Asociación Argentina de Astronomía
BAAA, Vol. 51, 2008
G. Dubner, D. García Lambas, A. Piatti & F. A. Bareilles, eds.

PRESENTACIï¿½N MURAL

First estimates of the fundamental parameters of the very small open cluster Ruprecht 1

A.E. Piatti[1,4], J.J. Clariá[3,4], M.C. Parisi[3,4], A.V. Ahumada[2,3,4]

(1) IAFE, Buenos Aires, Argentina
(2) European Southern Observatory, Chile
(3) Observatorio Astronómico, Universidad Nacional de Córdoba, Argentina
(4) CONICET, Argentina

Abstract.
New CCD observations with the Washington C and T_1 filters in the field of the open cluster Ruprecht 1 are presented. The cluster turned out to be very small, its linear radius being 2.6 ± 0.2 pc. Ruprecht 1 is moderately reddened [E(B-V) = 0.25] and moderately young (∼ 230 Myr). Heliocentric distances of 1.9 ± 0.4 kpc and 1.5 ± 0.3 kpc are determined for Z (metallicity) = 0.02 and 0.008, respectively, although evidence is presented favouring a solar metal content rather than a subsolar one. We compare the cluster properties with those of known open clusters located within 1 kpc around it.

Resumen.
Presentamos nuevas observaciones CCD con los filtros C y T_1 del sistema de Washington en el campo del cúmulo abierto Ruprecht 1. Este objeto resultó ser muy pequeño, siendo su radio lineal de 2.6 ± 0.2 pc. Ruprecht 1 está moderamente enrojecido [E(B-V) = 0.25] y es moderadamente joven (∼ 230x10^6 años). Se determinan distancias heliocéntricas de 1.9 ± 0.4 kpc y 1.5 ± 0.3 kpc para Z (metalicidad) = 0.02 y 0.08, respectivamente, aunque se presenta evidencia que favorece una metalicidad solar antes que subsolar. Comparamos las propiedades de Ruprecht 1 con las de cúmulos conocidos ubicados dentro de 1 kpc alrededor del mismo.

1. Colour-magnitude diagram features

We obtained images of the field of Ruprecht 1 with the Washington C and T_1 filters using the 0.9 m telescope at Cerro Tololo Inter-American Observatory (Chile), equipped with a 2048x2048 pixels CCD. To disentangle the stars belonging to the lower part of the cluster main sequence (MS) from those of the surrounding field, we traced the cluster stellar density profile starting by determining the location of the cluster centre. To do this, we applied the method described by Piatti et al. (2006). The calculated background level resulted in (17 ± 2)x10^{-5} stars/pixel, which leads to an estimated cluster radius of r_{cls} = 800 ± 50 pixels, equivalent to 5.3' ± 0.4'. The radius at the FWHM (r_{FWHM}) and the estimated radius r_{clean} which maximizes the cluster population and minimizes the field star contamination in the colour-magnitude diagram (CMD) turned out to be 150 and 300 pixels, respectively. We finally derived the field star contamination of 22%, 38% and 68% for the radial intervals $r < r_{FWHM}$, $r_{FWHM} < r < r_{clean}$ and $r_{clean} < r < r_{cls}$, respectively. Fig. 1 (left) shows three CMDs constructed including different circular extractions around the cluster (upper-left). They exhibit the stellar population variations from the innermost to the outermost of the cluster field. We start with the CMD for stars distributed within $r < r_{FWHM}$ (upper-right), followed by the CMD for the cluster regions delimited by $r < r_{clean}$ (bottom-left) and finally by the adopted field CMD (bottom-right). We used the CMD corresponding to the stars within r_{FWHM} as the cluster fiducial sequence reference. Then, we performed different circular extractions by varying the distance from the cluster centre, in order to build an optimum cluster CMD. This results from a compromise between maximizing the number of cluster stars and minimizing the field star contamination. Finally, we chose that CMD which exhibits the best enhanced cluster fiducial features (bottom-left panel of Fig. 1). The cluster MS does not show clear signs of evolution except for three turnoff stars and a probable red giant star located at $T_1 \sim 11.5$. In the subsequent analysis, we will use the CMD with $r < r_{clean}$ for Ruprecht 1.

2. Cluster fundamental parameters and discussion

Firstly, we fitted the zero-age main sequence (ZAMS) to the (C-T_1,T_1) CMD and derived E(C-T_1) and T_1-M_{T_1} for each cluster metallicity. By using E(C-T_1)/E(B-V) = 1.97 and A_{T_1}/E(B-V) = 2.62 (Geisler et al. 1996), we derive [E(B-V), V-M_V] = (0.25 $\pm$ 0.05, 12.25 $\pm$ 0.25) and (0.25 $\pm$ 0.05, 11.75 $\pm$ 0.25) for Z = 0.02 and 0.008, respectively. Secondly, we selected isochrones of Girardi et al. (2002) of some hundred million years of age, younger than the Hyades, and used the two derived pairs of [E(B-V),V-M_V] values to estimate the cluster age. In order to reach the adjustment which best resembles the cluster features, we assumed different scenarios: i) the three brightest MS stars observed in the cluster CMD are placed at the top of the cluster's MS, ii) the red star located at (C-T_1,T_1) $\approx$ (2.1, 11.5) is a cluster red giant clump; iii) both hypotheses combined. Finally, we fitted the observed cluster MS without any assumption about the brightest turnoff magnitudes of Ruprecht 1. The isochrones which most properly reproduce the cluster features turned out to be those of log t = 8.3 $\pm$ 0.1 and 8.4 $\pm$ 0.1 for Z = 0.02 and 0.008, respectively. To match these isochrones, we used the E(C-T_1) and T_1-M_{T_1} values derived for each metallicity level independently. Fig. 1 (right) shows in solid and dotted lines, respectively, the results of the fits of the ZAMS and of the isochrones which best resemble the cluster MS for Z = 0.02 and 0.008. Note that both sets of adjusted isochrones are indistinguishable within the errors so that we cannot favour any of the two assumed Z values for the cluster.

From the derived cluster reddenings and apparent distance moduli, we obtained heliocentric distances of d = 1.9 $\pm$ 0.4 kpc and 1.5 $\pm$ 0.3 kpc for Z = 0.02 and 0.008, respectively. A representative average value of 1.7 kpc yields (9.706,

-1.164, -0.286) kpc for the Galactic coordinates (X,Y,Z). The present analysis reveals that Ruprecht 1 is a very small open cluster, its linear radius being 2.6 $\pm$ 0.2 pc. The derived cluster parameters are in good agreement with those recently reported by Vázquez et al. (2008). We used the WEBDA database to search for known clusters located within $\sim$ 1 kpc around Ruprecht 1 and found 83 clusters which satisfy this requirement. Unfortunately, the metal content has been estimated for only 16 of these clusters. The upper panels of Fig. 2 show the distribution of the clusters in different Galactic coordinate planes. We have schematically marked the Perseus spiral arm according to Drimmel & Spergel (2001) in the upper-right panel. Note that most of the selected clusters are distributed close to the Galactic plane (upper-left panel), even though Ruprecht 1 is $\sim 10^o$ below it. On the other hand, as far as the distribution of dust in front of the selected clusters is concerned, we confirm, in general terms, that the greater the height out of the Galactic plane, the lower the interstellar visual absorption A_V (bottom-left panel). However, we also note that the dispersion between the different interstellar extinction values of clusters with $|Z| > 0.1$ kpc reflects the inhomogeneity of the dust distribution. In this sense, we can infer that Ruprecht 1 is affected by a statistically expected amount of absorption for the $|Z|$ range. We also examined the distribution of cluster ages as a function of their height out of the Galactic plane and conclude that Ruprecht 1 is as old as the average age of the selected clusters in the studied volume. A few older clusters are also present at relatively low Z values, though. However, we note that as a consequence of their orbital motions (Piatti et al. 1995) such values can be very different from those the clusters had when they were formed. For this reason, we believe it is well worth enlarging our knowledge of the clusters' birthplaces for a comprehensive study of the metal abundance gradient perpendicular to the Galactic plane. Finally, from the 16 clusters with metallicity estimates, we derive a mean value of $<$[Fe/H]$>$ = -0.01 $\pm$ 0.14 dex. If we adopt this metallicity as representative of the considered space volume, we conclude that Ruprecht 1 is more likely to have a solar metal content than a subsolar one.

References

Drimmel, R., and Spergel, D.N., 2001, ApJ, 556, 181

Geisler, D., Lee, M.G., and Kim, E. 1996, AJ, 111, 1529

Girardi, L., Bertelli, G. et al., 2002, A&A, 391, 195

Piatti, A.E., Clariá, J.J., and Abadi, M.G. 1995, AJ, 110, 2813

Piatti, A.E., Clariá, J.J., and Ahumada, A.V. 2006, MNRAS, 367, 599

Vázquez, R.A., May, J. et al. 2008, ApJ, 672, 930

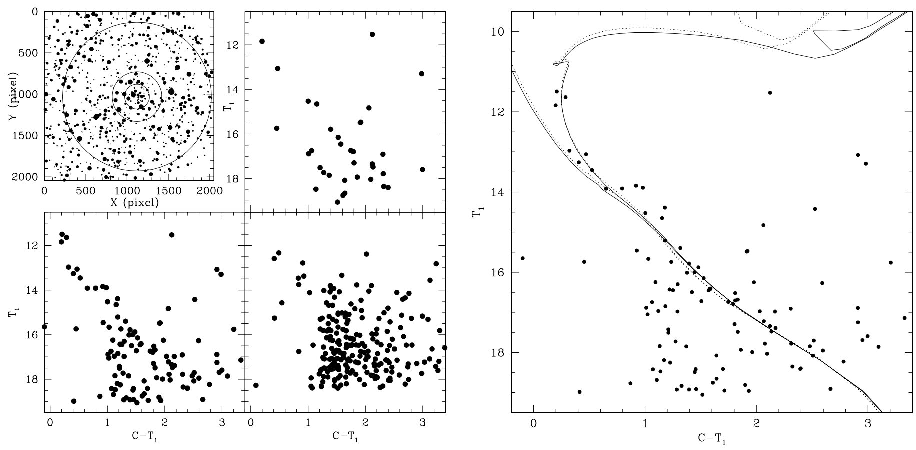

Figure 1. *Left*: Stars observed in Ruprecht 1 (upper left), with 3 concentric circles corresponding to the extracted CMDs for: r < r_{FWHM} (upper right), r < r_{clean} (bottom left) and r > r_{field} (bottom right). North is up and east is to the left. *Right*: r < r_{clean} CMD. The ZAMS and the adopted isochrones for Z = 0.02 and 0.008 are overplotted with solid and dotted lines, respectively.

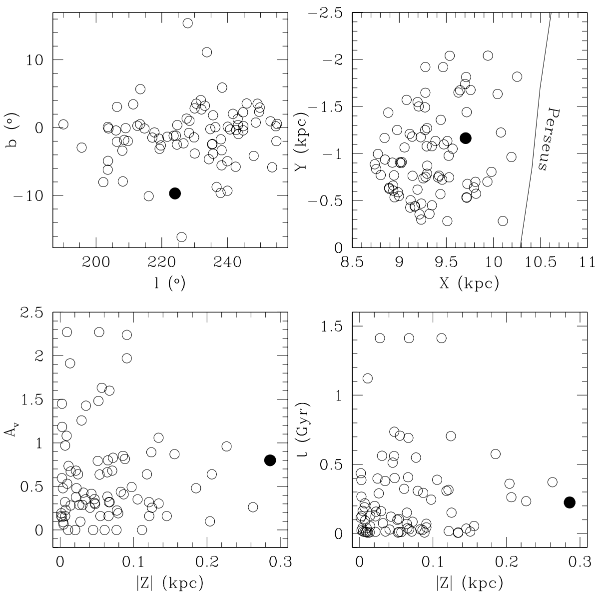

Figure 2. Relationships between Galactic coordinates (upper panels) and between other parameters (bottom panels) for known open clusters (open circles) located within 1 kpc around Ruprecht 1 (filled circle). The Perseus spiral arm is shown in the upper righ-hand panel.