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A multicolour CCD photometric study of the open clusters NGC 2866, Pismis 19, Westerlund 2, ESO96-SC04, NGC 5617 and NGC 6204

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ABSTRACT

Accurate and deep *BVI* CCD photometry is presented for the core regions of six southern compact open clusters (supplemented in one case by *U* and *R* bands), which generally have only scanty photometric data published, in some cases only photoelectric or photographic. Together with adoption of modern reference isochrones, this has allowed us to derive improved values for their distance, reddening, age and main sequence morphology.

Key words: stars: evolution – Hertzsprung–Russell (HR) diagram – open clusters and associations: general.

1 INTRODUCTION

In this paper we present new CCD multicolour photometry for the compact southern open clusters NGC 2866, Pismis 19, Westerlund 2, ESO96-SC04, NGC 5617 and NGC 6204, aiming at deriving updated estimates of their fundamental parameters. The basic parameters of the clusters are summarized in Table 1. This study is part of a survey of southern open clusters conducted by us at the South African Astronomical Observatory (SAAO) in 1992. Another 11 young open clusters observed during the same survey have already been investigated by Munari & Carraro (1995, 1996a), Munari, Carraro & Barbon (1998), Barbon et al. (2000) and Sagar, Munari & de Boer (2001).

All clusters considered in this paper have already received some attention in the literature. None the less, uncertainties remain here and there because of a limited number of measured members, bright limiting magnitude, absence of profile CCD photometry in crowded areas or uncertain data calibration. This paper intends to offer high-quality photometry of the program cluster and an homogeneous derivation of basic parameters using the most recent family of isochrones.

The layout of the paper is as follows. In Section 2 we briefly summarize the present knowledge of the clusters under investigation; Sections 3 and 4 illustrate the observations and data reduction strategies, respectively, whereas Section 5 is devoted to the detailed comparison of our photometry with previous ones. Section 6 present our results on a cluster-by-cluster basis, and, finally, Section 7 briefly summarizes the content of the paper.

2 PREVIOUS INVESTIGATIONS

NGC 2866. This is a compact, young and poorly populated cluster. It was first studied by Vogt & Moffat (1973, hereafter VM73) who obtained *UBV* photoelectric photometry of the four brightest stars. Later Clariá (1979, hereafter Cl79) provided *UBV* photoelectric photometry of 23 stars, from which the cluster turned out to have a reddening $E_{B-V} = 0.66 \pm 0.02$ and a distance of 2.6 ± 0.2 kpc. No precise estimates are available for its age, only the suggestion it is probably too old to be a spiral arm indicator.

Pismis 19. This is an intermediate-age open cluster. CCD photometry has been obtained by Phelps, Janes & Montgomery (1994, hereafter Ph94) in *VI* and by Piatti et al. (1998a, hereafter Pt98a) in *BVI*. The latter provide also integrated spectra. They estimated the reddening in the direction of Pismis 19 to be $E_{B-V} = 1.45 \pm 0.10$, and a 2.40 ± 0.88 kpc cluster distance. They also derived a 1.0 ± 0.2 Gyr age and (from the integrated spectra) [Fe/H] $= -0.1$ metallicity.

Westerlund 2. This is a very young cluster, embedded in nebulosity. Vogt & Moffat (1975, hereafter VM75) first obtained *UBV* photoelectric photometry for nine stars in this cluster. Later on Moffat, Shara & Potter (1991, hereafter Mf91) got *UBV* CCD photometry of 220 stars, deriving a distance of about 8 kpc. The cluster was found to exhibit a high differential reddening. In addition, spectral classification for seven stars was reported, one being a newly identified WN7 Wolf Rayet star, which implies a very young age for the cluster. Finally, Piatti, Bica & Clariá (1998b, hereafter Pt98b) obtained integrated spectra, from which they derived an age of 2–3 Myr and an absorption of $A_V = 5$ mag. Interestingly, they revised the cluster distance, shortening it to 5.7 ± 0.3 kpc.

ESO96-SC04. This is a faint cluster of intermediate age. It has been observed by Ph94 and Carraro, Vallenari & Ortolani (1995, hereafter Ca95) who both obtained *BV* CCD photometry. The latter derived a distance of 11.8 kpc, a reddening of $E_B - V = 0.75$ mag and an age of somewhat less than 1 Gyr.

NGC 5617. Photoelectric photometry for 30 stars has been obtained by Moffat & Vogt (1975, hereafter MV75), who derived $E_{B-V} = 0.52 \pm 0.03$ and a distance of 1.34 kpc from the Sun. Subsequently, the cluster was studied by Haug (1978, hereafter Ha78), who carried out photoelectric and photographic photometry and

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Table 1. Basic parameters of the program clusters. Coordinates are for the J2000.0 equinox.

Name	IAU	OCL	Other	Trumpler class	α (h : m : s)	δ (° : ′ : ″)	l (°)	b (°)
NGC 2866	C0920-509	744	Pismis 13	I2m:b	09:22:07	−51:06:06	273.12	−0.76
Pismis 19	C1426-607	921		I1r:b	14:30:42	−60:59:00	314.68	−0.40
Westerlund 2	C1022-575	807	VdB 95	IV1 p n:b	10:24:02	−57:45:30	284.27	−0.33
ESO 96-SC04					13:15:09	−65:55:51	305.35	−3.17
NGC 5617	C1426-605	919	VdB 159	I2r	14:29:48	−60:43:00	314.68	−0.11
NGC 6204	C1642-469	982	VdB 196	I3m:b	16:46:08	−47:00:44	338.56	−1.03

found a similar reddening and a longer 1.82 kpc distance. CCD *UBV* photometry has been reported by Kjeldsen & Frandsen (1991, hereafter KF91), who found a smaller reddening $E_{B-V} = 0.48 \pm 0.02$, a larger distance of 2.05 ± 0.2 kpc and an age of 70 Myr age.

NGC 6204. This cluster was studied by Moffat & Vogt (1973, hereafter MV73), who obtained $E_{B-V} = 0.39$ and distance of 0.81 kpc from *UBV* photometry of 13 stars. Somewhat different results are found by KF91, who placed the cluster at 1.2 ± 0.15 kpc and suggest a reddening $E_{B-V} = 0.45 \pm 0.03$ and an age of 0.22 Gyr. More recently, new photoelectric photometry was carried out by Forbes & Short (1996, hereafter FS96), who reported a reddening $E_{B-V} = 0.51 \pm 0.07$, the same KS91 distance and an age of 125 ± 25 Myr.

3 OBSERVATIONS

The observations were carried out between 1992 June 4 and 6, and on July 13, in the Cousins *UBVRI* photometric system, using an RCA SID53612 thinned CCD detector at the $f/15.8$ Cassegrain focus of the 1.0-m Elizabeth Telescope at the SAAO, Sutherland. A 30-μm square pixel of the 320 × 512 CCD corresponded to 0.388 arcsec and the entire chip covered a field of 2.1×3.3 arcmin^2 on the sky. The readout noise for the system was 73 electron pixel^{-1}, while the number of electrons per ADU was 11. The photometric quality of the sky was monitored using an off-axis photoelectric photometer that continuously measures a bright, non-variable star located close to the field imaged on the CCD. The four nights were of good photometric quality, with seeing ranging between 1.2 and 2.2 arcsec. Table 2 lists the log of our observations. Prior to each exposure, a 330-ms pre-flash was given to avoid charge transfer problems. Before that, the CCD chip was quickly cleaned 50 times and read once. Every hour a 33-s pre-flash was acquired to obtain a pre-flash pattern. It was found to be extremely stable, with scatter resulting only from photon statistics. Flat-field exposures were made of the twilight sky. Dark current frames were secured in night-time dark conditions.

About 40 E- and F-region standards covering a range in brightness ($7.9 \leqslant V \leqslant 10.3$) as well as in colour ($0.01 \leqslant (V - I) \leqslant 2.4$) were observed for calibration purposes. The actual timings of the CCD camera shutter was monitored by a series of LEP-PSD couples that accurately record the *effective* exposure time to 10 ms precision, thus permitting the use of bright photometric standards from the E and F regions. Typically every 1–1.5 h, we observed one red and one blue standard star at small airmass and one red and one blue standard at large airmass in order to have several independent determinations of the primary and secondary coefficients during the night, as well as system colour equations. They were found to be quite constant during the observing run. The excellent photometric quality of the sky and the small values of airmass at which the observations have been done ensure the accuracy of the data here presented.

Table 2. Journal of observations. *N* denotes the number of stars measured in the different passbands.

Cluster	Band	Exposure (s)	Date (1992)	N
NGC 2866				
	B	60, 60, 180, 900	Jun 5	377
	V	60, 60, 90, 600	"	377
	I	60, 60, 60, 600, 600	"	330
Pismis 19				
	B	900, 900	Jun 4	372
	V	600	"	372
	I	600	"	370
Westerlund 2	U	965	Jun 5	90
	B	180, 180, 600, 900	"	139
	V	60, 180, 180, 600	"	351
	R	60, 60, 180	"	282
	I	60, 60, 180, 900	"	281
ESO 96-SC04				
	B	60, 60, 1200	Jun 6	890
	V	60, 60, 900, 900	"	890
	I	60, 60, 900	"	860
NGC 5617				
	B	90, 140, 600	Jul 13	100
	V	30, 60, 400	"	140
	I	60, 90, 600	"	140
NGC 6204				
	B	120, 240, 400	Jul 13	50
	V	30, 60, 300	"	75
	I	30, 180, 300	"	101

4 REDUCTION

The data were reduced using the computing facilities available at the Astronomy Department of the University of Padova, Italy, and at the European Southern Observatory in Garching, Germany, with initial data processing performed in the usual way via IRAF[1] directly at SAAO in Cape Town. Stellar magnitudes were obtained by using the DAOPHOT software (Stetson 1987, 1992), and following processing and conversion of the raw instrumental magnitudes into those of the standard photometric system were done using procedures outlined by Stetson (1992). Several stars brighter than $V \approx 10.5$ mag could not be measured because they saturated even on the shortest cluster and field regions frames.

In deriving the colour equations for the CCD system and evaluating the zero-points (zp), we have used nightly values of atmospheric

[1] IRAF is distributed by the National Optical Astronomy Observatories, which is operated by the Association of Universities for Research in Astronomy, Inc., under contract to the National Science Foundation.

Table 3. Average photometric coefficients obtained during 1992 June 4–6 and July 13.

Filter	Ref. colour	zp	γ	k
		1992 June 4–6		
U	$(U-B)$	18.11 ± 0.02	0.020 ± 0.010	0.46 ± 0.02
B	$(B-V)$	20.27 ± 0.01	0.082 ± 0.015	0.27 ± 0.02
V	$(B-V)$	20.31 ± 0.01	-0.025 ± 0.014	0.12 ± 0.02
R	$(V-R)$	20.56 ± 0.01	0.018 ± 0.020	0.09 ± 0.02
I	$(V-I)$	19.69 ± 0.01	0.045 ± 0.015	0.06 ± 0.02
		1992 July 13		
B	$(B-V)$	20.33 ± 0.01	0.002 ± 0.005	0.27 ± 0.02
V	$(B-V)$	20.11 ± 0.01	-0.015 ± 0.011	0.12 ± 0.02
I	$(V-I)$	17.21 ± 0.01	0.005 ± 0.015	0.06 ± 0.02

Table 4. Global photometric rms errors as function of the magnitude in the given band.

Mag	σ_U	σ_B	σ_V	σ_R	σ_I
9–11	0.04	0.03	0.03	0.03	0.03
11–13	0.04	0.03	0.03	0.03	0.03
13–15	0.04	0.03	0.03	0.03	0.03
15–17	0.05	0.03	0.03	0.03	0.03
17–19	0.08	0.03	0.04	0.04	0.05
19–20	–	0.04	0.05	0.07	0.09
20–21	–	0.07	0.09	0.15	0.22

extinction coefficients. The colour equation for the CCD system are derived by performing aperture photometry on the photometric standards. By fitting least-squares linear regressions in the observed aperture magnitudes as a function of the standard photometric indices, we obtained the colour equation listed in Table 3, where γ_i is the colour term, k_i the extinction coefficients, M_i and m_i the calibrated and instrumental magnitudes, zp_i the zero-points and z the airmass:

$$M_i = m_i + zp_i + \gamma_i(M_i - M_j) - k_i z \qquad (1)$$

We estimated global rms errors following the expression given in Patat & Carraro (2001, equation A3), and the results are shown in Table 4.

Complete photometric data for the stars observed in the 6 program clusters are given in electronic form only. They are made available also via the WEBDA data base[2] maintained by J.-C. Mermilliod. Astrometric coordinates to J2000 are provided for all observed stars, as obtained by astrometric calibration of recorded frames against local USNO-A2.0 stars.

5 COMPARISON WITH PREVIOUS PHOTOMETRY

All program clusters have some photometry already available in literature, and a comparison is made in order to assess the accuracy and evaluate the agreement of the data sets as well as to compare completeness and photometric band coverage. The comparisons in this section are always in the sense of *our* data minus *literature* data.

NGC 2866. We have observed 377 stars, in *BVI*, down to $V =$ 22 mag. Only scanty, photoelectric photometry is available in literature for this cluster. VM73 have measured four stars (in *UBV* bands) brighter than 13 mag, and for the three stars in common with our results, it is:

$$\Delta V = 0.030 \pm 0.026,$$

$$\Delta(B-V) = 0.021 \pm 0.008.$$

Cl79 measured 23 stars brighter than 16 mag, and for the 19 in common with our results it is

$$\Delta V = 0.058 \pm 0.114,$$

$$\Delta(B-V) = -0.028 \pm 0.039.$$

The large dispersion in ΔV seems to be caused by field stars contaminating Cl79 photometry in the core of the cluster, where he used a relatively large diaphragm (7.6 arcsec).

Pismis 19. We have observed 372 stars, in *BVI*, down to $V =$ 21 mag. *BVI* CCD photometry has been presented by Pt98a and *VI* CCD one by Ph94. For the 250 stars in common with Pt98a it is:

$$\Delta V = 0.010 \pm 0.016,$$

$$\Delta(B-V) = 0.011 \pm 0.008,$$

$$\Delta(V-I) = -0.009 \pm 0.009,$$

and for the 200 in common with Ph94 it is:

$$\Delta V = -0.041 \pm 0.037,$$

$$\Delta(V-I) = -0.020 \pm 0.087.$$

Westerlund 2. We have obtained *UBVRI* photometry for ∼300 stars, down to 19 mag in V. Photoelectric photometry has been presented by VM75 for 10 stars and CCD photometry of 89 stars by Mf91, calibrated on the eight stars in common with VM75, but spanning a quite limited range in colour. Mf91 report that they find insignificant slopes for the colour equations, and therefore they have not colour-corrected their photometry. Actually, the colour term is not negligible, and comparison of their and our (colour-corrected) U-band photometry for the 28 stars in common yields:

$$\Delta U = 0.076 \times (U-B) - 0.214.$$

Similar problems were encountered previously (Munari & Carraro 1995) when comparing our *UBVRI* photometry of Bochum 2 with the CCD one by Turbide & Moffat (1993) that used MV75 photoelectric photometry as local calibrators. In that case too, as kindly pointed out by A. F. J. Moffat (private communication), the CCD photometry was not colour-corrected. For these reasons we here refrain from comparison with Mf91 photometry of Westerlund 2.

ESO 96-SC04. We have observed 890 stars, in *BVI*, down to $V = 22$ mag. Ph94 presents *BVI* CCD observations of this cluster, which has been used by Ca95 to calibrate their own *BV* photometry. Our *BVI* photometry extends ∼1 mag fainter than Ph94, while Ca95 photometry is about ∼1 mag deeper than ours. The comparison with the 600 stars in common with Ph94 yields:

$$\Delta V = -0.098 \pm 0.049,$$

$$\Delta(B-V) = -0.053 \pm 0.080.$$

NGC 5617. We have obtained *BVI* photometry for 140 stars, down to 17.5 mag in V. Ha78 gives photoelectric *UBV* photometry of 20 stars, used to calibrate photographic *UBV* photometry of 377

[2] http://obswww.unige.ch/webda/navigation.html

star brighter than 15 mag in V. For the 12 unblended stars in common with our photometry, the comparison gives:

$$\Delta V = 0.069 \pm 0.033,$$

$$\Delta(B - V) = 0.049 \pm 0.031.$$

UBV and Gunn-*r* CCD photometry is presented by KF91. The comparison with our photometry for the 59 stars in common gives:

$$\Delta V = -0.054 \pm 0.027,$$

$$\Delta(B - V) = -0.002 \pm 0.003.$$

NGC 6204. We have obtained *BVI* photometry for ∼75 stars, down to 17.5 mag in V. *UBV* and Gunn-*r* CCD photometry is presented by KF91. The comparison for the 45 stars in common provides:

$$\Delta V = -0.041 \pm 0.020,$$

$$\Delta(B - V) = -0.003 \pm 0.005.$$

The mean deviation of our photometry from the cited references is:

$$\Delta V = -0.009 \pm 0.017, \quad (2)$$

$$\Delta(B - V) = -0.006 \pm 0.009, \quad (3)$$

which is very small and well within the error of the mean. This confirms previous findings (cf. Munari & Carraro 1995, 1996a; Munari et al. 1998; Barbon et al. 2000; Sagar et al. 2001) that the *UBVRI* photometry of open clusters that we secured during the 1992 observing runs with the SAAO 1.0-m telescope is accurate and well placed on the international absolute scale.

6 RESULTS

The main parameters for each cluster were adopted in the following way.

The reddening of Westerlund 2, for which our photometry includes the U band, has been derived via the standard Q-method. For all the other clusters, for which we obtained only *BVI* photometry, the reddening has been obtained from the distribution of member stars on the $B - I$, $B - V$ plane. As discussed in Munari & Carraro (1996b, hereafter MC96), the linear fit to the main sequence on such a plane

$$(B - I) = Q + 2.25 \times (B - V) \quad (4)$$

can be expressed in terms of E_{B-V} as

$$E_{B-V} = \frac{Q - 0.014}{0.159} \quad (5)$$

for a standard $R_V = 3.1$ extinction law and stars in the colour range $-0.23 \leqslant (B - V)_o \leqslant +1.30$.

Distances and ages of the program clusters have been derived by fitting the observed CMDs with isochrones from the Padova group (Girardi et al. 2000). The fit provides an estimate of the reddening too, which has always been very close to that obtained with the MC96 method just outlined. The fit to theoretical isochrones has been performed by eye, paying particular attention to the shape of the main sequence (MS), the position of the brightest MS stars, the turn-off point and the location of evolved stars, if present.

The theoretical isochrones are available for a wide range of metallicities. We have adopted for all clusters those with a solar value because we lacked firm photometric or spectroscopic determinations of metallicities of individual clusters, and this information is missing from literature too. The effect of metallicity has been frequently considered in literature: increasing it shifts the isochrones fitting toward older ages, larger distances and smaller reddening.

The results are finally summarized in Table 5, where the basic parameters are listed together with their uncertainties. The latter correspond to the shift allowed to isochrone fitting before a mismatch is clearly perceived by eye inspection.

Table 5. Derived fundamental parameters for the program clusters.

Name	E_{B-V} (mag)	$(m - M)$ (mag)	d (kpc)	Age (Myr)
NGC 2866	0.66 ± 0.10	14.0 ± 0.2	2.6 ± 0.3	200
Pismis 19	1.48 ± 0.15	15.3 ± 0.3	1.5 ± 0.4	800
Westerlund 2	1.67 ± 0.23	19.2 ± 0.4	6.4 ± 0.4	⩽2
ESO 96-SC04	0.70 ± 0.20	17.6 ± 0.6	12 ± 1	800
NGC 5617	0.48 ± 0.05	13.0 ± 0.2	2.0 ± 0.3	80
NGC 6204	0.46 ± 0.05	12.0 ± 0.3	1.2 ± 0.2	80

6.1 NGC 2866

Cl79 has derived for this cluster $E_{B-V} = 0.66 \pm 0.02$, with no marked evidence of differential reddening. Our colour–magnitude diagram (CMD) presented in Fig. 1 shows however a certain breath of the cluster MS suggesting some $\Delta E_{B-V} \sim 0.1$ mag. Applying to our photometry the method by Munari & Carraro (1996b) to derive the reddening from *BVI* photometry of cluster MS stars, we obtain $E_{B-V} = 0.68 \pm 0.10$. The result is close to what found by Cl79, with a larger error due to our deeper and wider field photometry that increases the chance of contamination of the observed cluster zero-age main sequence (ZAMS) by field stars.

Cl79, while not providing an estimate of the age, argued that NGC 2866 is too old to be considered a spiral arm indicator. From ZAMS and the isochrone fitting in Fig. 1, a distance of 2.6 ± 3 kpc can be inferred, in fine agreement with similar findings by Cl79, and ruling out the much shorter distance of 1.2 kpc proposed by VM73 on the basis of photoelectric photometry of four 4 stars. The isochrone fitting indicates an age of 200 Myr.

6.2 Pismis 19

Pt98a have estimated $E_{B-V} = 1.45 \pm 0.10$, 1.1 ± 0.3 Gyr age and 2.2 ± 0.6 kpc distance for this cluster.

Following the same approach for NGC 2866, our reddening estimate from *BVI* photometry is $E_{B-V} = 1.48 \pm 0.15$, while isochrone fitting in Fig. 2 suggests a 0.8-Gyr age and $(m - M) = 15.3 \pm 0.3$ distance modulus, corresponding to a distance of 1.5 ± 0.4 kpc. The MS is well defined down to the magnitude limit of our photometry, with the turn-off located at $V \approx 17.0$, $(B - V) \approx 1.80$. The bluer, less-populated sequence visible in the CMDs of Fig. 2 is due to foreground galactic disc MS stars.

The discrepancy in distance and age between our results and those of Pt98a can be – at least in part – traced to the different set of fitting isochrones adopted. We have performed a direct fitting of our accurate photometric data on to a modern family of theoretical isochrones from the Padova group (Girardi et al. 2000). Pt98a fitting is instead against an set of seven empirical isochrones built from fiducial points derived from observed CMDs of 10 clusters calibrated against older theoretical isochrones (including those of

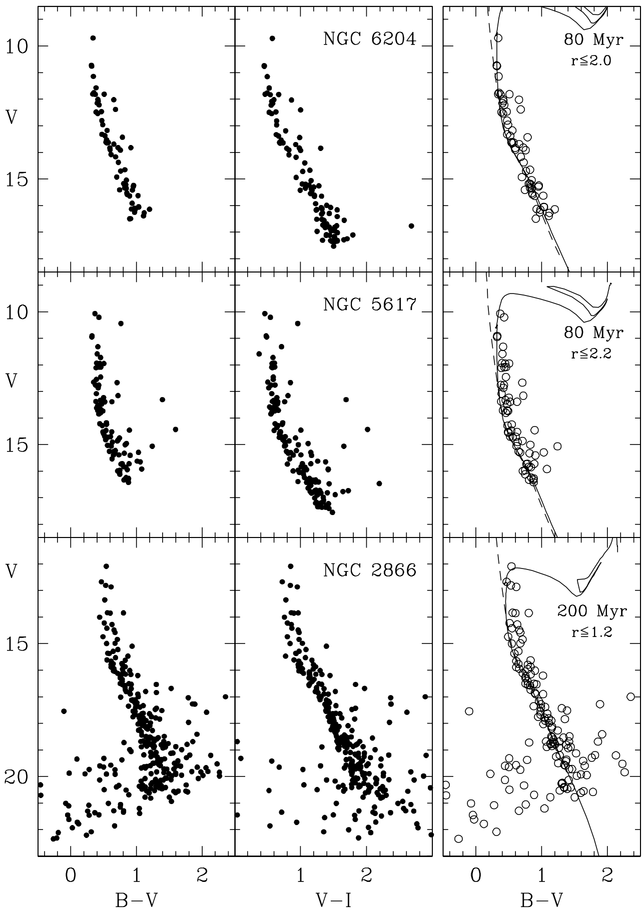

Figure 1. CMDs of the stars in the field of NGC 6204, NGC 5617 and NGC 2866. Left-hand panels: all the stars in the *V* vs (*B*−*V*) diagrams. Central panels: all the stars in the *V* vs (*V*–*I*) diagrams. Right-hand panels: stars lying within *r* arcmin from the cluster centre (indicated for each cluster). The dashed line is the empirical ZAMS from Schmidt-Kaler (1982), whereas the solid lines are isochrones from Girardi et al. (2000) for the solar metallicity and the indicated age.

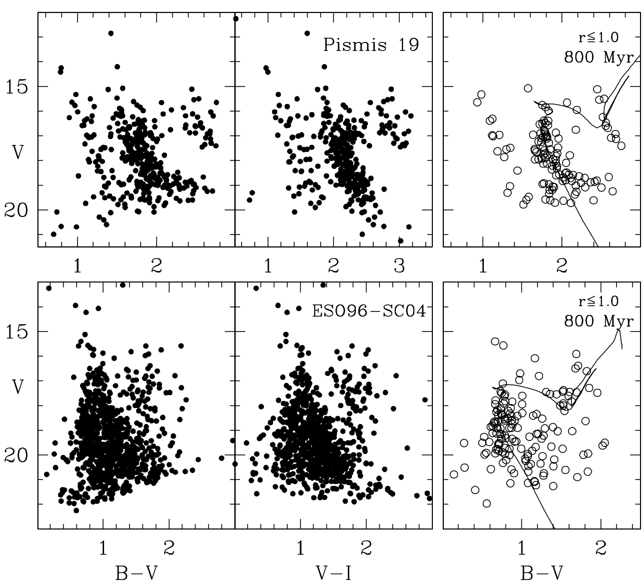

Figure 2. Similar to Fig. 1, for the clusters Pismis 19 and ESO96-SC04.

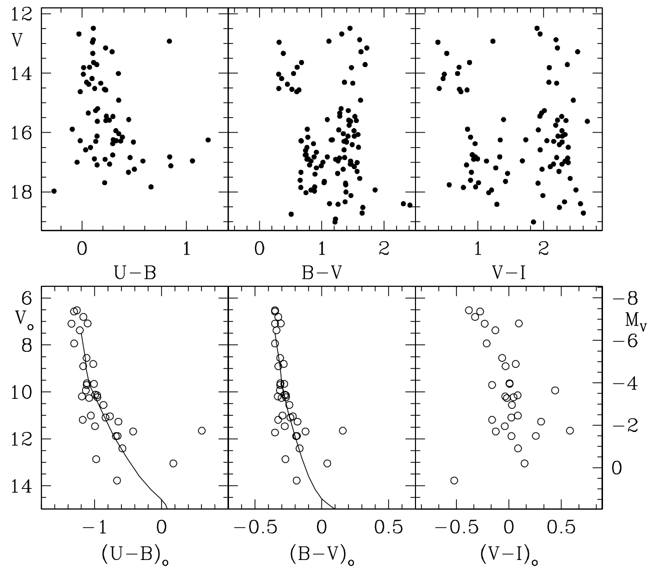

Figure 3. Observed CMD diagrams for all stars in the Westerlund 2 field (top panels) and colour-corrected ones for the stars represented by open squares in Fig. 4 (lower panels), the differentially and highly reddened members of the cluster.

the Padova group released by Bertelli et al. 1994). For such reasons we are inclined to consider our estimates of distance and age more accurate than those of Pt98a.

6.3 Westerlund 2

This is a rather compact open cluster believed to be responsible for the excitation of the core the H II region RCW 49 (Belloni & Mereghetti 1994). Mf91 and Shara et al. (1991) report the discovery of a WN7 Wolf–Rayet member, indicating that Westerlund 2 is very young.

The observed CMDs for Westerlund 2 are presented in Fig. 3. They look very sparse and depict two 'sequences'. When the observed stars are plotted in a $U-B/B-V$ diagram (cf. Fig. 4), the stars of the bluer sequence appear to be galactic disc stars along the line of sight, while those of the redder sequence are cluster members heavily and differentially reddened by $1.5 \leqslant E_{B-V} \leqslant 2.1$. Only the latter are considered in the lower panels of Fig. 3, where they are plotted after reddening correction following the standard *Q* method. The mean cluster reddening turns out to be $E_{B-V} = 1.67 \pm 0.23$, in close agreement with the $A_V \sim 5.0$ spectroscopically estimated by Pt98b.

None of the cluster members appear to be clearly evolving away from the ZAMS. The isochrone fitting against it is presented in Fig. 3, providing a distance modulus of $(m - M) = 14.0$, corresponding to 6.3 kpc. The same distance is obtained by combining our photometry and the spectral classification of its brightest members by Mf91. The close placing of all members on the empirical ZAMS confirms the cluster to be very young, probably not older than 2 Myr. A similar young age and distance have been estimated by Pt98b.

6.4 ESO96-SC04

CMDs of this cluster presented in Fig. 2 are evidently largely contaminated by field stars, as given by the previous CCD photometry of this faint target Ph94 and Ca95.

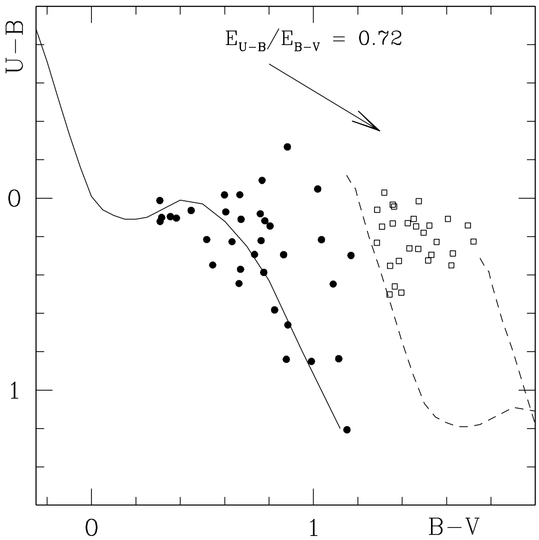

Figure 4. Color–colour diagram for the stars in the field of Westerlund 2 recorded on *UBV* frames. The solid line is the empirical ZAMS from Schmidt-Kaler (1982). The two dashed lines are the ZAMS shifted by $E_{B-V} = 1.5$ and 2.1, to bracket the highly and differentially reddened cluster members, represented by open squares. Filled circles mark foreground galactic disc stars.

Application of the MC96 method to *BVI* photometry to derive the reddening provides $E_{B-V} = 0.7 \pm 0.2$ for ESO96-SC04, with the strong contamination from field stars causing a large uncertainty. Ca95 estimated a similar $E_{B-V} \sim 0.75$.

Our fit to Padova modern isochrones provides and age of 0.8 Gyr and a 12 ± 1 kpc distance, close to the values of 0.7 Gyr and 12 kpc derived by Ca96 using older versions of the Padova isochrones. From radial star counts and the radial behaviour of the observed CMDs, it may be concluded that the whole cluster is contained within a radius of 1.5 arcmin from its apparent centre. The turn-off appears located at $V \approx 17.5$, $(B - V) \approx 0.90$.

6.5 NGC 5617

To cover enough area of this open cluster (the larger on the sky among the program targets), two adjacent fields have been observed, over which cluster members largely outnumber field stars (cf. Fig. 1).

Application of the MC96 method to *BVI* photometry to derive the reddening provides $E_{B-V} = 0.48 \pm 0.05$ for NGC 5617, which is close to literature based on photoelectric data (Ha78 has derived $E_{B-V} = 0.53$, MV75 found $E_{B-V} = 0.52 \pm 0.02$ and Lindoff 1968 got $E_{B-V} = 0.53 \pm 0.02$) and identical to more recent CCD determinations (KF91 found $E_{B-V} = 0.48 \pm 0.02$).

The MS is well defined down to the limit of our photometry, with $V \leqslant 12.5$ stars evolving away from it. Our fitting to modern isochrones provides an age of 80 Myr and a distance of 2.0 ± 0.3 kpc (cf. Fig. 1), close to KF91 values of 70 Myr and 2.05 ± 0.20 kpc. This is significantly largen than old values based on photoelectric photometry: Lindoff (1968) derived 1.1 kpc and MV75 1.3 kpc, while Ha78 got closer with 1.8 kpc.

6.6 NGC 6204

Application of the MC96 method to *BVI* photometry to derive the reddening provides $E_{B-V} = 0.47 \pm 0.05$ for NGC 6204, which is close to and intermediate between KF91 value of $E_{B-V} = 0.45 \pm 0.03$ and FS96 determination of $E_{B-V} = 0.51 \pm 0.07$.

Similarly to NGC 5617, our photometry (cf. Fig. 1) is dominated by cluster members showing a perfectly defined MS down to the magnitude limit, with $V \leqslant 11.5$ stars evolving away from it. The fitting to modern isochrones provide an age of 80 Myr and a distance of 1.2 ± 0.2 kpc. In previous studies, KF91 found 200 Myr and 1.20 ± 0.15 kpc, while FS96 obtained 125 Myr and 1.2 ± 0.1 kpc.

Thus the three available CCD investigations of this cluster pretty well converge on the distance and reddening, with the age estimate getting younger with time, probably reflecting different and improved sets of reference isochrones.

7 CONCLUSIONS

We have presented new homogeneous CCD multicolour photometry for the six Galactic open clusters NGC 2866, Pismis 19, Westerlund 2, ESO96-SC04, NGC 5617 and NGC 6204. For all of them we have provided updated estimates of their fundamental parameters useful in statistical investigations of the open clusters in our Galaxy. The results are summarized in Table 5, where we report for each cluster the reddening, the apparent distance modulus, the distance and the age, together with their uncertainties.

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