Astron. Astrophys. 291, 106–109 (1994)

ASTRONOMY AND ASTROPHYSICS

Pismis 3: an unstudied old open cluster*

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Received 7 April 1994 / Accepted 13 June 1994

Abstract. We have obtained CCD BV photometry for the open cluster Pismis 3 and a nearby field. This previously unstudied object appears to be rich, loose and strongly absorbed. Our analysis suggests that Pismis 3 is of intermediate age and probably metal poor. Adopting the theoretical metal content $Z = 0.008$, which provides the best global fit, we obtain an age of about 2 Gyr. Simultaneously a color excess $E_{B-V} = 1.35$ and an apparent distance modulus $(m - M) = 14.70$ are derived. These results put Pismis 3 about 1.5 Kpc distant from the Sun. The relation of the cluster with the surrounding field is also investigated.

Key words: open clusters: Pismis 3 – HR diagram

1. Introduction

The study of intermediate age and old open clusters in the Galactic Disk is nowadays a very active research field. Over the last years a considerable amount of high quality photometric and spectroscopic data has been collected, and what was a very poor sample of objects a decade ago is now becoming statistically significant.

Many clusters have been re–observed with CCD detectors, improving their color–magnitude diagram (CMD) and fundamental parameters, such as age, distance, reddening and metal content. Relevant examples are M 67 (Montgomery et al. 1993) and NGC 752 (Daniel et al. 1994).

At the same time , it is difficult to find the oldest open cluster among objects which are listed in the catalogues, but that have been studied either poorly or not at all. (Janes & Phelps 1990; Phelps et al. 1994). The reasons for this are discussed in detail by the same authors, and basically are tied to the unique role this population of cluster plays in probing our knowledge of the structure and early chemical and dynamical evolution of the Galactic Disk.

This paper is a continuation of a series, begun with the study of NGC 4815 (Carraro & Ortolani 1994), aiming to the acquisition of new or updated good quality CMDs for this family of clusters.

Pismis 3, the cluster here investigated, appears (like NGC 4815) in the list of probably old open clusters proposed by Janes (1988), and is also designated as C0829-3830 and OCL 731.

The cluster ($\alpha = 8^h\ 29^m\ 6^s$, $\delta = -38^o\ 30'\ 0''$; $l = 257^o\ 49'\ 50''$, $b = 0^o\ 25'\ 50''$; Eq. 1950.0) takes the name from the astronomer who in the late fifties (Pismis 1959) compiled a catalogue of 2 globular and 24 new open star clusters in the Galactic Plane between $l = 225^o$ and $l = 353^o$. Pismis 3 has an angular diameter of about $6'.5$, appears the richest of the list and it is located in an obscured region (Janes 1988). To our knowledge no other studies preceded this one.

In Sect. 2 we present the observations and the data reduction; in Sect. 3 the CMDs of Pismis 3 and the accompanying field are discussed. Finally Sect. 4 gives some concluding remarks.

2. Observations, data reduction and photometric errors

Observations were conducted using the 1024×1024 CCD ESO #19 mounted on the 2.2m ESO telescope, at la Silla, on two nights spanning 1993 November 20-21. Both nights were photometric with an average seeing of $1''.0$. The scale on the chip is $0''.33$ per pixel, the array covering about $5'.5 \times 5'.5$ on the sky. Two fields, one centered in the cluster, and the other about $4'.0$ further away, were observed in the B and V passbands. Tab. 1 summarizes the observations, while Fig. 1 shows a CCD B image in the region of Pismis 3.

Table 1. Journal of observations, 2.2m , ESO, La Silla (Chile).

Frame	Date (UT)	Time (UT)	Filter	Exposure (secs)	FWHM ($''$)
Field	Nov. 20, 1993	08^h01^m	V	300	0.95
Field	Nov. 20, 1993	08^h09^m	B	900	1.12
Pismis 3	Nov. 21, 1993	08^h17^m	V	180	0.94
Pismis 3	Nov. 21, 1993	08^h23^m	B	360	1.08

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* Based on observations carried out at ESO, La Silla (Chile)

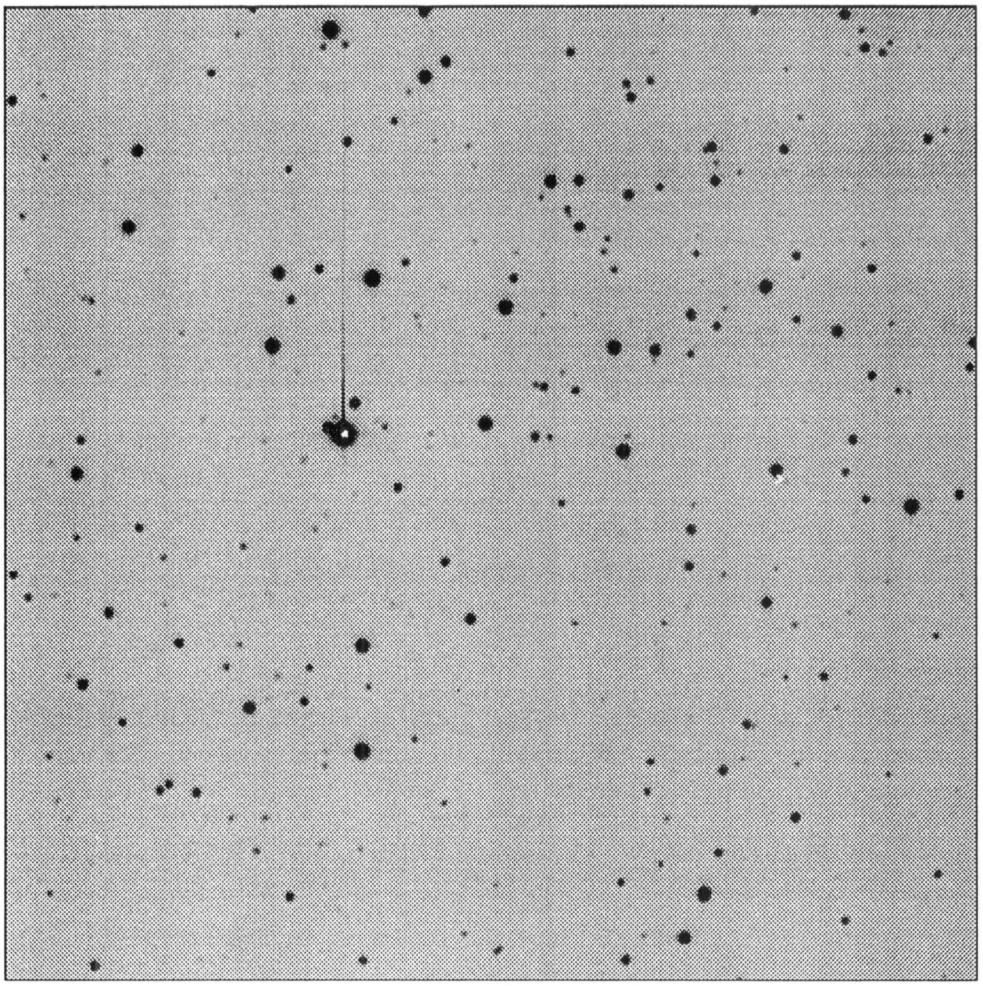

Fig. 1. CCD B image of Pismis 3. The field is $5'.5 \times 5'.5$. The North is upward, the east rightward

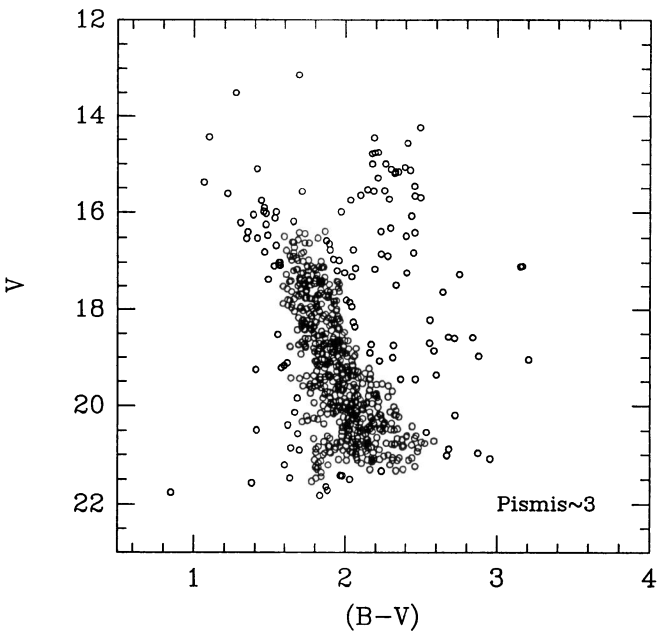

Fig. 2. CMD for all the stars studied in the region of Pismis 3

Landolt (1992) standard fields Rubin149, SA 98-650 and T Phoenix were observed at the beginning (the latter) and at the end (the two formers) of every nights. At the same time, every evenings during the observational run a series of dome and skyflats were obtained.

Pre-processing, to apply bias and flat-field corrections, was done with standard routines in the MIDAS software package. The dome flats were applied to all images but for B, the B dome flats lefting residuals, that have been corrected combining the dome and sky flats.

The reductions were performed using the DAOPHOT package (Stetson 1991) and the accompanying ALLSTAR program, in the MIDAS environment, at the Department of Astronomy in Padova (Italy).

The instrumental b and v magnitudes have been transformed in standard Johnson B and V magnitudes using fitting coefficients (color term and zero point) derived from observations of the standard field stars from Landolt (1992), after including airmass and aperture corrections (Stetson 1990). The transformations are given in the following equations:

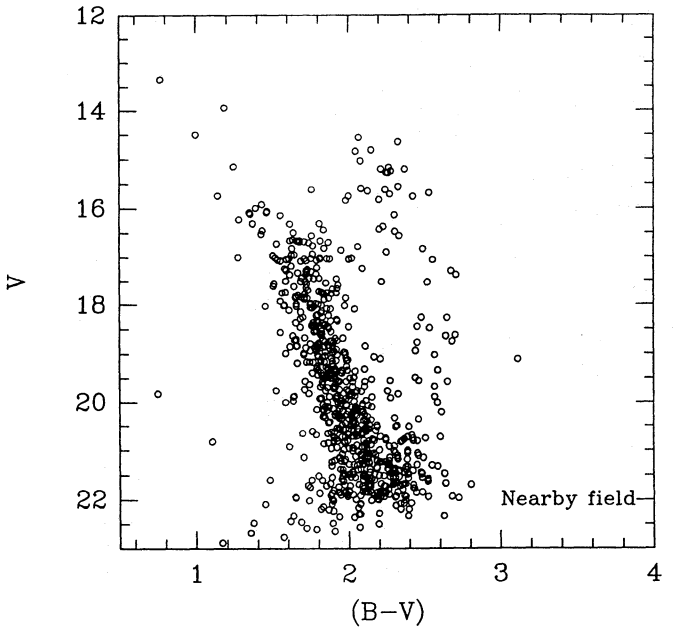

Fig. 3. CMD for all the stars in the field background near Pismis 3

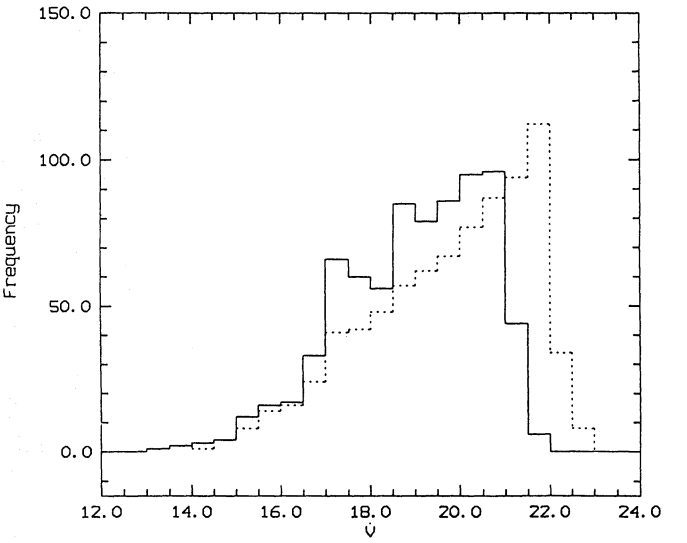

Fig. 4. MS luminosity function for Pismis 3 (solid line) and for the nearby field (dotted line)

$$V = v + 0.058(\pm 0.006) \cdot (B - V) - 1.370(\pm 0.010) \quad (1)$$

$$B = b + 0.226(\pm 0.018) \cdot (B - V) - 2.748(\pm 0.024) \quad (2)$$

The resulting magnitudes and colors are contained in two tables available upon request, together with the frame coordinates (X and Y) and the instrumental ALLSTAR errors, indicated with σ, for the cluster and the field, respectively. Due to the $(B - V)$ range covered by the standards sample, the magnitudes and colors for the stars redder than about $(B - V) = 1.2$ have been extrapolated.

To obtain more realistic error estimates, we have performed some experiments with artificial stars (see Carraro & Ortolani 1994 for more details) by means of the ADDSTAR routine of DAOPHOT. We found errors of 0.04, 0.09 and 0.12 *mag.* at V magnitudes 17, 19 and 21 and error of 0.03, 0.08 and 0.13 *mag* at the same B magnitude levels. These values are consistent with the DAOPHOT outputs, and in discrete agreement with the natural width of the main sequence (MS) at the same magnitude levels, that turns out to be 0.13, 0.19 and 0.29 *mag*, respectively. We found basically the same errors for the field frames. The broadness of the MS is clearly due to various causes, among which we recall the photometric errors, the presence of a fraction of unresolved binary stars, a possible internal reddening, and a spread in metallicity.

3. The color–magnitude diagrams

In Figs. 2 and 3 we show the CMDs of Pismis 3 and the nearby field, respectively. The field background has been taken about 4′.0 far from the cluster.

To compare the cluster and the field we have plotted together the MS histograms in Fig. 4, from which one can argue that, as suggested below, the field luminosity function (LF) appears to be steeper than the cluster one.

3.1. The cluster CMD

The CMD of Pismis 3 is shown in Fig 2. The MS extends for about 5 magnitudes, and the turn off point (TO) is located at $V \simeq 17.0$, $(B - V) \simeq 1.7$. A poorly populated red "clump" is detectable at $V \simeq 15.3$ and $(B - V) \simeq 2.2$. These values suggest a strong absorption, as expected from the position of the cluster onto the galactic plane (see Neckel & Klare 1980, Fig. 9a).

The overall morphology of this CMD bears a close resemblance with the cluster NGC 2158 (Arp & Cuffey 1962). This fact indicates that Pismis 3 belongs to the family of the intermediate age open clusters with an age of about 1–2 Gyr. Moreover the poorly developed red giant branch suggests that the cluster TO mass is slightly greater than about $1.1 M\odot$, the mass at which the inner star core during the MS H-burning switches from radiative to convective.

If we adopt the $age - \Delta V$ relation (with ΔV defined as the magnitude difference between the TO and the clump) proposed by Carraro & Chiosi (1994) for the old open clusters population, for a measured $\Delta V \simeq 1.7$ we get the approximate age of 2 Gyr.

This age value is finally confirmed by the fitting with theoretical isochrones including convective overshoot (Alongi et al. 1993), from which we find out a color excess $E_{B-V} = 1.35 \pm 0.05$, an apparent distance modulus $(m - M) = 14.70 \pm 0.10$ and an age of 2 Gyr. The color excess is in agreement with Neckel & Klare (1980), who in the same galactic direction find $A_V = 2\ mag \cdot Kpc^{-1}$. The range in age of isochrone that makes an acceptable fits is about of 20%. These results have been derived adopting a metal content $Z = 0.008$, which provides the best fit of the overall CMD (see Fig. 5). Open cluster of similar

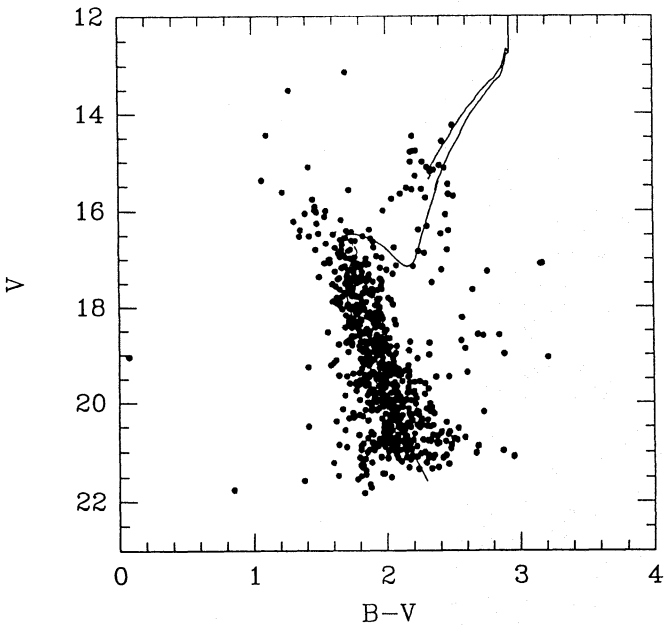

Fig. 5. The CMD of Fig. 2. Superimposed is a Z = 0.008 isochrone for an age of 2 Gyr including convective overshoot. It has been drawn adopting E_{B-V} = 1.35 and $(m - M)$ = 14.70

ages (NGC 2506 and NGC 2420, for example) have about the same metal abundance (Friel & Janes 1993).

3.2. The field CMD

The CMD of the background field is shown in Fig 3. The appearance of this diagram is quite similar to the cluster counterpart, in that the two covered areas are not too distant and, as a consequence of this, the field frames contain a significant portion of cluster stars. Due to a different time exposures the field MS is slightly deeper, but the TO and the red giant clump are at about the same locations. The giant branch and the clump show a slightly different appearance in comparison with the cluster, and appear more blurred.

The MS LFs plotted in Fig. 4 clearly demonstrate that the field MS LF is steeper than the cluster one, suggesting the possibility of the presence of different contaminating populations of various ages (see the analysis of NGC 6603 by Bica et al. 1993).

The star counts in the field show that in the MS magnitude interval between 16.0 and 18.0 there are about 2.7 stars per squared arcmin, in agreement with analogous counts at a similar galactic position (Ortolani, private comunication). We stress, however, that some contamination of stars from the cluster in our "field" diagram is certainly present.

4. Discussion and conclusions

In this paper we have presented a CMD for the previously unstudied open cluster Pismis 3. As suggested by Pismis (1959) and Janes (1988) the cluster appears rich and strongly absorbed. To our knowledge Pismis 3 results the oldest of the Pismis list, if one excludes the two globulars.

We suggest in fact that the cluster is metal poor and about 2 Gyr old. It is however important to stress that the lack of any knowledge about the metal abundance of Pismis 3 allows us to get only approximate determinations of the cluster fundamental parameters. Spectroscopic analysis of the cluster giants could greatly improve further studies of this object.

Acknowledgements. This work has been financially supported by the Italian Ministry of University, Scientific Research and Tecnology (MURST) and the Italian Space Agency (ASI).

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