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CCD photometry of the open clusters Melotte 101 and NGC 4852

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Abstract. CCD Johnson-Cousins photometry of the southern open clusters Melotte 101 (C1040−648) and NGC 4852 (C1257−593) is presented. The data were obtained with the 2.15-m telescope at CASLEO (Argentina) and the 1-m telescope at CTIO (Chile). The clusters' color-magnitude diagrams were compared with the renormalized isochrones of Bertelli et al. (1994) and Girardi et al. (2000), and the following cluster parameters were derived. For Melotte 101, log(age) = $8.2^{+0.1}_{-0.2}$, $E(B-V) = 0.42^{+0.04}_{-0.03}$, and $(m-M)_0 = 11.85^{+0.40}_{-0.30}$; for NGC 4852, log(age) = 7.0 ± 0.1, $E(B-V) = 0.43 \pm 0.01$, and $(m-M)_0 = 10.57^{+0.86}_{-0.66}$.

Key words. open clusters and associations: general — open clusters and associations: individual (Melotte 101, NGC 4852)

1. Introduction

Observations were carried out with the 2.15-m telescope at the Complejo Astronómico El Leoncito (CASLEO, Argentina), and the 1-m SMARTS (ex-YALO) telescope at the Cerro Tololo Interamerican Observatory (CTIO, Chile). At CASLEO the detector was a CCD TEK 1024, and the observed field was a circle of diameter $\sim 9'$ (scale: $0.813''$/pixel). At CTIO the recently installed Y4K Camera with a CCD of 4K×4K was used; here the observed field was a square of $\sim 20 \times 20'$ (scale: $0.289''$/pixel). The open cluster Melotte 101 was observed from CASLEO through standard Johnson-Cousins *BVRI* filters on the 19-20 April 2001 night, and from CTIO (*UBV*) on the 21-22 April 2006 night. The cluster NGC 4852 was observed only from CTIO through *UBVRI* filters during the 22-23 and 23-24 April 2006 nights. A comparison field was observed at $\sim 20'$ of each cluster. The quality of the nights ranged from regular to good, with a mean FWHM of the stellar images between 3 and $4''$ (CASLEO), and between 1.5 and $2.3''$ (CTIO). Many observations of Graham's (1982) standard stars were also performed throughout each night.

2. Reductions and photometry

The frames were processed as usual. The images of the Y4K Camera, however, required an additional step since, to avoid a high readout time, the chip's four quadrants are read independently and thus have different levels of bias. Following the procedure suggested by P. Massey,[1] each raw image was first cut into four quadrants; then each part was corrected by the corresponding overscan, and finally the

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[1] http://www.lowell.edu/users/massey/obins/y4kcamred.html

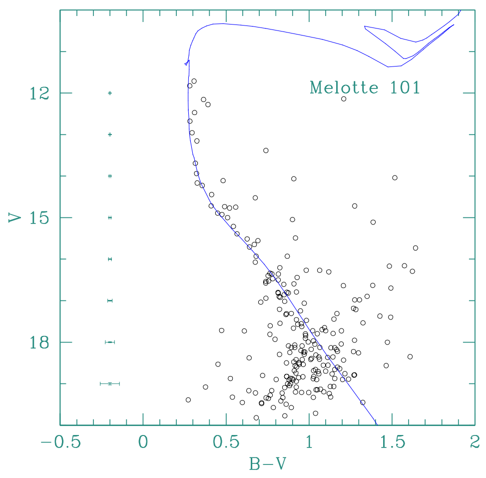

Fig. 1. Color-magnitude diagram of Melotte 101, for stars up to 2′ from the cluster center. The isochrone by Girardi et al. (2000) of solar metallicity and log(age) = 8.2 is also plotted and shifted as indicated in the text.

quadrants were rejoined to continue the processing of the entire image. It was impossible, however, to eliminate the differences fully, but they are not significant enough for the aims of this work, with a jump of at most 30 counts among the quadrants of a typical V frame. The photometry was then carried out on a section of about one-third of the 4K×4K images, with the packages DAOPHOT and PHOTCAL (Stetson 1987) inside the IRAF environment: the standard star magnitudes were determined with aperture photometry, and the instrumental magnitudes of the program stars were obtained by PSF-fitting and aperture correction. The equations to bring the instrumental magnitudes to standard ones were in all cases of the form

$$M = m + c_0 + c_1 \times X + c_2 \times C,$$

where X is the airmass, and C is an appropriate color index. In Ahumada (2003, 2005) are presented the transformation coefficients for CASLEO, while in Ahumada (2007) are shown the preliminary B and V coefficients for CTIO. The magnitudes and colors of the cluster stars obtained on different nights were averaged wherever possible. The mean difference in the sense (Tololo minus CASLEO) was, for Melotte 101, of +0.03 mag in V and −0.05 mag in $(B-V)$; for NGC 4852, the mean difference between the first and second night at CTIO was of +0.02 mag in V and +0.02 mag in $(B-V)$.

3. Analysis of the color-magnitude diagrams

The analysis of the clusters' diagrams followed the lines described in Ahumada (2003), and is essentially based on the well-known method of isochrone-fitting. In first place, the number of stars plotted was delimited to define better the observed sequences; next, isochrones of three metallicities (covering the range expected for galactic open clusters), were fitted. For the Girardi et al. (2000) isochrones, the metallicities are: ($Y = 0.25$, $Z = 0.008$), solar ($Y = 0.273$, $Z = 0.019$), and ($Y = 0.30$, $Z = 0.03$); as a complement for very young clusters, the Bertelli et al. (1994) isochrones for analogous metallicities were used. All the isochrones were renormalized to the solar values $M_V = 4.84$ and $(B-V) = 0.65$ as described and justified in Ahumada (2003). The adopted parameters are those resulting from the fitting of the isochrone of intermediate metallicity (i.e., solar). By using the differences in color and magnitude among the three isochrones, the aim was to define an uncertainty in the reddening and apparent distance modulus due to the lack of knowledge about the real metallicity. The intrinsic photometric error was then added: this was assumed to be the half-sum of the mean error bars at the bright and faint magnitude ends, as returned by DAOPHOT. These errors are 0.015 mag in V and 0.030 mag en $(B-V)$ for Melotte 101, and 0.012 mag in V and 0.025 mag in $(B-V)$ for NGC 4852. Finally, the uncertainty in age was taken to be the difference among the ages of the three isochrones, plus the step in log(age) in Bertelli's models, i.e., 0.1.

3.1. Melotte 101

The diagrams of this cluster show a long and relatively rich main sequence, but with a very

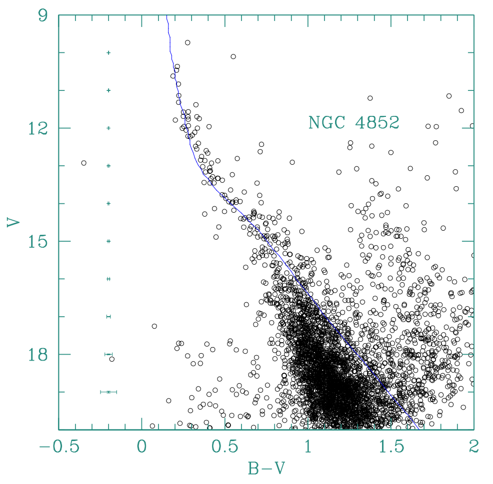

Fig. 2. Color-magnitude diagram of NGC 4852 for all the observed stars. The isochrone by Bertelli et al. (1994) of solar metallicity and log(age) = 7.0 is also plotted.

dispersed upper part; as shown by the comparison field diagram, strong contamination obliterates the main sequence below $V \sim 16.5$. However, the plot of only those stars inside a radius of 2′ around the cluster center (Fig. 1) reveals a fairly well defined sequence. This is rather a young cluster, with log(age) = $8.2^{+0.1}_{-0.2}$ ($1.58^{+0.41}_{-0.58} \times 10^8$ yr), and reddening $E(B-V) = 0.42^{+0.04}_{-0.03}$. Assuming the well-known standard relationships with $E(B-V)$, the following visual extinction and reddenings result: $A_V = 1.30^{+0.31}_{-0.10}$ mag, $E(U-B) = 0.30$, $E(V-R) = 0.26$, and $E(V-I) = 0.53$, with errors for the latter of the order of that of $E(B-V)$. The apparent distance modulus of Melotte 101 is $13.15^{+0.38}_{-0.27}$ mag; the true modulus is $11.85^{+0.40}_{-0.30}$ mag, and the distance is $2.3^{+0.4}_{-0.1}$ kpc. According to this analysis, the cluster is at 230 pc below the galactic plane, and at 8 kpc from the galactic center. A comparative analysis of the radial distributions of cluster- and comparison-field-stars per unit area suggests that there is an excess of cluster stars even at a radius of 4′.

3.2. NGC 4852

Similarly to Melotte 101, the diagrams of this cluster show a long, bright main sequence, but here it appears acceptably defined even when plotting all the observed stars (Fig. 2). The comparison-field diagram, however, indicates than the cluster main sequence virtually disappears in the field from $V \sim 16$ downwards; a plot of stars inside smaller areas does not seem to change this. The cluster is younger than Melotte 101; the isochrones for log (age) = 7.0 were used in the three fittings. If only the interval (±0.1) is taken as the error for the logarithm, the cluster is $1.00^{+0.26}_{-0.21} \times 10^7$ yr old, and its reddening is $E(B-V) = 0.43 \pm 0.01$. With this value and the standard relationships result an extinction in V of $1.33^{+0.13}_{-0.05}$ mag, and the reddenings $E(U-B) = 0.31$, $E(V-R) = 0.27$, and $E(V-I) = 0.54$. The apparent distance modulus of NGC 4852 is $11.90^{+0.85}_{-0.65}$ mag; the true modulus turns out to be $10.57^{+0.86}_{-0.66}$ mag, and the distance is $1.3^{+0.5}_{-0.4}$ kpc; the cluster is relatively near the galactic plane (+74 pc) and is at 7.8 kpc from the galactic center. As for the apparent size of NGC 4852, an analysis similar to that for Melotte 101 also suggests an apparent radius larger than 4′, but in this case the comparison can only be meaningfully performed down to $V = 16$ since the cluster becomes indistinguishable from the general field at fainter magnitudes, as said before.

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