An Investigation of 11 previously unstudied open star clusters

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Abstract

The main astrophysical properties of 11 previously unstudied open star clusters are probed with JHK Near-IR (2MASS) photometry of Cutri et al. [Cutri, R., et al., 2003. The IRSA 2MASS All-sky Point Source Catalog, NASA/IPAC Infrared Science Archive] and proper motions (NOMAD) astrometry of Zacharias et al. [Zacharias, N., Monet, D., Levine, S., Urban, S., Gaume, R., Wycoff, G., 2004. American Astro. Soc. Meeting 36, 1418]. The fundamental parameters have been derived for IC (1434, 2156); King (17, 18, 20, 23, 26); and Dias (2, 3, 4, 7, 8), for which no prior parameters are available in the literature. The clusters’ centers coordinates and angular diameters are re-determined, while ages, distances, and color excesses for these clusters are estimated here for the first time.

Key words: Galaxy: open clusters and associations: general – individual: ID clusters (IC - King - Dias) – Stars: Hertzsprung-Russell (HR) diagram
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1 Introduction

According to some estimations, there are as many as 100,000 open star clusters in the Galaxy, but less than 2000 of them have been discovered and cataloged, Glushkova et al. (2007). Actually, not all the discovered clusters have their basic photometrical parameters in the current literatures indeed. So, our aim in the previous and present continuation series of papers to determine the

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main astrophysical properties of rarely or unstudied open star clusters using modern databases (cf. Tadross 2008 and references therein; hereafter TA08). On this respect, the present study introduces the first photometric analysis of the color magnitude diagrams (CMDs) of the clusters under investigation.

The Naval Observatory Merged Astrometric Dataset (NOMAD) of Zacharias et al. (2004) and the Two Micron All Sky Survey (2MASS) of Cutri et al. (2003) are used to determine the fundamental parameters of 11 open star clusters of IC, King, and Dias; which were never studied insofar. The only information known about these clusters are their centers’ coordinates and sometimes their apparent diameters; listed here in Table 1; which are provided by Mermilliod (1995) and Dias (2002) catalogs. These catalogs are constantly updated and maintained in electronic form (WEBDA and DIAS sites). Note that cluster King 20 has no parameters in WEBDA, but only in Dias catalog. Hence, we used this cluster to calibrate our reductions’ procedure. For that purpose, the basic parameters of King 20 are re-estimated and compared with those available in the literature (Bica et al. 2006). The derived parameters are found very close to the published ones, which make our reductions’ procedure is fairly acceptable.

2 Data Reductions Procedure

Data extraction have been performed using the known tool of VizieR Catalogs of (2MASS) and (NOMAD). The investigated clusters have been selected from WEBDA and DIAS catalogs under the following conditions:

1. The clusters’ data have been extracted at a preliminary radii of about 10 arcmin from their obtained centers;
2. The clusters should have good blue images on Digitized Sky Surveys DSS and clearly distinguished from the background field, (see Fig. 1 in TA08);
3. The foreground stars have been separated from the cluster stars using the proper motion data of (NOMAD) dataset (i.e., all stars with nonzero proper motions and those distributed over the field with no concentration around the cluster center have been removed);
4. The clusters should have enough members with prominent sequences in their CMDs;
5. A cutoff of photometric completeness limit at $J < 16.5$ mag is applied on the (2MASS) data to avoid the over-sampling (cf. Bonatto et al. 2004);

3 http://obswww.unige.ch/webda
4 http://www.astro.iag.usp.br/~wilton/clusters.txt
5 http://vizier.u-strasbg.fr/viz-bin/VizieR?-source=2MASS
6 http://vizier.cfa.harvard.edu/viz-bin/VizieR?-source=I/297/
7 http://cadcwww.dao.nrc.ca/cadcbin/getdss
(6) The stars with observational errors more than 0.20 mag are cancelled; and
(7) According to Bonatto et al. (2005), the membership criteria is adopted for
the location of the stars in the CMDs. Therefore, color-magnitude filters have
been applied to the $J \sim (J-H)$ and $K \sim (J-K)$ sequences to isolate probable
member stars, whereas the stars located away from the main sequences are
excluded. The maximum departure accepted here is about 0.15 mag.

3 Astrometry

To derive better cluster center, the cluster center is re-determined and taken
at the maximum stellar density of the cluster’s area. The location of the clus-
ter center is found by fitting a Gaussian to the profiles of star counts in right
ascension $\alpha$ and declination $\delta$, (see Fig. 3 in TA08).

Within concentric shells in equal incremental steps from the cluster center, the
radial stellar density distribution is performed out to the preliminary radius.
Density distributions of all our sample are well-represented by King (1962)
profiles. The real radius (genuine border) of the cluster can be defined at that
point which reaches enough stability of the background density and covers all
the cluster area. At that radius, the $JHK$ photometric data would be extracted
and taken into account for estimating the photometrical clusters’ properties,
see Fig. 4 in TA08. The estimated clusters centers and diameters are shown
in Table 2; columns 2-3 and 4 respectively.

4 Photometry

Most of the clusters’ sample have lower galactic latitudes, whereas the back-
ground field is found very crowded and consequently CMDs are found very
contaminated as well. Therefore, the CMDs profiles are comprising stars insi-
de radii of $1', 2'$, and $3'$ from the cluster center. The simultaneous fitting
of the solar metallicity isochrones of Bonatto et al. (2004) are attempted on
$J \sim (J-H)$ and $K \sim (J-K)$ diagrams for the inner stars, in which they
should be less contaminated by field stars. If the number of stars are not
enough for an accepted fitting, the next larger area would be included, and
so on. Moreover, the reddening estimation values have been guided by the
galactic absorption values of Schlegel et al. (1998).

$R_V = 3.2$, $\frac{A_J}{A_V} = 0.276$, $\frac{A_K}{A_V} = 0.118$ and $\frac{E_{J-H}}{E_{B-V}} = 0.33$ have been used for red-
dening and absorption transformations according to Dutra et al. (2002) and
references therein. $\frac{E_{\lambda} - K}{E_{\lambda} - H} \approx 1.6 \pm 0.10$, which was derived from absorption ratios in Schlegel et al. (1998).

5 Conclusion

Determining the clusters main parameters with the present reductions showing a good agreement with that published for the previously studied cluster King 20. Following the above procedure, the cluster center, diameter, age, reddening, distance modulus, distance from the sun, distance from the galactic center, $R_{gc}$, and the projected distances on the galactic plane from the Sun, $X_\odot$, $Y_\odot$, and the distance from galactic plane, $Z_\odot$ of all our clusters’ have been estimated and listed here in Table 2. The CMDs and isochrone fits for all the investigated clusters can be seen in Figs. 1-3.

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Table 1
The equatorial and galactic coordinates and the diameters of the investigated clusters, as taken from "Webda" and "Dias" catalogs.

| Cluster | \( \alpha \ h \ m \ s \) | \( \delta \ ^\circ\ '\ '' \) | G. Long.\(^\circ\) | G. Lat.\(^\circ\) | Diameter |
|---------|-----------------|-----------------|-----------------|-----------------|-----------|
| IC 1434 | 22:10:30        | +52:50:00       | 99.937          | -2.700          | 6         |
| IC 2156 | 06:04:51        | +24:10:00       | 186.291         | +1.297          | 3         |
| King 17 | 05:08:24        | +39:05:00       | 167.291         | -0.731          | 5         |
| King 18 | 22:52:06        | +58:17:00       | 107.768         | -1.031          | 5         |
| King 20 | 23:33:18        | +58:29:00       | 112.853         | -2.851          | 5         |
| King 23 | 07:21:48        | -00:59:00       | 215.529         | +7.202          | 5         |
| King 26 | 19:29:00        | +14:52:00       | 50.409          | -1.339          | 2         |
| Dias 2  | 06:09:09        | +04:35:24       | 203.965         | -7.254          | 5         |
| Dias 3  | 07:10:28        | -08:26:14       | 222.603         | -0.350          | 12        |
| Dias 4  | 13:43:40        | -63:01:30       | 308.814         | -0.751          | 1.4       |
| Dias 7  | 19:49:22        | +21:09:48       | 58.276          | -2.461          | 1.7       |
| Dias 8  | 19:52:07        | +11:37:54       | 50.335          | -7.827          | 2.3       |

Table 2
The redetermined coordinates and diameters of the investigated clusters with the derived astrophysical main parameters. Columns display, respectively, cluster name, center coordinates, angular diameter, age, reddening, distance modulus, distance from the sun, distance from the galactic center, the projected distances on the galactic plane from the sun, and the distance from galactic plane.

| Cluster | \( \alpha \ h \ m \ s \) | \( \delta \ ^\circ\ '\ '' \) | Diameter | Age | \( E_{B-V} \) | m-M | Distance | \( R_{gc} \) | \( X_\odot \) | \( Y_\odot \) | \( Z_\odot \) |
|---------|-----------------|-----------------|----------|-----|------------|-----|----------|-------------|-----------|-----------|-----------|
| IC 1434 | 22:10:34        | +52:49:40       | 7.0      | 0.32| 0.66       | 13.0| 3035 ± 140| 9.5         | 523       | 2986      | -143      |
| IC 2156 | 06:04:51        | +24:09:30       | 4.0      | 0.25| 0.67       | 12.2| 2100 ± 95 | 10.6        | 2087      | -230      | 47        |
| King 17 | 05:08:25        | +39:05:04       | 5.6      | 0.79| 0.73       | 13.0| 2960 ± 135| 11.4        | 2887      | 650       | -38       |
| King 18 | 22:52:07        | +58:16:57       | 4.8      | 0.35| 0.52       | 11.8| 1860 ± 85 | 9.2         | 567       | 1770      | -33       |
| King 20*| 23:33:18        | +58:27:52       | 6.0      | 0.28| 0.67       | 12.2| 2100 ± 95 | 9.5         | 815       | 1930      | -104      |
| King 23 | 07:21:47        | -00:59:06       | 7.2      | 0.89| 0.16       | 12.6| 3113 ± 140| 11.2        | 2513      | -1795     | 390       |
| King 26 | 19:59:01        | +14:52:02       | 4.4      | 0.44| 1.27       | 13.2| 2600 ± 120| 7.1         | -1656     | 2003      | -61       |
| Dias 2  | 06:09:11        | +04:35:35       | 11.0     | 0.79| 0.61       | 12.8| 2835 ± 130| 11.2        | 2570      | -1142     | -358      |
| Dias 3  | 07:10:31        | -08:25:39       | 16.0     | 1.41| 0.64       | 13.9| 4650 ± 215| 12.3        | 3423      | -3147     | 28        |
| Dias 4  | 13:43:25        | -63:00:48       | 6.4      | 1.26| 0.60       | 12.2| 2150 ± 100| 7.3         | -1347     | -1675     | -28       |
| Dias 7  | 19:49:21        | +21:10:12       | 10.0     | 2.00| 0.42       | 12.4| 2540 ± 115| 7.5         | -1334     | 2158      | -109      |
| Dias 8  | 19:52:06        | +11:38:04       | 10.0     | 2.24| 0.30       | 12.0| 2220 ± 100| 7.3         | -1404     | 1693      | -302      |

* From Bica et al. (2006): Diam.=6.0 arcmin.; Age=0.2 Gyr; \( E_{B-V} \)=0.65 mag; Distance=1900 pc
Fig. 1. The radial stellar density distribution, and CMDs with isochrone fits for the investigated clusters from "IC 1434" to "King 18".
Fig. 2. The radial stellar density distribution, and CMDs with isochrone fits for the investigated clusters from "King 20" to "Dias 2".
Fig. 3. The radial stellar density distribution, and CMDs with isochrone fits for the investigated clusters from "Dias 3" to "Dias 8".