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UBVI photometric study of open star clusters Ruprecht 25 and Czernik 6

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ABSTRACT

We present a *UBVI* CCD photometric study of two open star clusters Ruprecht 25 and Czernik 6 using the data taken with 104-cm Sampurnanand telescope, ARIES, Nainital, India. The optical CCD data for these clusters are obtained for the first time. The clusters radii are found to be 2′.4 and 1′.5. Using two colour $(U-B)$ versus $(B-V)$ diagram we have estimated the reddening as $E(B-V)=0.55\pm0.05$ mag for Ruprecht 25 and 0.48 ± 0.05 mag for Czernik 6, while the corresponding distances are 5.8 ± 0.5 and 5.0 ± 0.3 kpc. Ages of 800 ± 80 Myr for Ruprecht 25 and 40 ± 10 Myr for Czernik 6 are determined using the stellar isochrones of metallicity $Z=0.019$. We have also determined the relaxation time for the clusters Ruprecht 25 and Czernik 6. Our analysis indicates that both clusters are dynamically relaxed. This may be due to the dynamical evolution or imprint of star formation itself or both.

1. Introduction

Open clusters (OCs) are excellent tools to the study of Galactic structure, dynamical evolution and star formation processes in the Milky Way Galaxy. Colour magnitude and colour-colour diagrams of OCs play very important role in the derivation of cluster's fundamental parameters, such as ages, distances, reddening and metallicity. These parameters can help us to constrain theories of star formation and dynamical evolution of the Galaxy (Lynga, 1982; Janes and Phelps, 1994; Friel, 1995; Piskunov et al., 2006).

Number of known OCs in the Milky Way Galaxy are ~3000 (Kharchenko et al., 2013). At present, fewer than half of them have been studied with the aim to derive their fundamental parameters. To examine how the disc properties evolved with time, we must improve the statistics of well-studied OCs. In fact, greater the number of OCs with well determined parameters, the more precise detailed analysis of the structure of the Galactic disc as well as their evolution over time can be done.

Old or intermediate open clusters show mass-segregation effect and it could be due to their dynamical evolution. But recently, some young OCs which are too young to be relaxed dynamically, mass segregation is observed (Lada and Lada, 1991). This is because of heavy mass stars forming towards the cluster center and lower mass stars formed surrounding them (Testi et al., 1999). Hence, it is still a matter of investigation whether mass segregation is the result of dynamical evolution or is an imprint of star formation process itself.

In the light of above discussions we aim to investigate the two poorly studied open star clusters Ruprecht 25 and Czernik 6. The *UBVI CCD* photometric data for these two clusters are presented for the first time. The basic parameters taken from Dias et al. (2002), based on 2*MASS* data are listed in Table 2. Ruprecht 25 and Czernik 6 are located in third and second Galactic quadrant respectively. Both clusters are situated towards the Galactic anti-centre direction. Czernik 6 is younger while Ruprecht 25 is intermediate age open cluster. Czernik 6 has been studied by Camargo et al. (2009), by using 2*MASS JHKs* data. To our knowledge, there is no study available in the literature on these clusters.

The layout of the paper is as follows. Section 2 presents the observational material and data reduction. In Section 3, we described the derivation of different fundamental parameters of the clusters. Mass-segregation of the clusters are described in Section 4. Finally, results are summarized in Section 5.

2. Data collection and reduction

The *UBVI* broad band CCD photometric observations of two open star clusters Ruprecht 25 and Czernik 6 were carried out using 104-cm Sampurnanand Telescope located at Aryabhatta Research Institute of Observational Sciences (ARIES), Manora peak, Nainital, India. Images were collected using a $2K\times2K$ CCD with

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1384-1076/

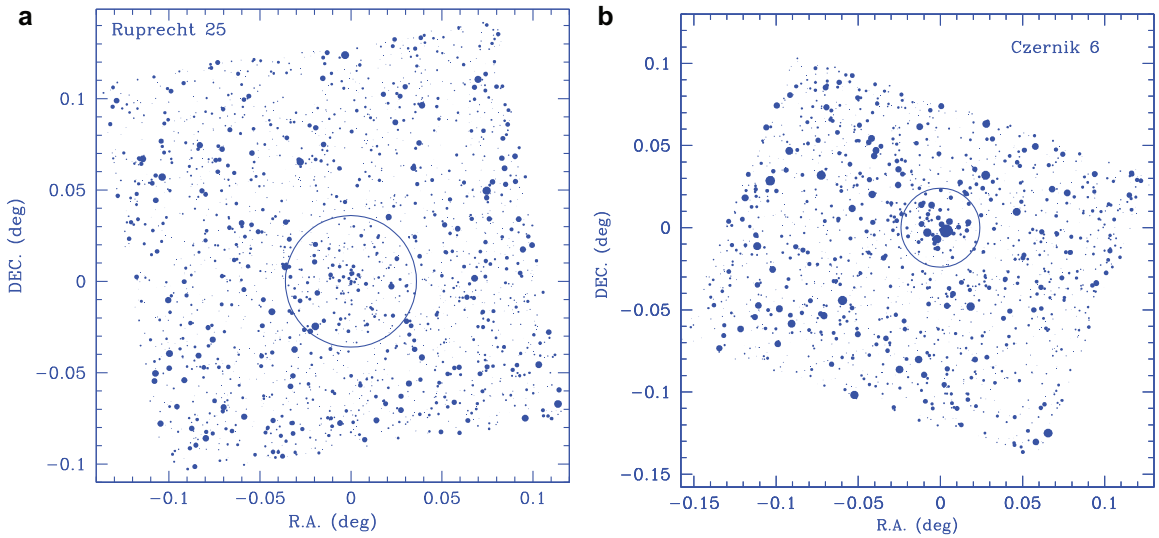

Fig. 1. Finding chart of the stars in the cluster and field regions of Ruprecht 25 and Czernik 6. Filled circles of different sizes represent the brightness of the stars. The smallest size denotes stars of $V \sim 21$ mag. The open circle represents the radius of the cluster

pixel size 24 μm. The scale was 0″.36 pixel^{-1} giving 12′.6 on a side. The CCD gain was 10 e$^-$/ADU while the read out noise was 5.3 e$^-$. To improve the S/N ratio, the observations were made in 2 $\times$ 2 pixel binning mode. The observational information alongwith dates are listed in Table 2. Identification maps of the observed regions of the clusters are shown in Fig 1.

We have taken many bias and flat-field frames during the observations. Flat-field exposures were made of the twilight sky in each filter. The CCD images were reduced using computing facilities available at ARIES, Nainital. Initial processing of the data were done using the IRAF[1] data reduction package. Photometry of cleaned images was carried out using DAOPHOT/ALLSTAR (Stetson, 1987) packages. The instrumental magnitudes were obtained through quadratically varying point spread function (PSF).

We observed the standard field PG0918 and SA98 (Landolt, 1992) in *U, B, V* and *I* pass-band for calibrating the instrumental magnitudes into standard magnitudes. The standard stars considered in the calibrations have brightness and colours range $11.93 \leq V \leq 15.67$ and $-0.27 < (B-V) < 1.90$ respectively. For the extinction coefficients we have taken the typical values for the ARIES site. Calibration of the instrumental magnitude to standard system was done using procedure outlined by Stetson (1992). The photometric calibration equations used are as follow:

$$u = U + Z_U + C_U(U-B) + k_U X$$
$$b = B + Z_B + C_B(B-V) + k_B X$$
$$v = V + Z_V + C_V(B-V) + k_V X$$
$$i = I + Z_I + C_I(V-I) + k_I X$$

where *u, b, v* and *i* are the aperture corrected instrumental magnitudes and *U, B, V* and *I* are the output standard magnitudes and *X* is the air mass. The color coefficients (*C*) and zero-points (*Z*) obtained by us for different filters are listed in Table 3. The errors in zero points and colour coefficients are ~0.01 mag for Ruprecht 25 and ~0.03 mag for the cluster Czernik 6 in *B, V* and *I* pass band. The internal errors derived from DAOPHOT in *U, B, V* and *I* magnitudes, are plotted with *V* magnitude in Fig. 2. This figure shows that photometric error is $\leq$ 0.02 mag at $V \sim 20^{th}$ mag for *B, V* and *I* filters while it is $\leq$ 0.09 mag for *U* filter. Photometric global (DAOPHOT+Calibration) errors are also determined, which is listed in Table 4. For the *V* filter, the errors are ~0.05 at $V \sim$ 20th mag. The final photometric data are available in electronic form at the WEBDA site [2] and also from the authors.

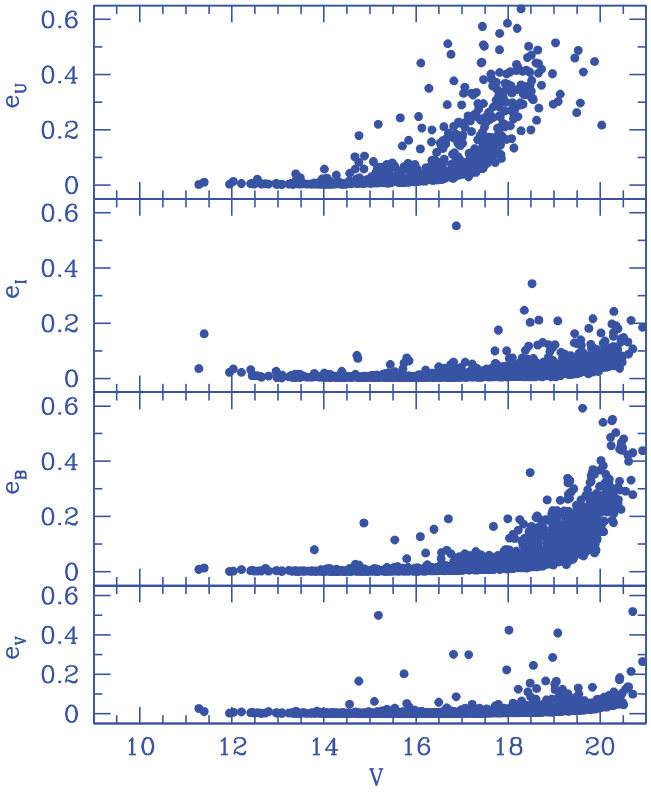

Fig. 2. Photometric errors in *U, B, V* and *I* magnitudes against *V* magnitude. Errors on the y-axis represent the internal errors as estimated by the DAOPHOT routine.

[1] IRAF is distributed by the National Optical Astronomical Observatory which are operated by the Association of Universities for Research in Astronomy, under contract with the National Science Foundation.

[2] http://obswww.unige.ch/webda/