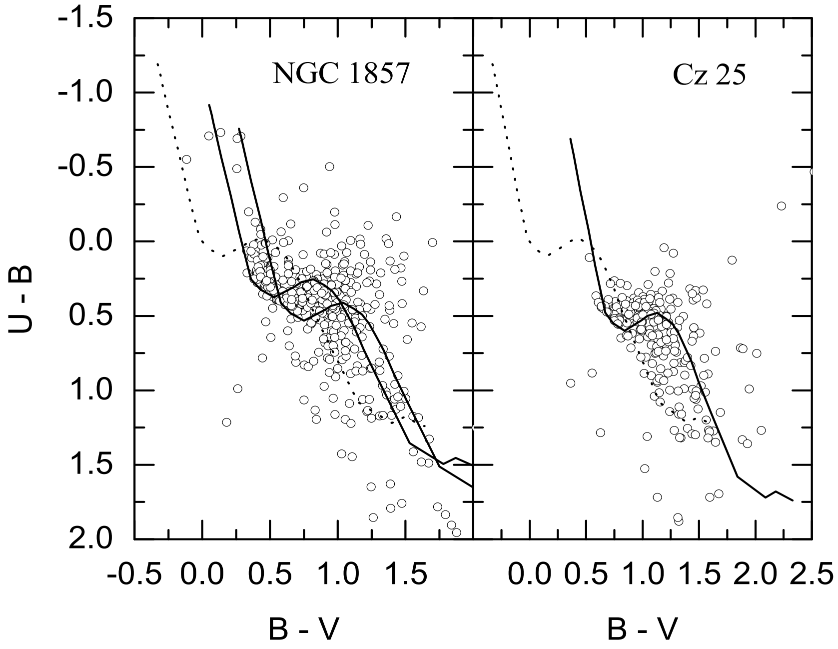

Figure 5. The colour-colour diagrams (CCDs) of stars located inside the adopted radius of NGC 1857 and Cz 25 respectively. The dashed curves in the figure are the ZAMS (Schmidt-Kaler, 1982). The solid curves represent the ZAMS, shifted parallel to the reddening line, by 0.38 and 0.60 mag in (B-V) indicating the minimum and maximum values of the colour excess E(B-V) for NGC 1857, while the value for Cz 25 is 0.69 mag.

and 0.69 mag for Cz 25 respectively (Fig. 5). Similarly the values of E(U-B)$_{min}$ and E(U-B)$_{max}$ were found to be 0.27 and 0.43 mag for NGC 1857 while it is 0.50 mag for Cz 25. This clearly indicates the presence of non-uniform extinction in the direction of NGC 1857 while in the case of Cz 25 it appears to be constant. It may be noted here that Colegrove et al. (1994) estimated a slightly larger value of E(B-V) for NGC 1857.

The major causes for the spread in the observed sequence have been outlined by Burki (1975), who pointed out that all the physical and observational causes put together may produce only a small spread which may be termed as natural dispersion. It was also mentioned that the differential extinction across the field of the cluster, if present, would however be the cause for a much larger spread. Thus, as the difference between E(B-V)$_{max}$ and E(B-V)$_{min}$ is found to be considerably larger for NGC 1857, a variable extinction across the field of this cluster could be envisaged and mean values were applied to (U-B) and (B-V) colours of such stars which are determined to be the cluster members (see Sect. 6). However, for Cz 25, a single value for (B-V) and a corresponding value for (U-B) were used for the corrections. For the estimation of extinction in the other two colour indices (V-R) and (V-I), we have used the relation E(V-R) = 0.60 E(B-V) as given by He et al. (1995) and Cardelli et al. (1989), while the relation E(V- I) = 1.25 E(B-V) is taken from Dean et al. (1978).

Then, using the respective mean E(B-V) values, the corresponding values of A_v in the direction of each cluster, were obtained from the expression A_v=R x E(B-V), where R is the ratio of total-to-selective absorption, taken to be 3.1. The A_v values thus obtained were used for correcting the observed V values. These interstellar extinction corrected colours and magnitudes are denoted by the upper case UBVRI with the subscript 'o'.

6. Cluster membership

The extinction corrected colour-magnitude diagrams (CMDs) of NGC 1857 and Cz 25 are shown in Fig. 6 along with their respective comparison field regions. These comparison fields were chosen in such a way that they cover equal sky surfaces as the corresponding clusters. Both clusters exhibit clear main sequences, with the cluster NGC 1857 showing the presence of some bright red stars that could be the evolved members of that cluster.

Normally, a most reliable cluster membership may be obtained by knowing the proper motions and radial velocities of the cluster stars. However, in the absence of such data for NGC 1857 and Cz 25 we have used the classical photometric criterion by a detailed comparison of the stellar positions in all the photometric diagrams (e.g., Sujatha & Babu, 2006; Baume et al, 2003) for stars brighter than $V_o \sim 15$ mag. On the other hand, for the stars which are fainter than $V_o \sim$ 15 mag we have used the statistical method described by Sagar & Joshi (1978) (see Sect. 8).

7. Distances and ages

The distance modulii of the two clusters have been estimated by fitting the relevant zero age main sequences (ZAMS) given by Schmidt-Kaler (1982) onto the respective CMDs of $(U\text{-}B)_o$ vs V_o and $(B\text{-}V)_o$ vs V_o. In addition, for the $(V\text{-}I)_o$ vs V_o diagram, the ZAMS is taken from Walker (1985), while the procedure given by Caldwell et al. (1993) is used for obtaining the ZAMS of $(V\text{-}R)_o$ vs V_o diagram (*cf.* Fig. 6). Then by considering only the members and the probable members, the respective CMD's are constructed and the ages of the clusters have been obtained by comparing the distance-modulus-corrected-CMDs (*cf.* Fig. 7) with the theoretical isochrones.

7.1 NGC 1857 (OCl 427)

The upper part of Fig. 6 which shows the CMDs for NGC 1857, yielded the distance modulus of 13.8±0.3 mag, which corresponds to the distance of 5.75±0.8 kpc. At this distance, considering the angular diameter of the cluster to be 7 arcmin, its linear diameter is estimated as ~11.7 pc. It may be noted that the distance obtained in the present work is closer to that given by Babu (1989) than the estimation given by Cuffey (1937), which appears to be somewhat underestimated.

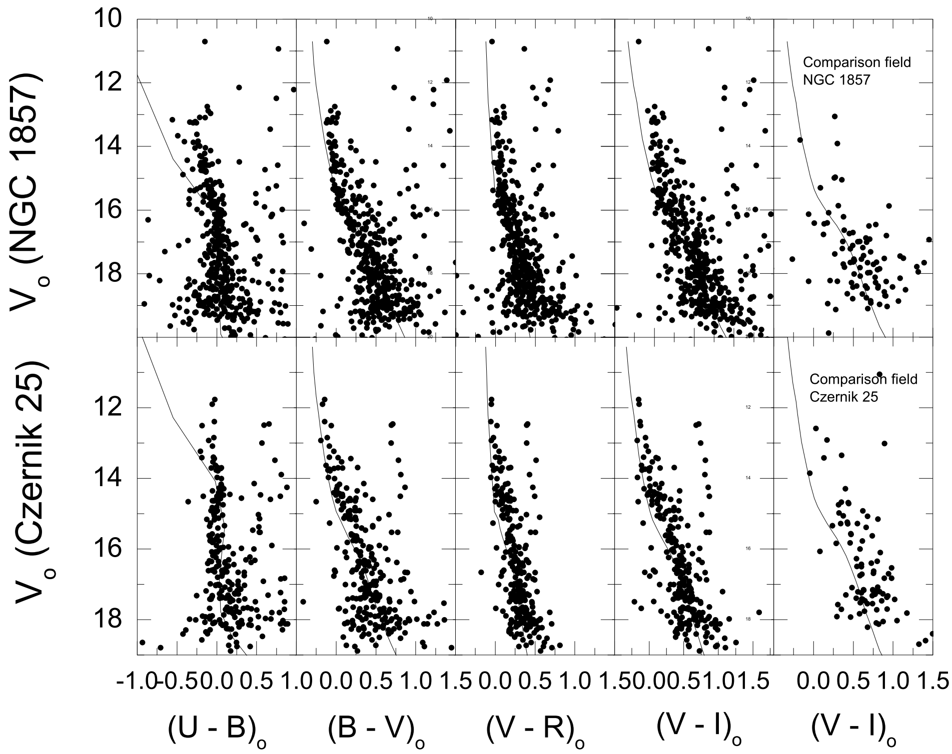

Figure 6. Extinction corrected colour-magnitude diagrams (CMDs) of stars located inside the adopted radius of NGC 1857 and Cz 25. The solid curves in the CMDs of $(U\text{-}B)_o$ vs V_o and $(B\text{-}V)_o$ vs V_o are the Schmidt-Kaler (1982) empirical ZAMS. For the $(V\text{-}I)_o$ vs V_o diagram, the ZAMS is taken from Walker (1985), while the procedure given by Caldwell et al. (1993) is used for obtaining the ZAMS of $(V\text{-}R)_o$ vs V_o diagram. $(V\text{-}I)_o$ vs V_o diagrams for stars of the respective comparison field regions are also shown.

By superimposing the theoretical isochrones of Z = 0.019 given by Girardi et al. (2000) on to the cleaned distance-modulus-corrected-CMDs, the logarithmic value of the age of this cluster has been found to be in the range of 8.0-8.25 (Fig. 7). The log(age) has also been estimated on the basis of the relationship between age and the earliest $(B\text{-}V)_o$ on the main sequence of the cluster (Allen, 2000). This $(B\text{-}V)_o$ is found to be -0.058 mag for NGC 1857 and yields a log(age) = 7.9 which is close to the lower limit of the ages obtained through isochrones. It may also be seen that the age estimate given by Colegrove et al. (1994) matches well with the upper limit of age found in the present work.

7.2 Czernik 25 (OCl 493)

The CMDs for Cz 25 are shown in the lower part of Fig. 6, from which a distance modulus of 13.4±0.2 mag was obtained. This corresponds to the distance of 4.79±0.5 kpc, which yields the

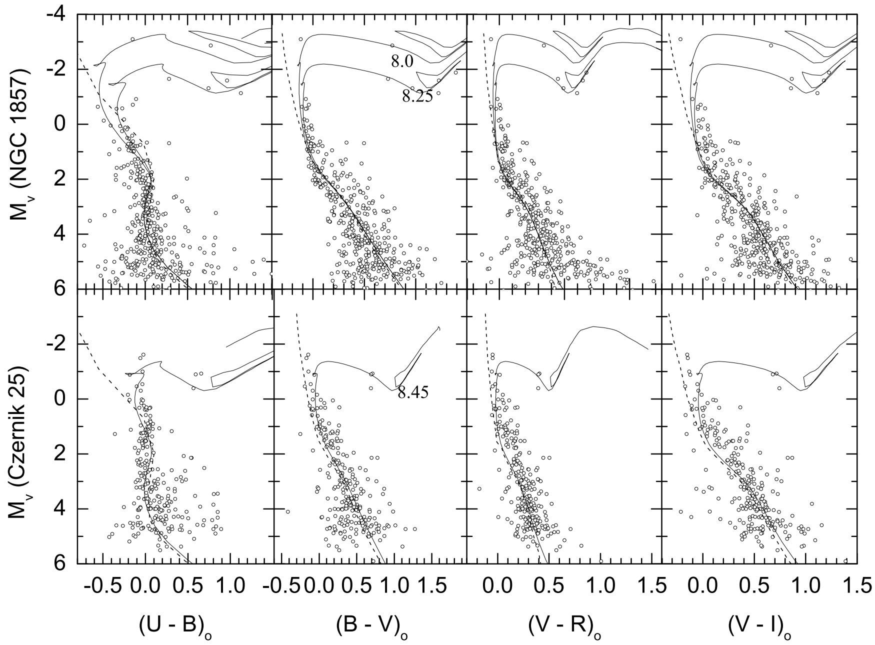

Figure 7. The various cleaned CMDs of the open clusters NGC 1857 and Cz 25 are shown in this figure. The ZAMS is indicated as dashed line in each CMD. The solid curves shown for NGC 1857 are the isochrones of log age 8.0 and 8.25 as seen from top and similarly for Cz 25 the solid curve is of log age 8.45 taken from Girardi et al. (2000). The ZAMS for the CMDs of (U-B)$_o$ vs V$_o$ and (B-V)$_o$ vs V$_o$ are taken from Schmidt-Kaler (1982). For the (V-R)$_o$ vs V$_o$ diagram, the ZAMS is taken from Walker (1985), while the procedure given by Caldwell et al. (1993) is used for obtaining the ZAMS of (V-I)$_o$ vs V$_o$ diagram.

linear diameter of the cluster as ∼11.2 pc by adopting the cluster angular diameter to be 8 arcmin. The theoretical isochrones of Z = 0.019 given by Girardi et al. (2000) are plotted onto the cleaned distance-modulus-corrected-CMDs of Cz 25 to obtain its age, which has been found to be of log (age) 8.45 (Fig. 7).

8. Luminosity function and mass function

After correcting the distribution of stars for completeness (see Section 3), the apparent luminosity function (LF) for stars brighter than V$_o$ = 15 mag is derived in both the clusters by directly counting them in luminosity bins of 1 mag each. On the other hand, for obtaining the brightness distribution of the stars fainter than V$_o$ = 15 mag, we have used the statistical method (Sagar & Joshi, 1978) of computing the apparent magnitude distribution of stars located in the comparison field regions of 1 mag bins and subtracting the same from a similar distribution of the respective cluster regions. The resulting apparent LFs for the clusters NGC 1857 and Cz 25 are shown in Figure 8.

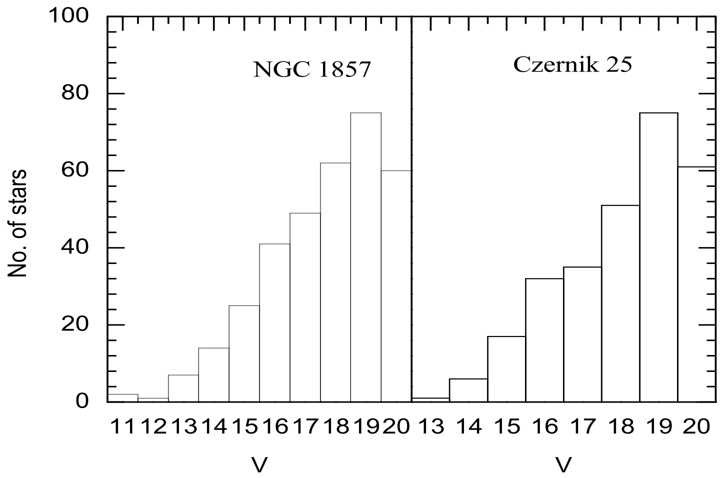

Figure 8. The apparent LFs of the open clusters NGC 1857 and Cz 25.

The mass function (MF) which is the number of stars formed over the mass interval at the same time in a given region of space (Scalo, 1986) has been well studied by Salpeter (1955) for the stars of mass range 1-10 $M_\odot$ from the luminosity function of the present day field stars assuming a constant rate of star formation and correcting for the stellar evolution.

It is represented as

$$\frac{dN}{dM} \propto M^{-\alpha}$$

where $\alpha = 2.35$. The steep slope of the MF indicates that the number of low-mass stars is greater than the high-mass ones.

In the present work, for the computation of MF, the masses have been estimated for the cluster members by using the stellar mass-luminosity relation. For this purpose, the following procedure is considered.

The masses of the stars have been estimated from the isochrones (Girardi et al., 2000) of metallicity Z = 0.019 for NGC 1857 and Cz 25. Then the polynomial equations of second degree have been used for two ranges of luminosities of each cluster, as shown below:

NGC 1857	$M/M_\odot = 3.48\text{-}0.87\ M_v + 0.003\ M^2_v$	$(1 \leq M_v < 4)$
	$M/M_\odot = 2.26\text{-}0.28\ M_v + 0.009\ M^2_v$	$(4 \leq M_v < 10)$
Czernik 25	$M/M_\odot = 3.12\text{-}0.76\ M_v + 0.067\ M^2_v$	$(1 \leq M_v < 4)$
	$M/M_\odot = 1.89\text{-}0.19\ M_v + 0.004\ M^2_v$	$(4 \leq M_v < 10)$

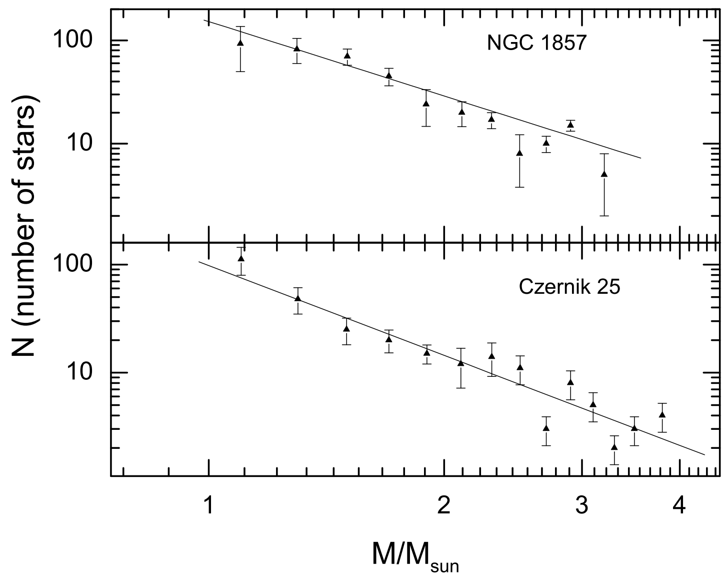

Figure 9. Mass Functions of NGC 1857 and Cz 25. The slopes of the MF are found to be -2.39±0.26 for NGC 1857 and -2.70±0.25 for Cz 25.

The resulting scatter plot is displayed in Fig. 9. It shows the number of stars in the range of 0.9-3.5 $M_\odot$ for NGC 1857 and 1.0-4.0 $M_\odot$ for Cz 25. Using the least-squares fit, the slopes of the MF are found to be -2.39±0.26 for NGC 1857 and -2.70±0.25 for Cz 25. These values are in good agreement with that given by Salpeter (1955).

9. Mass segregation and dynamical relaxation time

An examination of the distribution of masses of the stars along the radius of the cluster showed a clear segregation of mass in both the clusters, with the massive stars located at the central part of the cluster. To check whether the existing mass segregation is due to dynamical evolution or imprint of star formation process, we need to estimate the dynamical relaxation time. The dynamical relaxation (T_E) is the time in which the individual stars exchange energies and their velocity distribution approaches a Maxwellian equilibrium. Because of dynamical relaxation, low mass stars in a cluster may possess largest random velocities trying to occupy a large volume than the high mass stars do (*cf.* Mathieu and Latham, 1986). In the present study, we have used the relation given by Spitzer and Hart (1971) to compute the dynamical relaxation time for the clusters.

$$T_E = \frac{8.9x10^5 N^{1/2} R_h^{3/2}}{< m >^{1/2} \, log(0.4N)}$$

where R_h is the radius containing half the cluster mass, N is the number of cluster members and $< m >$ is the average mass of the cluster stars. Assuming that the R_h is equal to half of the cluster radius in linear units estimated in this study, we have adopted R_h = 2.93 pc and 2.79 pc respectively for the clusters NGC 1857 and Cz 25. Then estimating the mean mass $< m >$ as 1.50 $M_\odot$ for NGC 1857 and 1.60 $M_\odot$ for Cz 25 and calculating the values of N based on the LF of the individual clusters, we computed T_E = 34.05 Myr for NGC 1857 and 27.0 Myr for Cz 25. As N and $< m >$ are lower and upper limit approximations respectively, the values of T_E obtained may be considered as lower estimates.

Comparing the values of T_E with the cluster ages we find Age/$T_E \approx 5$ and 11 respectively for NGC 1857 and Cz 25, indicating that NGC 1857 is not as affected by dynamical effects as Cz 25. Since the values of the T_E are smaller than the respective cluster ages it may be inferred that both the clusters are dynamically relaxed and the mass segregation effect due to dynamical evolution must be important.

10. Conclusions

The interstellar reddening is found to be higher in the direction of the cluster Cz 25 with an E(B-V) value of 0.69 mag compared to the mean value of 0.49 mag in the direction of NGC 1857. The open cluster NGC 1857 is located at a distance of 5.75±0.8 kpc and is spread over a linear diameter of ~11.7 pc, while Cz 25 is placed at 4.79±0.5 kpc from the Sun with its linear diameter as ~11.2 pc. Both the clusters are of intermediate age, in the log (age) range of 8.0 to 8.45 in the direction of the Perseus arm of the Galaxy.

The LF and MF are determined by applying the corrections of data incompleteness and field star contamination. The LF of both the clusters show a gradual increase towards low luminosity stars from the high luminosity ones with a deficiency of stars after V_o = 19 mag. The mass of individual stars in both the clusters are found to lie between 0.8 and 4 $M_\odot$. The values of MF slopes are -2.39±0.26 for NGC 1857 and -2.70±0.25 for Cz 25 which are in good agreement with the Salpeter value. The observed mass segregation in both the clusters could be due to the dynamical evolution or imprint of star formation process or both.

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