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POSTER PAPER

NGC 5288: an open cluster with a low-density extended coronal region located beyond the Carina spiral arm

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Abstract. We present CCD BVI images of 15688 stars in the field of the previously unstudied open cluster NGC 5288. The cluster has a core of angular size $\sim$ 1.3' and a low-density extended coronal region of $\sim$ 6.3'. Using theoretical isochrones and adopting Z = 0.040, which provides the best global fit, we derive an age of (130 $\pm$ 35) Myr, E(B-V) = 0.75, E(V-I) = 0.95 and V-M_V = 14.00. The cluster is located at (2.1 $\pm$ 0.3) kpc from the Sun beyond the Carina spiral arm. Using CCD VI data published for the open cluster NGC 5381, its fundamental parameters are derived for the first time. The properties of some open clusters aligned along the line-of-sight of NGC 5288 and others of similar ages to NGC 5288 are examined. Evidence is presented that the latter ones did not form mainly along the spiral arms but rather in the thin disc (Z $\sim$ $\pm$ 100 pc).

Resumen. Presentamos imágenes BVI de 15688 estrellas en el campo de NGC 5288, un cúmulo abierto aún no estudiado. NGC 5288 posee un núcleo de $\sim$ 1.3′ de radio angular y una región coronal extendida de $\sim$ 6.3′. Usando isócronas teóricas y adoptando Z = 0.040, valor con el cual se obtiene el mejor ajuste global, resulta una edad de (130 $\pm$ 35) millones de años, excesos de color E(B-V) = 0.75 y E(V-I) = 0.95 y un módulo de distancia V-M_V = 14.00. El cúmulo está ubicado a (2.1 $\pm$ 0.3) kpc del Sol más allá del brazo espiral de Carina. Usando datos CCD VI publicados para NGC 5381, se determinan por primera vez los parámetros fundamentales de este cúmulo. Se examinan las propiedades de cúmulos abiertos ubicados en la misma dirección que NGC 5288 y en particular de aquéllos con una edad similar a éste. Se concluye que estos últimos no se formaron a lo largo de los brazos espirales sino más bien en el disco delgado (Z $\sim$ $\pm$ 100 pc).

1. Structural cluster features

CCD images of NGC 5288 were obtained with the Johnson B and V and Kron-Cousins I filters using the 0.9 m telescope at CTIO (Chile). The telescope was equipped with a 2048x2048 pixels Tektronix CCD (scale 0.4"/pixel). The cluster center was determined statistically by fitting stellar density profiles and by applying a method described by Piatti et al. (2005). From the stellar density

cluster profile we estimated a cluster radius of (950 ± 50) pixels (∼ 6.3′ ± 0.3′). NGC 5288 has a relatively small but conspicuous nucleus of ∼ 200 pixels (∼ 1.3′) and a low-density extended corona. The existence of coronae in open clusters is well documented. Nilakshi et al. (2002) showed that the corona can exist from the very beginning of cluster formation and that dynamic evolution is not the reason for its occurrence. They also found that the average value of the ratio between the annular width of the corona and the core radius is 4.3 ± 1.9. For NGC 5288, we derived a ratio of 3.6, which is in good agreement with the above mentioned value.

2. Colour-magnitude diagrams and fundamental cluster parameters

The resulting (V,B-V) (Fig. 1, left) and (V,V-I) CMDs reveal a crowded broad sequence of stars that traces the cluster main sequence (MS) along ∼ 6 mag. No clump of red stars is visible. Most of the field stars are grouped in a redder sequence roughly shifted from the cluster MS that extends fairly parallel to it. In spite of the relatively low densities in the cluster coronal region, it contains ∼ 75 % of the cluster members. Fig. 1 (right) shows circular extracted (V,B-V) CMDs with radii of 200 and 950 pixels for the cluster core and core plus corona region, respectively (upper panels), and r > 1000 pixels for the star field region (lower right panel). Similarly extracted (V,V-I) CMDs were also built. To differentiate the sequences of the cluster core from field CMDs, we first overplotted the fitted ZAMS of Lejeune & Schaerer (2001) on the upper left CMDs. Then, we drew by eye the field star sequence using the lower right extracted CMDs and, finally, we added the adjusted ZAMS to these extracted field CMDs. The differences between the two sequences are Δ(B-V) ∼ 0.1-0.2 mag and Δ(V-I) ∼ 0.2-0.3 mag. To eliminate field stars in the CMDs we applied the statistical method described by Piatti et al. (2003). The upper right and lower left panels of Fig. 1 (right) illustrate the application of this method and show the r < 950 pixel CMDs before and after the cleaning process.

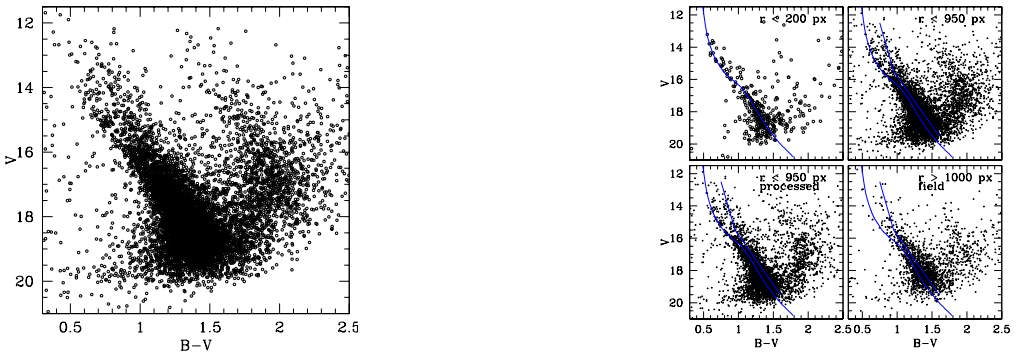

Figura 1. *Left*: (V,B-V) CMD for NGC 5288. *Right*: (V,B-V) CMDs for different extracted circular regions. The Geneva ZAMS (Z = 0.04) and the fiducial MS of the cluster surrounding field are shown.

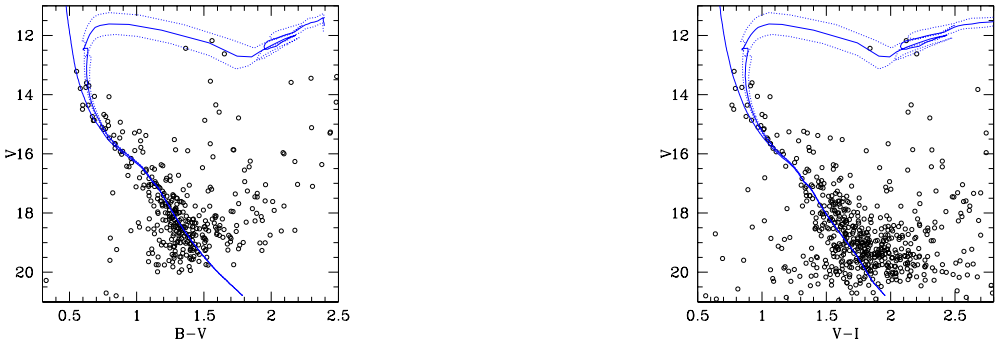

Figura 2. Field cleaned (V,B-V) and (V,V-I) CMDs for NGC 5288. The Geneva ZAMS and isochrones of log t = 8.00, 8.10 and 8.20 for Z = 0.04 are overplotted.

To estimate the cluster fundamental parameters, we chose the r < 200 pixel CMDs. Note that most bright stars defining the cluster turnoff are not spread all over the cluster area, core plus corona, but are concentrated in the core region. We fitted theoretical isochrones computed by Lejeune & Schaerer (2001) to the observed CMDs. Using Z = 0.008, 0.020 and 0.040, we derived colour excesses and distance moduli in each case. Although the ZAMSs for the three distinct metallicities fit the lower MS very well, that for Z = 0.040 is the one which best continues the non-evolved star sequence. The isochrone of log t = 8.10 (t = 130 Myr) turned out to be the one which most accurately reproduces the cluster features in the two CMDs. To match this isochrone, we used E(B-V), E(V-I) and V-M_V of 0.75, 0.95 and 14.00, respectively. In Fig. 2 we overplotted the ZAMS and the isochrone of log t = 8.10 (solid lines) for Z = 0.040 on the cluster CMDs, and two additional isochrones of log t = 8.00 and 8.20 for comparison purposes (dotted lines). The derived E(V-I)/E(B-V) ratio shows an excellent agreement with the value 1.25 from the normal reddening law. If we adopt the most frequently used value for the A_V/E(B-V) ratio (Straižys 1992), we determine for NGC 5288 a distance from the Sun of (2.1 ± 0.3) kpc.

3. Comparison with other Galactic open clusters

28 open clusters were found in WEBDA to be located at $(l,b)_{NGC\,5288}$ ± 5°, among them NGC 5381. Pietrzyński et al. (1997) performed CCD VI observations of NGC 5381 with the aim of searching variable stars in the cluster field. However, they did not derive the cluster parameters. Using their VI data and the same method as for NGC 5288, we determined for NGC 5381 the following basic parameters: E(V-I) = 0.65 ± 0.05 and V-M_V = 13.25 ± 0.25, which turned into E(B-V) = 0.52 ± 0.05 and d = (2.1 ± 0.4) kpc, if we assume E(V-I)/E(B-V) = 1.25 and A_V/E(B-V) = 3.2. We also derived an age of 450 Myr for Z = 0.040.

The top left panel of Fig. 3 shows the distribution of the selected clusters and NGC 5288 in the Galactic (X,Y) plane. We indicate with an arrow BH 144, located at 12 kpc. Note that the distance between the outermost and innermost

clusters is nearly 12 kpc and that NGC 5288 is located behind the Carina spiral arm. The top right panel shows the relation between the visual absorption and the distance from the Sun. Note that the absorption in the direction of NGC 5288 appears not to be much more pronounced than the one along the direction of Baade's window (solid line). The bottom left panel shows the distribution in the (X,Y) plane of 66 open clusters with ages similar to that of NGC 5288, i.e., 8.0 $<$ log t $<$ 8.2. The circle centered at the Sun's position has a radius of 2 kpc. NGC 5288 is one of the two most distant inner disc clusters (we use the solar circle to distinguish between inner and outer disc clusters). The bottom right panel shows the clusters projected on to the Galactic (Z,X) plane. By looking at both bottom panels, we conclude that clusters of that age range did not form preferentially along the Galactic spiral arms, but in the thin disc (Z $\sim \pm$ 100 pc).

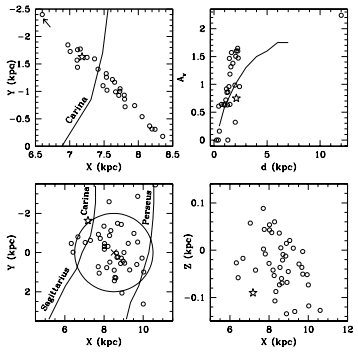

Figura 3. *Top*: Relations between the Galactic coordinates X and Y (*left*), and the distance from the Sun and the visual absorption of known open clusters in the direction of NGC 5288 (*right*). Selected clusters and NGC 5288 are represented by open circles and by an open star, respectively. *Bottom*: Relation between the Galactic coordinates X,Y and Z of open clusters with ages in the range log t = 8.0-8.2. A circle of 2 kpc radius centered at the Sun's position is drawn in the bottom left panel. The Galactic center position is given by (X,Y,Z)=(0,0,0).

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