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Photometric and kinematic study of red giants in open clusters located in the galactic center direction

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Abstract. We present CORAVEL radial velocities and high precision UBV and DDO photoelectric photometry for a sample of red giant candidates of the open clusters NGC 6192, NGC 6208 and NGC 6268. We discovered 3 new spectroscopic binaries and determined mean radial velocity, reddening and metallicity for the three clusters. We also examined the properties of a sample of 42 inner disk open clusters projected towards almost the same direction.
Resumen. Presentamos velocidades radiales CORAVEL y fotometría fotoeléctrica UBV y DDO de alta precisión de candidatas a gigantes rojas de los cúmulos abiertos NGC 6192, NGC 6208 y NGC 6268. Descubrimos 3 nuevas binarias espectroscópicas y determinamos velocidad radial media, enrojecimiento y metalicidad para los tres cúmulos. Examinamos además las propiedades de 42 cúmulos abiertos del disco interior proyectados casi en la misma dirección.

1. Cluster membership and interstellar reddening

37 potential members of the red-giant branches of NGC 6192, NGC 6208 and NGC 6268 were observed in the UBV system, while 22 of them were also observed in the DDO system. The observations were carried out at La Silla and Cerro Tololo Inter-American observatories (Chile), using pulse-counting photoelectric photometers. CORAVEL radial velocities (RVs) were obtained at La Silla for 24 red giant candidates in the three clusters. Five stars of NGC 6192 have RVs in the narrow range -8.8 km/s < VR < -6.4 km/s, including two new spectroscopic binaries (SBs). Three stars of NGC 6208 - including a new SB - and three stars of NGC 6268 show similar RVs so that their physical membership to NGC 6208 and NGC 6268, respectively, is highly probable. Mean radial velocities are: -7.7 ± 0.38 km/s (NGC 6192), -32.21 ± 0.28 km/s (NGC 6208) and -15.11 ± 0.08 km/s (NGC 6268).

We have also evaluated photometric membership probabilities by applying criteria A and B defined by Clariá & Lapasset (1983). We adopted the colour excesses for the main sequence (MS) stars and true distance moduli derived by Loktin et al. (2001). The predicted luminosity class (LC) for each cluster star was determined from the Straižys' (1992) calibration. Table 1 presents the results: (1)

Star designation. (2) E(B-V)$_{GK}$ derived from Janes's (1977) iterative method. (3) Standard deviation of the E(B-V)$_{GK}$ colour excess. (4) LC each star should have in order to be a cluster member. (5) MK spectral type derived from the calibration of Clariá et al. (1994). (6) Results from applying criteria A and B. (7) Radial velocity (km/s). (8) Final membership status assigned to each star. There is a good agreement between the photometric analysis and the kinematic data. The mean E(B-V) values derived here are: 0.63 ± 0.02 (NGC 6192), 0.31 ± 0.02 (NGC 6208) and 0.43 ± 0.02 (NGC 6268). The present measurements allow us to resolve the strong discrepancies existing in the literature regarding the reddening of NGC 6192.

2. Colour-magnitude diagrams and metal content

The colour-magnitude diagram (CMD) of NGC 6192 (Fig. 1, left) was built with the CCD UBV data reported by King (1987). Using E(B-V) = 0.63, the best fit is obtained with the Padova isochrone (Girardi et al. 2000) for log t = 8.25 (Z = 0.019) and V-M$_V$ = 13.00. Because there are no modern UBV data available for NGC 6208, we have computed (B-V) indices from the (g1-y) indices of Paunzen & Maitzen (2001). The number of members appears to be small and the MS fit is not well constrained (Fig. 2, middle). Given E(B-V) = 0.32, one solution results in V-M$_V$ = 11.15 and log t = 9.10 (Z = 0.008). Likewise, for NGC 6268 we have computed (B-V) indices from (g1-y) (Paunzen 2006, Fig. 3 right). Using E(B-V) = 0.38, we obtained V-M$_V$ = 11.25 and log t = 8.35 for the Padova isochrone for Z = 0.019. We have computed for each cluster giant the cyanogen anomaly ΔCN defined by Piatti et al. (1993). The resulting mean ΔCN values for the cluster giants imply: [Fe/H] = +0.29 ± 0.06 (NGC 6192), -0.05 ± 0.05 (NGC 6208) and +0.22 ± 0.06 (NGC 6268). Therefore, NGC 6192 and NGC 6268 lie in the metal-rich side of the metallicity distribution of open clusters, while NGC 6208 is found to be of nearly solar metal content.

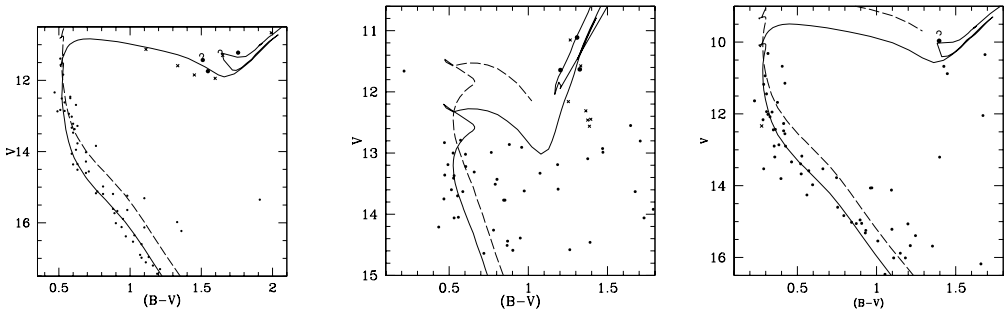

Figura 1. CMDs for NGC 6192 (*left*), NGC 6208 (*middle*) and NGC 6268 (*right*). The Padova isochrones for log t = 8.25 (Z = 0.019), 9.10 (Z = 0.008) and 8.35 (Z = 0.019) have been adjusted to E(B-V) = 0.63, 0.32 and 0.38 and V-M$_V$ = 13.00, 11.15 and 11.25, respectively. The dashed curves are the same isochrones shifted by 0.75 mag to reproduce the upper binary ridge. For the red giants, filled and open circles stand for single and binary members respectively, while crosses stand for non-members.

3. Open clusters aligned along the line-of-sight to NGC 6192

We have found 42 open clusters with known properties whose galactic coordinates differ within ±10° from those of NGC 6192. Their distribution in the Galactic (X,Y) plane is shown in Fig. 2 (left). NGC 6192 is located on or slightly behind the Carina spiral arm as seen from the Sun, while NGC 6208 and NGC 6268 are placed in front of this feature. Fig. 2 (right) shows the relation between the visual absorption and the distance from the Sun, including that relation for Baade's Window. Note that BH 222 and Westerlund 1 (W1) are the farthest open clusters of the selected sample. At the distance of these two clusters, the visual absorption towards Baade's Window - not far from the direction of NGC 6192 - is between 4 and 8 mags smaller. In spite of being located at approximately the same distance, these two clusters appear to be affected by very different visual absorptions. The reddening of W1 - the most massive compact young cluster identified in the Local Group up to now (Clark et al. 2005) - is produced in front of the Carina spiral arm, probably caused by a single small dark cloud. Note also that NGC 6216, located farther than 4 kpc from the Sun, is reddened as would be expected if it were situated exactly in the Baade's Window direction.

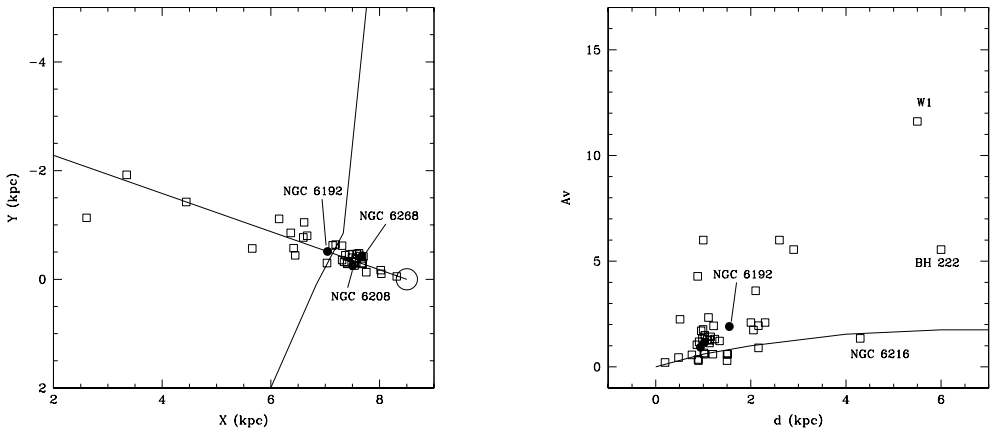

Figura 2. Rectangular (X,Y) coordinates of inner disk open clusters located in the direction of NGC 6192 (*left*). The Carina spiral arm, the line-of-sight from the Sun to NGC 6192 (straight line) and the position of the Sun are indicated. Visual interstellar absorption vs. distance from the Sun (*right*). The relationship for the Baade's Window is indicated.

Cuadro 1 Photometric membership results

Star	$E(B-V)$ (mag)	$\sigma_{(B-V)}$ (mag)	LC (Pred)	MK (DDO)	Criteria (A)	(B)	RV km/s	Membership
NGC 6192								
4	0.28	0.04	II-III	K1 III	NM	M	+45.28	NM
9	0.60	0.06	II-III	G8 III	M	M	-8.16	M
28	0.55	0.04	II	K3/4 III	NM	PM	+24.81	NM
45	0.63	0.05	II-III	G5 II	M	M	-8.06	M
91	0.62	0.04	II-III	G5/8 II	M	M	-8.82	M
96	0.63[a]	-	II-III	G2 III	-	M	-6.40	M
137	0.67	0.03	II-III	G8/K0 III	M	M	-7.17	M
253	0.27	0.04	II-III	G5/8III-IV	NM	PM	-19.32	NM
255	0.70	0.04	II-III	K0IV-V	PM	NM	-88.51	NM
265	0.41	0.02	II-III	K2 IV	NM	NM	-59.69	NM
274	0.56	0.04	II-III	K1 III	NM	M	-	NM
NGC 6208								
19	0.31	0.05	III	K0/1 III-IV	PM	M	-32.17	M
27	0.40	0.02	III	G5 III	NM	M	-69.01	NM
31	0.29	0.04	III	G5/8 III	PM	M	-32.83	M
48	0.33	0.06	III	K0/1 III	PM	M	-31.63	M
133	0.24	0.03	III	K1/2 III	M	M	+29.30	NM
NGC 6268								
13	0.36	0.04	III	G9 IV-V	M	NM	-2.59	NM
22	0.53	0.03	III	G8/9 III-IV	NM	PM	-	NM
44	0.41	0.03	III	G8 II-III	M	M	-15.28	M
48	0.22	0.03	III	K0/1 IV	NM	PM	-	NM
73	0.46	0.03	III	K0 II-III	NM	M	-	NM
76	0.46	0.04	III	G8 III	PM	M	-15.03	M

[a] Outside the range of Janes (1977) calibration

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