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Anomalous reddening law in the galactic giant H II region NGC 3603

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Abstract. We present the results of CCD photometry of open cluster associated with the galactic giant H II region NGC 3603. The aim of the paper is to examine interstellar extinction law in the region. It is found that the law of the intra-cluster extinction in NGC 3603 is anomalous. In front of the cluster the reddening law is normal.

Keywords: H II region - anomalous reddening

1. Introduction

NGC 3603 is the most massive visible giant H II region (GHR) in our galaxy. In short, NGC 3603 is a clone (slightly small scaled) of 30 Dor in the LMC. This active star forming region is of great interest to test the different hypotheses concerning the origin and evolution of star clusters. Photometry for this cluster has been obtained by Sher (1965), van den Bergh (1978), Melnick and Grosbøl (1982), Moffat (1983) and Melnick et al. (1989). Recently Moffat et al. (1994) and Drissen et al. (1995) have reported HST observations of the cluster.

Chini and Krügel (1983) found evidences for a higher value of R (ratio of total to selective extinction) in many H II regions. The value of R is an important quantity that must be known accurately to determine the stellar distances. The aim of this paper is to present CCD UBVRI and H_α photometry of the cluster and to analyse the extinction law in this region.

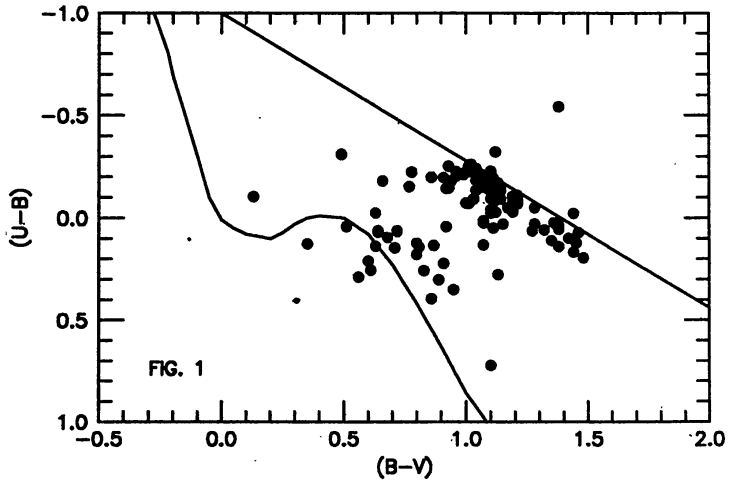
2. Observations and data reduction

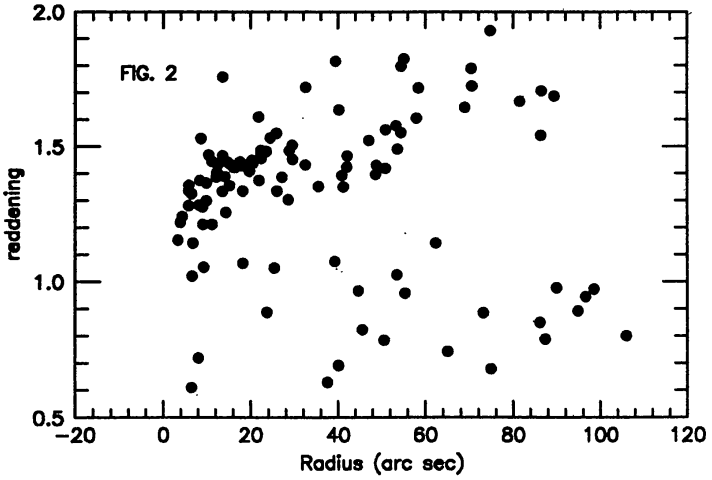
The observations of NGC 3603 were carried out in the continuum, U,B,V,R,I bands and in H_α using a RCA CCD chip having a size of 320×512 pixels, at the f/16 Cassegrain focus of the 1.0 metre telescope of the SAAO, on the night of April 3, 1994. Each pixel of the CCD corresponds to 0.39 arc sec. The exposure times were 900, 600, 450 seconds in the U,B,V bands respectively and 300 seconds in the H_α, continuum and R,I bands. The photometry of

the stars was performed using the DAOPHOT profile fitting software (Stetson 1987). Transformations to the standard UBV system were obtained using the UBV magnitudes given by Melnick et al. (1989). The colours (v-i) and (v-r) are given in the instrumental system and these colours have been used to check whether the extinction in the NGC 3603 is normal or anomalous. A comparison of the present data with the photometry given by Melnick et al. (present - Melnick et al.) gives $\Delta V = 0.01 \pm 0.07$ (s.d.), $\Delta(B-V) = 0.00 \pm 0.06$ and $\Delta(U-B)=0.00\pm0.11$. There is no systematic trend in the comparison. The large standard deviation probably arises due to the nebulous background.

3. Extinction

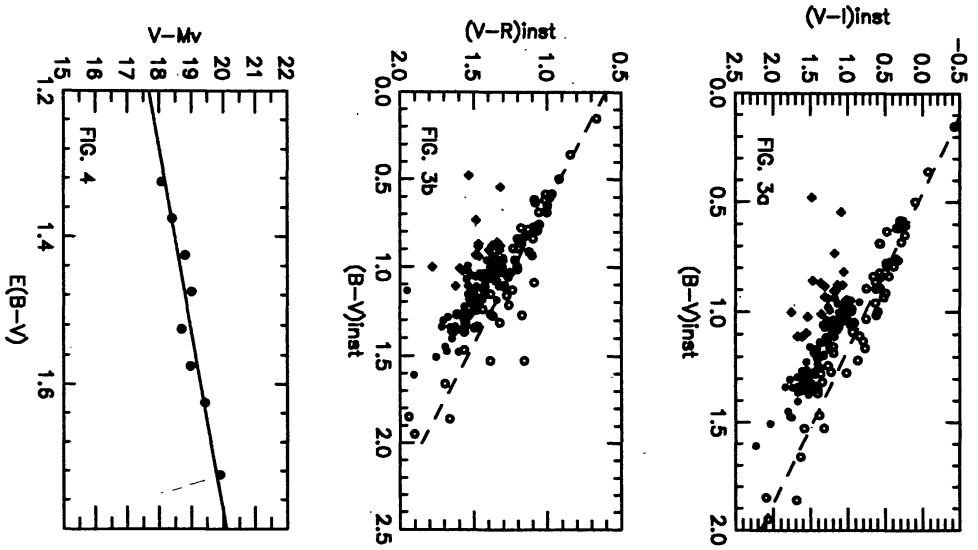
The (U-B, B-V) diagram (Fig. 1) shows that field stars are well separated from the cluster stars which are distributed along the line of slope roughly similar to that of reddening line. The radial variation of reddening in the cluster field is shown in Fig. 2. The remarkable features of the diagram are the variation in reddening with maximum at radius ~30" and 70". This feature was not observed by Melnick et al. (1989). The implication of the Fig. 2 may be that the core of the NGC 3603 is surrounded by two dust rings situated at radius 30" and radius 70".





4. The extinction law

It has been shown by Chini and Wargau (1990) that two - colour - diagrams (TCDs) of the form (V-X) vs. (B-V), where X denotes one of the broad band filters (R,I,J,H,K,L) between 0.7 and 3.7μm, provide an effective method of separating the influence of the normal extinction produced by the interstellar medium from an abnormal extinction arising within a dense region. The TCDs can distinguish between foreground stars (reddened by normal dust) and embedded stars (affected in addition by a special reddening law). Fig. 3 shows the V-R/B-V and V-I/B-V TCDs. An inspection of TCDs shows three distinct group of objects: i) Stars (open circles) follow the dashed line. These are foreground stars reddened by normal interstellar dust. ii) Stars (filled circles), which fall consistently below the dashed line in both the TCDs; their locations can also be represented by a straight line having a tilt against the normal reddening line. iii) Objects (open diamonds) located further left to the lines in both the TCDs indicate stars having IR - excess. To derive the value of $R_{cluster}$ (total to selective extinction in the cluster region) we used the approximate relation,



$$R_{cluster} = \frac{m_{cluster}}{m_{normal}} \times R_{normal} ,$$

where $m_{cluster}$ and m_{normal} are the slopes of the lines followed by cluster stars and normal stars respectively. The value of $R_{cluster}$ comes out to be ~ 4.3.

The differential extinction method (Turner 1976) can also be applied to derive the value of R. However, contamination by field stars produces some complications. In order to discriminate the field stars from the cluster members, we used a type of colour - magnitude diagram in which extinction free magnitude P= V-R(B-V) is plotted against a reddening - free colour Q = (U-B) -0.72 (B-V). The P-Q diagram has been used by Ogura and Ishida (1981) in case of a few H II regions. We drew several P-Q diagrams with R=3.1 to 6.0. The value of X is taken to be 0.72. The probable main sequence (MS) stars were selected for each P-Q diagrams and it was found that probable MS stars are almost the same in each case. The resultant variable - extinction diagram is shown in Fig. 4. We used the ZAMS - fitting version of the method. Apparent distance modulii V-M_v have been derived by using the ZAMS given by Schmidt - Kaler (1982). In Fig. 4 the stars were grouped in 0.5 mag bin of E (B-V). Mean value of (V-M_v) for each E(B-V) bin was obtained and these are plotted as a function of mean value of E(B-V). A least square fit to the points gives a value of R~4.4, which is in agreement with the value obtained from TCDs.

5. Conclusions

1) The reddening is minimum near the cluster centre, implying lower column density near the centre of the cluster.

2) The extinction law for the cluster NGC 3603 is found abnormal having R~4.3.

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