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The overall properties of intermediate-age galactic open clusters: fundamental parameters of NGC 2627

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Abstract. We present CCD VI_{KC} and CMT_1 photometry in the field of the open cluster NGC 2627. A mean cluster metallicity of [Fe/H] = -0.12 ± 0.08 was derived from four Washington abundance indices. Through comparison of the cluster CMDs with theoretical isochrones, we derived reddening, distance and age. We examined the overall properties of the intermediate-age open clusters and we identified four peaks of cluster formation at 0.7-0.8, 1.0-1.1, 1.6-1.7 and 2.0-2.1 Gyr. A radial abundance gradient of -0.08 dex kpc^{-1} was derived, but no clear evidence for a Z gradient was found.

Resumen. Presentamos fotometría CCD VI_{KC} y CMT_1 en el campo del cúmulo abierto NGC 2627. Cuatro índices de abundancia del sistema de Washington implican [Fe/H] = -0.12 ± 0.08. A partir de la comparación de los diagramas CM con isócronas teóricas derivamos enrojecimiento, distancia y edad. Un análisis de las propiedades globales de todos los cúmulos abiertos de edad intermedia permitió identificar 4 picos de formación estelar ocurridos entre hace 0.7-0.8, 1.0-1.1, 1.6-1.7 y 2.0-2.1 miles de millones de años. Estimamos además un gradiente radial de abundancia de -0.08 kpc^{-1} y no encontramos evidencia sobre la existencia de un gradiente en Z de abundancia.

1. Introduction

Two main reasons justify a revision of the parameters of NGC 2627. Firstly, the E(B-V) values determined in previous CCD works range from 0.05 (Ahumada 1995) to 0.63 (Ramsay & Pollaco 1992, RP92), while the distances vary from 1.91 kpc (Janes & Phelps 1994, JP94) to 3.31 kpc (RP92). Secondly, there exists no agreemen between the ages previously estimated, the different values ranging from 300 Myr (RP92) to about 2.8 Gyr (JP94).

2. The colour-magnitude diagrams

We obtained CCD images of NGC 2627 with the V, I_{KC} and Washington C, M and T_1 filters, using the CTIO 0.9-m telescope. Details on the reduction procedures are given in Piatti et al. (2003). Fig. 1 (left) shows a schematic finding chart of the cluster field built with all the measured stars in the V band. We divided the field CMD into boxes of 0.5 and 0.05 mag in V and V-I, respec-

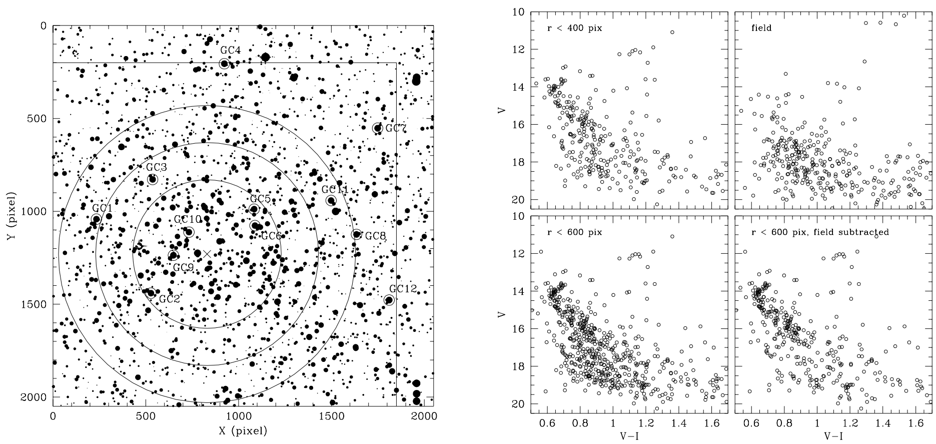

Figure 1. *Left:* Schematic finding chart of stars observed in NGC 2627. North is up and East is to the left. The 12 bright red giant candidates discussed here are identified. *Right:* (V,V-I) CMD for extracted regions as indicated in each panel.

tively. We then counted the number of stars in each box and subtracted from the circular extraction CMDs a number of stars ($N_{i,j}$) given by the expression: $N_{i,j} = (A_i/A_f)N_{f,j}$ where $N_{f,j}$ is the number of field stars counted in the j^{th} box and A_f and A_i represent the areas covered by the surrounding field and circular extraction, respectively. In Fig. 1 (right), the lower panels illustrate the application of this method, and show the r < 600 pixel CMD before and after applying the cleaning process. We used the cleaned r < 600 pixel CMD to derive the cluster fundamental parameters. In the (T_1,C-T_1) CMD, the cluster main sequence (MS) appears even more clearly defined and the turn-off presents a smoother curvature.

3. Cluster fundamental parameters

To estimate the basic cluster parameters we fitted isochrones computed by Lejeune & Schaerer (2001) to the observed (V,V-I) CMD. We thus derived E(V-I) = 0.25 ± 0.05 and V-M_V = 11.80 ± 0.25 for log t = 9.15 and Z = 0.02. Fig. 2 (left) shows, with a solid line, the isochrone that best resembles the cluster features, and two additional isochrones to illustrate the combination of varying ages and metallicities in the fitting procedure. The log t = 9.15 isochrone appears to tightly fit possible cluster stars placed in the transition path from the MS to the giant clump. By using E(V-I)/E(B-V) = 1.33 and A_V/E(B-V) = 3.2, we obtained E(B-V) = 0.19 ± 0.05 and a distance from the Sun of d = (1.7 ± 0.4) kpc. In the Washington CMD, the best fit is achieved for log t = 9.10, assuming solar metal content. From this fit we derive E(C-T_1) = 0.23 ± 0.07 and T_1-M_{T1} = 11.85 ± 0.25. By using the E(C-T_1)/E(B-V) and A_{T1}/E(B-V) ratios given by Geisler et al. (1996), we obtained E(B-V) = 0.12 ± 0.07 and V_o-M_V = 11.5 ± 0.4 (equivalent to 2.0 ± 0.4 kpc), in good agreement with those arising from the

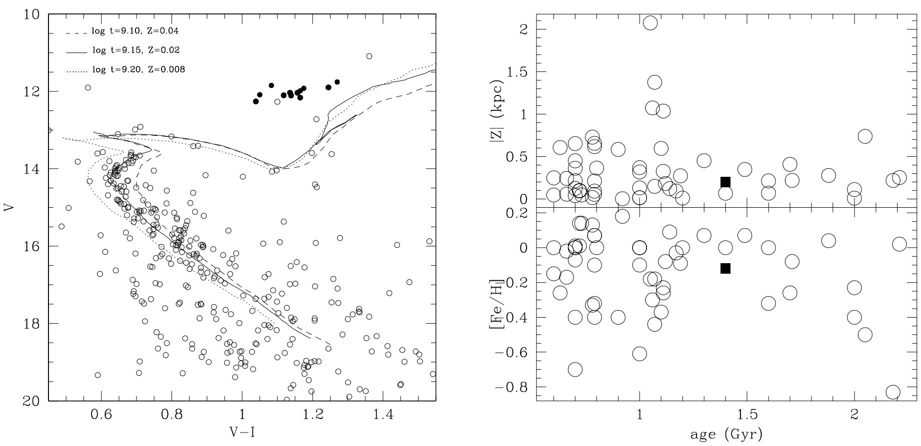

Figure 2. *Left:* (V,V-I) CMD for stars in NGC 2627. Geneva group's isochrones are overplotted. Full circles represent giant candidates discussed in Section 3. *Right:* Relations between cluster heights and metallicities as a function of cluster ages. Open circles are 54 selected IACs, while the filled square represents NGC 2627.

VI data. To derive the cluster metal content we applied the method described by Geisler et al. (1991, GCM91), taking into account the criterion suggested by Piatti et al. (2003). We have not employed here the iso-abundance relation between M-T_1 and T_1-T_2 on account of the fact that the resulting abundance in this case is not consistent with the ones obtained using the other four relations. The resulting values for 8 red clump stars are $[Fe/H]_1 = 0.04 \pm 0.04$, $[Fe/H]_3 = 0.14 \pm 0.06$, $[Fe/H]_4 = -0.27 \pm 0.02$ and $[Fe/H]_5 = -0.18 \pm 0.04$, if the GCM91 calibrations are used. We averaged the four derived [Fe/H] values by assigning double weight to the $[Fe/H]_4$ and $[Fe/H]_5$ values and adopted for NGC 2627 a weighted mean value $<[Fe/H]> = -0.12 \pm 0.08$ (σ_p), where σ_p is the standard deviation of the mean.

4. Discussion

We define here as intermediate-age clusters (IACs) those objects with ages between 0.6 and 2.5 Gyr and compiled a list of galactic IACs from a search in the WEBDA data base. IACs appear to have heights |Z|, with few exceptions, from the galactic plane up to 0.5 kpc (Fig. 2, right), which means that most of them were born and moved within the thin disc. Indeed, to reach higher |Z| values, clusters should preferably be born in the thick disc; otherwise, they would need high initial perpendicular velocities, which are unlikely for objects confined near the galactic plane. The sampled IACs do not show any relation between their metal abundances and their ages (Fig. 2, right), but there is some indication that they were born in different epochs more or less distinguishable from the disc lifetime, rather than in a continuous cluster formation process. Particularly, we identified peaks of cluster formation at 0.7-0.8, 1.0-1.1, 1.6-1.7 and 2.0-2.1 Gyr, separated by relatively quiescent epochs of 0.2-0.3 Gyr long.

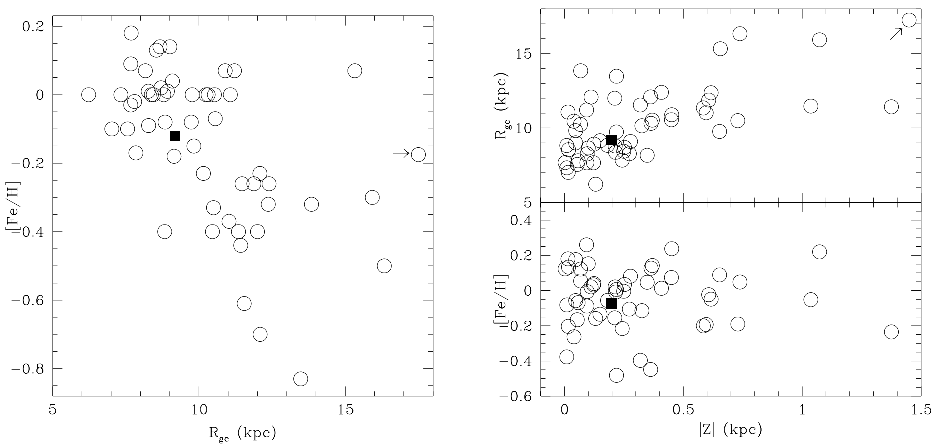

Figure 3. *Left:* Metallicity versus Galactocentric distance for 54 selected IACs. Symbols are the same as in Fig. 2 (right). *Right:* Relations of cluster Galactocentric distances and metallicities as a function of cluster heights. Symbols are the same as in Fig. 2 (right).

From Fig. 3 (left), we estimated a metal abundance radial gradient of (-0.08 $\pm$ 0.02) dex kpc^{-1}, in very good agreement with the most frequently derived values for the galactic disc. Clusters with $|Z| > 0.5$ kpc are located beyond 10 kpc from the galactic centre (Fig. 3, right). However, clusters can also be found far from the galactic center and near or in the galactic plane. In spite of such correlation, cluster metallicities do not seem to behave similarly with respect to |Z|. Once the [Fe/H] ratios are corrected for the radial gradient, a considerable dispersion only arises from the [Fe/H] versus |Z| diagram (bottom panel in Fig. 3, right) for IACs. The [Fe/H] versus |Z| relation of Fig. 3 (right) shows that metal-poor and metal-rich clusters are found at long or short distances from the galactic plane.

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