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# CCD photometry of the galactic open cluster NGC 2309

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## 1. Introduction

The comparison between the observed HR diagram of the clusters and the isochrones computed by means of evolutionary models provides a test for stellar structure and evolution. To get fundamental information for above mentioned studies the knowledge of reddening, distance, age and other parameters is necessary which can be derived from the colour-magnitude diagrams (CMDs) and colour-colour diagram (CCDs) of the clusters.

## 2. Observations and Reductions

The observations of the cluster NGC 2309 (C0655-071, l=219°.86, b=–2°.25) were carried out in UBVRI passbands using a cryogenically cooled Tektronix Thompson CCD chip having 24μ square 1024×1024 pixels chip at f/13 Cassegrain focus of the 104-cm Sampurnanand reflector of the U.P. State Observatory (UPSO) during November-December 1993. The observations were taken in the UBVRI passbands down to V~21.5 mag. Multiple exposures were taken with exposure times ranging from 10 sec to 1800 seconds depending on the presence of bright stars and filter used. The frames were coadded in order to achieve a total integration time of 10800 Sec in U, 6300 Sec in B, 3000 Sec in V, 200 Sec in R and 400 Sec in I filter. To improve S/N ratio the observations were taken in the binning mode of 2×2 pixel$^2$. In this set up the entire CCD chip covers a field of 6' × 6' of the sky. In addition we have also observed two nearby fields towards east and north of the cluster to estimate the extent of field star combination.

The data were reduced using the computing facilities available at the UPSO, Nainital. ESO MIDAS software package was used to obtain clean images. The cleaned frames in each filter having similar exposure times were coadded. The photometry was done using the DAOPHOT profile-fitting software (Stetson 1987). For each frame differential magnitude and colours were obtained using the observed magnitudes of the comparison star. These differential magnitudes were then standardised using the following transformation equations for the CCD system and for calibration purposes Landolt's (1983) standard stars were observed.

$$\Delta(U-B) = 0.919 \times \Delta(u-b) \pm 0.007$$

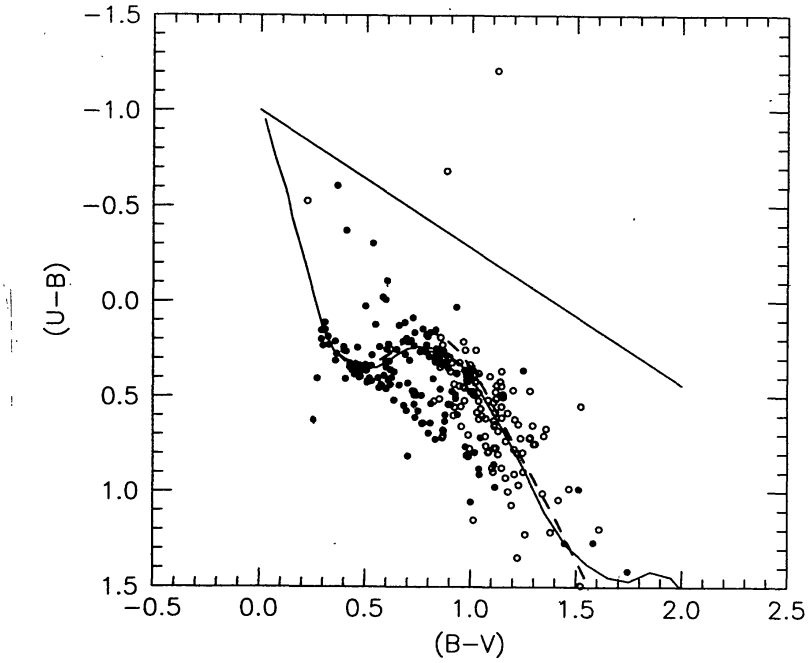


**Figure 1.** The colour-colour (U-B, B-V) diagram for the stars in cluster region. Filled and open circles are representing stars with V<17 and V>17 respectively. The ZAMS has been adjusted for E(B-V) = 0.31. Solid and dashed curves are for Schimdt-Kaler and Cameron (1985) ZAMS respectively. Straight line in this figure has slope=0.72.

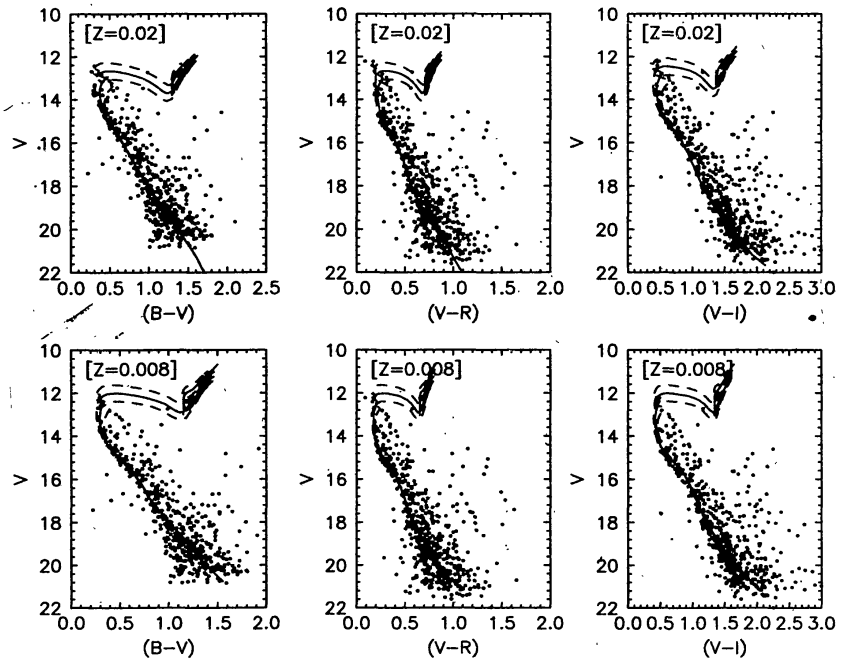


**Figure 2.** The comparison of theoretical isochrones of Bertelli (1994) for Z=0.02 and Z=0.008 with CMDs of NGC 2309.

$$\Delta(B\text{-}V) = 1.116 \times \Delta(b\text{-}v) \pm 0.008$$
$$\Delta(V\text{-}R) = 0.994 \times \Delta(v\text{-}r) \pm 0.007$$
$$\Delta(V\text{-}I) = 0.980 \times \Delta(v\text{-}i) \pm 0.008$$

## 3. Discussion and conclusions

1. CCD photometry of cluster NGC 2309 in UBVRI passbands have been made down to V~21.5. A comparison with the nearby fields indicates that probable cluster member stars have magnitude V<17. The stars fainter than V<17 mag are probably field stars.

2. Using the zero age main sequence (ZAMS) given by Schmidt-Kaler (1982) and a slope of E(U-B)/E(B-V) = 0.72 (Johnson & Morgan 1953) we find a good fit for a value of E(B-V)=0.31±0.05 mag.

3. Comparision of the observed CMDs with the convective overshoot models (Bertelli et al. 1994) having a metallicity Z=0.02 and Z=0.008 gives and age of ~ 0.4-0.6 Gyr for the cluster.

4. While comparing the isochrones having Z=0.02 we have used the ratio E(V-I)/E(B-V)=1.25 and E(V-R) = 0.6xE(B-V). Whereas, for the isochrones having Z=0.008 we have to use the ration E(V-I)/E(B-V)=1.42. This ratio is different from that (E(V-I)/E(B-V) = 1.25) given by Dean et al. (1978). This comparison suggests that if adopted reddening value is correct, the choice of isochrones having Z=0.02 is more reasonable. The comparison of isochrones with the CMDs also suggests that isochrones having Z=0.02 produce a better fit to the data.

5. If we adopt solar metallicity for the cluster, apparent distance modulus corresponds to a distance of 2.56 ± 0.25 Kpc. The uncertainty in distance determination is estimated from the errors in R, E(B-V) and the error in fitting the ZAMS.

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## References

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