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NGC 7762: A forgotten moderate age open cluster^{*,**}

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Abstract. — We report CCD *B* and *V* photometry for the central region of the old open cluster NGC 7762. The cluster appears very loose and occupies a large sky area. The Colour Magnitude Diagram (CMD) shows a distinct Main Sequence (MS) down to $V \simeq 16.5$, and a couple of evolved stars. The bottom of the sequence is characterized by a large spread, much greater than the expected broadness due to photometric errors, and probably related to low mass stars evaporation. The analysis here carried out allows us to conclude that NGC 7762 is an intermediate age cluster about 1.8 Gyr old. The comparison with theoretical isochrones from the Padova group constrains colour excess and apparent distance modulus in the range 0.85–0.90 and 12.00–12.20, respectively. The distance to the Sun comes out to be 800 pc, somewhat lower than Chincarini's (1966) estimate.

Key words: open clusters: NGC 7762 — HR diagram

1. Introduction

NGC 7762 (OCL 280, Cr 457, Mel 244 and Rb 151, Trumpler class *II 1 m U*) is a scarcely populated northern open cluster, very poorly known. It is located not far from the Cepheus *IV* association, and its equatorial and galactic coordinates for the 1950.0 equinox are $\alpha = 23^{\text{h}} 47^{\text{m}} 4$, $\delta = 67^{\circ} 45'$ and $l = 117^{\circ} 20$, $b = 5^{\circ} 84$, respectively. Estimates of its angular diameter are around 10–12 arcmin. It was studied in a very preliminary way by Chincarini (1966), who obtained *UBV* photoelectric photometry for 18 stars using the 1.22 m reflector at Asiago (Italy) and the 0.6 m and 0.9 m reflectors at Lick Observatory. From the analysis of this small sample he got a colour excess $E_{B-V} = 1.02$, an apparent distance modulus ($m - M$) = 13.10, a distance from the Sun of about 1.0 kpc, and a diameter of 3.5 pc. The CMD he obtained shows some MS stars with a Turn Off Point (TO) at about $V = 14.0$ mag, and a group of 6 evolved stars almost vertically distributed. Afterwards no other studies have been performed on NGC 7762 to our knowledge. The cluster is contained in a list of possible old open clusters in Phelps et al (1994, Table 4), and several investigators stressed in the last years the necessity to get better informations on it. The present study is a continuation of the observa-

tional program of old northern open clusters we started with NGC 1245 (Carraro & Patat 1994) at the Asiago Observatory.

The plan of this work is as follows. In Sect. 2 we present observations and data reduction; in Sect. 3 we describe the CMD of NGC 7762, while in Sect. 4 we derive its fundamental parameters. Finally Sect. 5 give some concluding remarks.

2. Observations and data reduction

Photometry of NGC 7762 in *B* and *V* passbands has been obtained with the 1.82 m telescope at Asiago Astrophysical Observatory (Italy) on December 28, 1994. The instrumental setup and the *CCD* features have been described in details in Carraro & Patat (1994). Details on the observations are listed in the log-book (see Table 1). The night was not completely photometric with typical seeing values around 2".0. This relatively poor seeing does not affect our results, given the very low concentration degree of the cluster. We observed three fields in the region of the cluster, and a field 15".0 northwards. The sampled area is presented in Fig. 1, together with a digitized POSS image (lower left corner) of the region of NGC 7762 to show that we succeeded to cover the very central region of the cluster. To accomplish photometric calibration we monitored the Landolt standard fields Rubin 149, PG 1047 and PG 1323 (Landolt 1992). Finally we took a series of dome flat-field frames.

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*Based on observations carried out at Mount Ekar, Asiago (Italy)

**Table 2 is only available in electronic form at the CDS via anonymous ftp 130.79.128.5

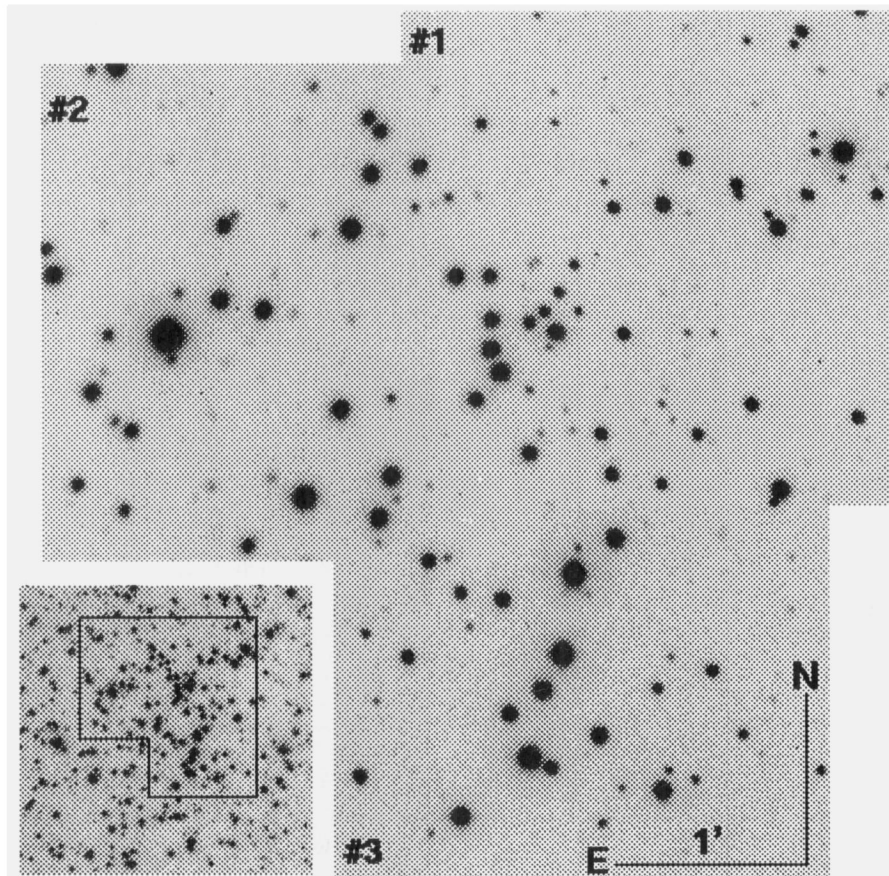


Fig. 1. CCD V image of the area covered in the center of NGC 7762. In the lower left corner a POSS digitized image for the region around the cluster is shown

Bias and flat-field corrections were done using the standard routines in the MIDAS package and the instrumental photometry was derived with the DAOPHOT/ALLSTAR (Stetson 1991) package in the MIDAS environment at ESO.

The instrumental b and v magnitudes have been transformed into standard Johnson B and V magnitudes using fitting coefficients derived from the observations of the standard field stars from Landolt (1992), after including exposure time normalizations and airmass corrections. Due to the low quality night we get only the colour terms making use of standard stars, and we fixed the zero points using 7 stars in common with Chincarini (1966). The final transformations are:

$$(B - V) = 1.125 \cdot (b - v) + 0.02 \quad (1)$$

$$V = v + 0.016 \cdot (B - V) - 2.02 \quad (2)$$

Table 1. Journal of observations, 1.82 m telescope, Mount Ekar, Asiago (Italy)

Region	Date (UT)	Filter	Exposure (sec)
#1	December 28, 1994	B	180
#1	December 28, 1994	V	60
#1	December 28, 1994	B	900
#1	December 28, 1994	V	600
#2	December 28, 1994	B	900
#2	December 28, 1994	V	600
#2	December 28, 1994	B	120
#2	December 28, 1994	V	60
#3	December 28, 1994	B	900
#3	December 28, 1994	V	600
#3	December 28, 1994	B	180
#3	December 28, 1994	V	60
Field	December 28, 1994	B	900
Field	December 28, 1994	V	600

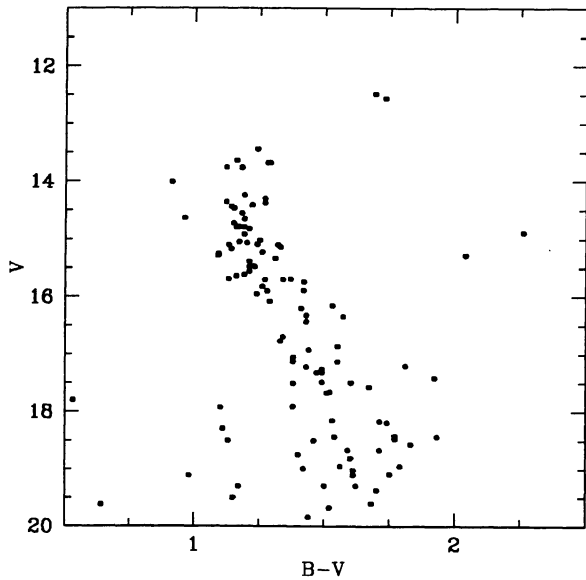


Fig. 2. CMD for all the stars we detected in the region of NGC 7762

The RMS errors affecting this calibration are expected to be of the order of 0.04 and 0.06 mag for V and $(B - V)$, respectively. Final magnitudes and colours are contained in Table 2 together with their identification number (ID), Chincarini numbering (C 66), the frame coordinates (X and Y) in pixels, and the instrumental ALLSTAR rms errors σ .

3. Colour–magnitude diagram

The CMD in the $V - (B - V)$ plane for all the stars (142) we detected in the field of NGC 7762 is shown in Fig. 2. Looking at this figure the main features of the diagram can be summarized as follows. The MS is well defined down to $V \simeq 16.5$, with the TO point at $V \simeq 14.5$ and $(B - V) \simeq 1.1$. The small group of stars above the TO are probably objects migrating from the MS to the evolved region due to exhaustion of hydrogen in their nuclei. We cannot exclude that some of these stars can be unresolved binaries. Below $V \simeq 16.5$ the sequence dramatically widens, and the CMD shows a significant population of blue stars which are likely interlopers between us and NGC 7762. The broadness of the sequence is much larger than expected from instrumental errors, and we suggest it is due to the evaporation of low mass stars. NGC 7762 is indeed a very sparse cluster (the estimates of the diameter are around $10'$) and its potential well is probably not sufficient to keep tied low mass stars. There are several cases of moderate age open clusters showing the same MS broadness. For instance NGC 3680 (Anthony-Twarog et al 1991) and IC 4651 (Anthony-Twarog et al 1988) are loose clusters of the same generation with the MS cut a few magnitudes below the TO. Anthony-Twarog et al (1991)

find that the MS of NGC 3680 is clearly underpopulated below $V \simeq 14.0$ (see Fig. 4), and attribute this fact to field stars contamination and low mass star evaporation. In our case contamination of disk field stars is not expected to play an important role because we sampled the central region of the cluster. Finally we recall the analysis of the MS luminosity function (LF) of NGC 6791 by Kaluzny & Rucinski (1995). They suggest that the greater slope they found for NGC 6791 LF with respect to younger clusters is imputable to low mass stars evaporation in less concentrated clusters.

Due to the small extension of the MS we restrain to study the MS luminosity function, and therefore we did not make use of the observed galactic disk field (see Table 1) to correct for contaminating disk field stars.

The evolved region of NGC 7762 CMD is defined by two stars, which correspond to the Red Giants clump of He-burners at $V \simeq 12.6$ and $(B - V) \simeq 1.7$. The CMD of Chincarini shows 6 evolved stars, 5 of them lying outside of the cluster region we covered. For a more reliable comparison with theoretical tools (see below) we decided to introduce the remaining 5 stars in our CMD. These stars are marked with an asterisk in Fig. 4.

4. Cluster parameters

4.1. Reddening and metallicity

The fundamental parameters of NGC 7762 are very poorly known. A hint on the colour excess E_{B-V} of the cluster is derivable from Neckel & Klare (1980) absorption maps in the neighborhood of the cluster. In this case the most suitable relation is in their Fig. 6a, 1–2, although they provide values for somewhat smaller latitudes. The selective absorption A_V turns out to be about 1.2–1.8 mag, which implies a colour excess $E_{B-V} \simeq 0.4$ –0.6 mag, respectively, significantly smaller than Chincarini's estimate. Chincarini (1966) got three colour photometry of 18 stars in the field of NGC 7762, and from the two colour diagram he determined the $E_{B-V} = 1.02$ and $E_{U-B} = 0.71$. Moreover he reminds of a spectroscopic study of the Cepheus IV association (Walker 1965), in which a star they have a common is measured to have $E_{B-V} = 0.89$. To summarize the colour excess seems to be reliably between 0.8 and 1.0 mag. As for the metallicity, an insight can be derived looking at the de-reddened TO colour $(B - V)_{0,TO}$, for clusters with roughly the same age, which depends only on the metallicity. Assuming $E_{B-V} = 0.80$ –1.0, we got $(B - V)_{0,TO} \simeq 0.1$ –0.3. NGC 3680, a coeval intermediate age cluster ($\Delta V = 1.70$, see below and Fig. 4) has $(B - V)_{0,TO} = 0.40$ and $[Fe/H] = -0.16$ (Friel & Janes 1993). This suggests that NGC 7762 should likely be metal poorer than NGC 3680.

4.2. Age and distance

In this section we compare the CMD of NGC 7762 with theoretical isochrones (Bertelli et al. 1994). It is possible to have a rough idea of the cluster age from the ΔV index, which is known do not depend on cluster parameters such as colour excess and distance modulus, and to have only a small dependence on metallicity (see Carraro & Chiosi 1994 for the definition). In the case of NGC 7762 ΔV turns out to be around 1.7 mag, which suggests an age of about 1.8–2.0 Gyr. This is confirmed also by comparing the CMD of NGC 7762 with that of NGC 3680 (see Fig. 4). The morphology of the two CMDs is quite similar, implying that the clusters have to be coeval. Adopting theoretical metal abundance $Z = 0.008$ ($Y = 0.25$) we confirm the previous arguments. The fit with a 1.8 Gyr isochrone is shown in Fig. 5, and has been performed assuming a colour excess $E_{B-V} = 0.85$ and an apparent distance modulus $(m - M) = 12.00$. The main regions of the CMD are nicely reproduced, but the scattered MS does not permit to fix the reddening and the distance modulus very firmly. Values of 0.90 and 12.20 for E_{B-V} and $(m - M)$ respectively would provide a rather good fit as well. The distance to the Sun we get is $d_{\odot} = 800$ pc, with an uncertainty of 20%. The galactocentric coordinates X , Y , and Z of NGC 7762 turn out to be 8800, 700 and 100 pc, respectively, while the resulting distance to the Galactic Center is 8.7 kpc, if for the distance of the Sun to the Galactic Center the value of 8.5 kpc is adopted

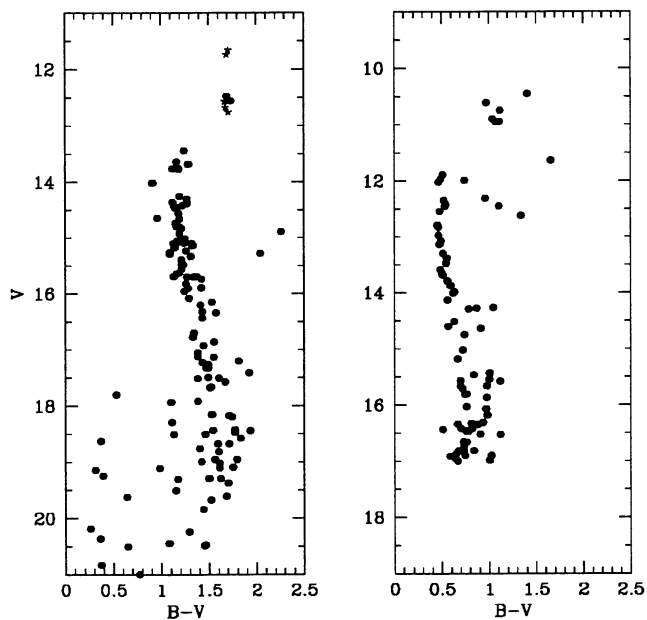


Fig. 3. CMDs of NGC 7762 (left panel) and NGC 3680 (right panel)

5. Concluding remarks

The photometric observations here presented show that NGC 7762 is a moderate age open cluster with a lower than solar metal abundance. We improve on a previous analysis by Chincarini (1966) showing that: 1) the cluster MS becomes ill-defined starting from $V \simeq 16.50$, due to low mass stars evaporation; 2) the age of the cluster is about 1.8 Gyr, suggesting that NGC 7762 is a cluster of the same generation of the better studied clusters NGC 3680 and IC 4651; 3) the reddening and distance are shown to be somewhat smaller than Chincarini's (1966) determinations. The morphology of the MS prevents us to produce a reliable luminosity function. Further studies of this cluster should concentrate on the spectroscopic determination of the metal abundance $[Fe/H]$ and on photometric coverage of a larger area to enlarge the stars sample.

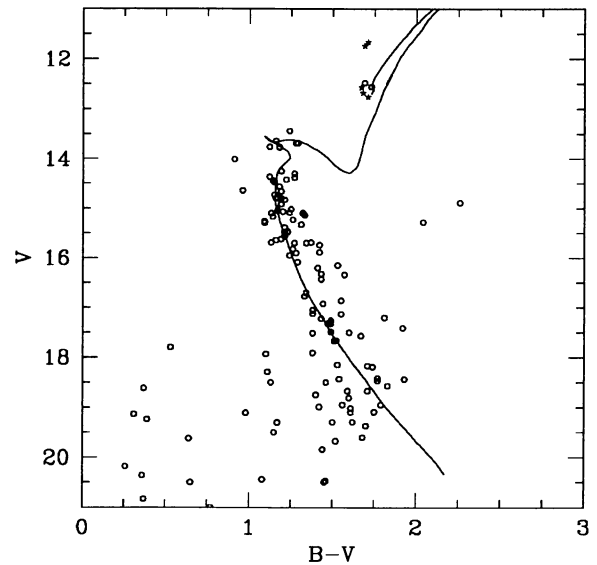


Fig. 4. CMD for all the stars we detected in the region of NGC 7762. Asterisks identify Chincarini's giants outside the region we sampled. Overimposed is an isochrone for 1.8 Gyr and $Z = 0.008$. See the text for the details

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