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A preliminary systematic search for red-clump stars in Galactic open clusters based on 2MASS data

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Abstract. Red-clump (RC) giants are intermediate-age, core-helium-burning stars. The RC can be used as a standard candle. In particular, the small variance of the RC's K-band intrinsic luminosity and its weak dependence on chemical composition and age make it an extremely useful distance indicator. In this paper, we use 2MASS data to search for RC stars in a sample of 60 Galactic open clusters with known reddening, ages, and distances, and obtain an average value for the RC's absolute K_s-band magnitude, $M_{K_s} = -1.72 \pm 0.17$ mag.

Keywords. open clusters and associations: general, distance scale

1. Selection of red-clump stars

Red-clump (RC) giants are intermediate-age, core-helium-burning stars. The RC can be used as a standard candle. In particular, the RC's intrinsic K-band luminosity exhibits a small variance and only a weak dependence on chemical composition and age, which makes it an extremely useful distance indicator.

Van Helshoecht & Groenewegen (2007) investigated how the RC's K-band magnitude, M_K (RC), depends on age and metallicity, using 2MASS infrared data for a sample of 24 open clusters with known distances. Here, also based on 2MASS data, we searched for RC stars in a much larger sample of 60 Galactic open clusters with known reddening, ages, and distances, and obtained an average value for the RC's absolute K_s-band magnitude.

We took a search radius of 60 arcmin around the center of our sample clusters, and adopted as the cluster radius the distance to the cluster center where the stellar density is 120% of the field-star density: see Fig. 1.

The RC has the advantage of being easily recognizable in the color–magnitude diagrams (CMDs) of most open clusters. Based on the CMDs of 60 sample clusters using 2MASS JHK_s data, we searched for possible RC members in each of our sample clusters by visual inspection. We focussed on their compact locus in the CMDs, in the knowledge that it is a highly populated region in CMD space that is brighter than the main sequence. To select RC stars in the CMD of a given cluster, a fixed-size box of 0.2 mag in color and 0.8 mag in magnitude was used (Van Helshoecht & Groenewegen 2007): see, for an example, Fig. 2.

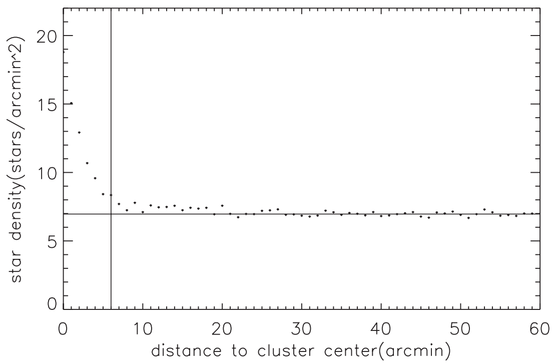

Figure 1. Example of cluster-radius estimation for the open cluster Haffner 10. The stellar density is plotted as a function of distance to the cluster center. We define the cluster radius as the distance to the cluster center where the stellar density is 120% of the field-star density. Here, a radius of 6′ is adopted.

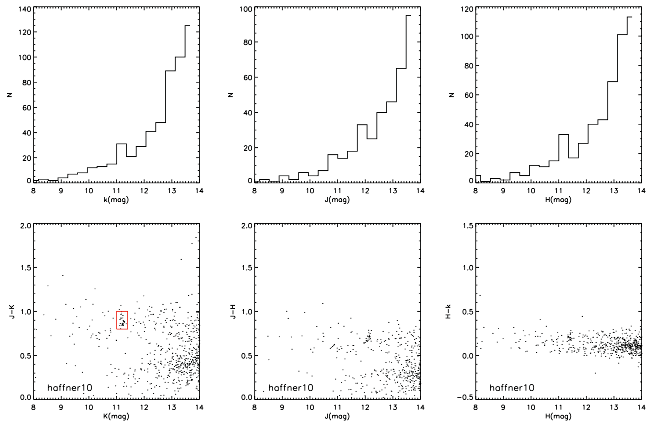

Figure 2. (top) J-, H-, and K_s-band luminosity functions of Haffner 10 within a cluster radius of 6′. (bottom) $(J - K_s)$ versus K_s, $(J - H)$ versus J, and $(H - K_s)$ versus H color–magnitude diagrams for the same area.

2. Results and Discussion

After selecting possible RC members from the cluster regions, the median apparent K_s magnitudes of the stars within the fixed box were calculated. Using the relations provided by Cardelli *et al.* (1989), in particular $R_V = 3.1, A_K = 0.11A_V$, and $M_{K_s} = m_{K_s} - (m - M)_V - A_K$, we calculated the median K_s-band absolute magnitude, M_{K_s}, of the RCs for all clusters (see Table 1) and obtained an average value for our 60 sample clusters of $M_{K_s} = -1.72 \pm 0.17$ mag. In Table 1, the first 24 sample open clusters are the same as those in Van Helshoecht & Groenewegen (2007); the reddening and $(m - M)_V$ data are from Twarog *et al.* (1997) and Chen *et al.* (2003).

References

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Table 1. K_s-band absolute magnitude of 60 open clusters.

Cluster	$E(B-V)$ (mag)	$(m-M)_V$ (mag)	M_{K_s}(RC) (mag)	$\sigma[M_{K_s}$(RC)] (mag)
BE 39	0.11	13.50	−1.98	0.23
IC 4651	0.11	10.25	−2.20	0.14
MEL 66	0.14	13.95	−2.21	0.15
NGC 188	0.09	11.35	−1.95	0.16
NGC 752	0.04	8.35	−1.32	0.18
NGC 1817	0.26	12.15	−2.68	0.17
NGC 2099	0.27	11.55	−2.96	0.22
NGC 2204	0.08	13.30	−1.90	0.21
NGC 2243	0.06	13.45	−2.09	0.18
NGC 2360	0.09	10.35	−1.49	0.20
NGC 2420	0.05	12.10	−1.88	0.09
NGC 2477	0.23	11.55	−2.10	0.35
NGC 2506	0.05	12.60	−1.77	0.37
NGC 2527	0.09	9.30	−2.03	0.07
NGC 2682	0.04	9.80	−1.85	0.02
NGC 3680	0.05	10.25	−2.07	0.05
NGC 3960	0.29	12.15	−2.06	0.08
NGC 5822	0.14	10.00	−2.12	0.30
NGC 6134	0.35	11.10	−2.18	0.20
NGC 6633	0.16	8.35	−2.16	0.18
NGC 6791	0.15	13.40	−1.92	0.22
NGC 6819	0.16	12.44	−2.15	0.26
NGC 7789	0.27	12.45	−2.51	0.27
TOM 2	0.30	15.60	−2.60	0.23
Berk 21	0.76	13.49	−1.16	0.11
Berk 24	0.40	13.36	−1.34	0.37
Berk 30	0.50	13.40	−2.75	0.12
Berk 44	1.40	11.28	−0.55	0.13
Berk 66	1.25	13.58	−1.54	0.09
Berk 78	0.01	13.41	−3.20	0.11
Collinder 74	0.38	12.00	−1.63	0.11
Collinder 110	0.50	11.45	−1.35	0.15
Dolidze 38	0.15	10.40	−1.09	0.07
Haffner 10	0.52	13.60	−2.58	0.08
IC 166	0.18	12.99	−0.92	0.66
King 5	0.00	11.39	−0.79	0.21
NGC 1241	0.25	13.03	−1.52	0.16
NGC 1245	0.30	12.29	−1.13	0.32
NGC 2158	0.36	13.35	−2.16	0.22
NGC 2180	0.00	9.80	−2.33	0.16
NGC 2192	0.00	12.68	−0.92	0.16
NGC 2194	0.38	12.89	−2.42	0.31
NGC 2236	0.48	12.33	−1.91	0.27
NGC 2266	0.10	11.90	−1.24	0.20
NGC 2304	0.10	13.01	−2.19	0.19
NGC 2355	0.12	11.71	−1.64	0.13
NGC 2423	0.10	9.42	−0.75	0.14
NGC 2425	0.21	12.75	−1.87	0.15
NGC 2479	0.10	10.40	−0.76	0.11
NGC 2533	0.05	12.64	−1.89	0.10
NGC 2627	0.09	11.54	−2.06	0.12
NGC 2660	0.31	12.26	−1.32	0.24
NGC 6728	0.15	10.00	−0.94	0.13
NGC 6802	0.35	10.25	−0.62	0.20
NGC 6939	0.33	11.28	−1.53	0.18
NGC 6940	0.21	9.43	−0.65	0.20
NGC 7044	0.59	12.50	−1.26	0.41
Pismis 2	0.05	12.60	−1.21	0.05
Pismis 15	0.53	12.31	−1.66	0.11
TOM 1	0.30	11.71	−1.08	0.11

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