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MULTICOLOR PHOTOMETRY OF RED GIANT CANDIDATES IN THE SOUTHERN OPEN CLUSTER NGC 2447

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Abstract. Photoelectric photometry in the *UBV*, *DDO* and *Washington* systems is presented for 14 late-type giant candidates of the southern open cluster NGC 2447. By applying two independent photometric criteria, nine stars are found to have a high probability of being cluster giants. The photometric membership results are in good agreement with those derived from published Coravel radial velocities. The mean interstellar reddening $E_{B-V} = 0.05 \pm 0.04$ has been derived from the confirmed cluster giants. NGC 2447 has a mean ultraviolet excess $<\delta(\text{U-B})> = 0.01 \pm 0.02$ (σ_n) with respect to solar composition K giants, and a mean cyanogen anomaly $<\Delta\text{CN}> = 0.01 \pm 0.02$ (σ_n), both implying a small metal deficiency ([Fe/H] $\simeq -0.1$). Five independent *Washington* abundance indices yield a mean cluster metallicity of [Fe/H] $= -0.09 \pm 0.06$, in agreement with the two previous estimates. Therefore, NGC 2447 is found to be slightly metal-poor.

Key words: methods: observational – techniques: photometric: *UBV* system – *DDO* system – Washington system – open clusters: metal abundance

1. INTRODUCTION

NGC 2447 (IAU designation C0742-237), also known as M 93 or Cr 160 (Collinder 1931), located at $\alpha = 7^{\text{h}}44^{\text{m}}30^{\text{s}}$, $\delta = -23°51.2'$ (J2000) and $\ell = 240.1°$, $b = +0.1°$, is a medium-sized open cluster in the Puppis constellation. Archinal & Hynes (2003) described it as belonging to class I3r, i.e., a rich open cluster with strong central concentration composed of bright and faint stars. The first color-magnitude diagram (CMD) was obtained by Becker (1959) combining photoelectric and photographic data in the Cape *UBV* system. The individual *UBV* measurements for 104 stars in the cluster field were published later by Becker et al. (1976). Eggen (1983) derived a color excess $E_{b-y} = 0.012$, equivalent to $E_{B-V} = 0.02$ (Crawford 1978), and a true distance modulus $V_0 - M_V = 10.15 \pm 0.25$ from *uvby*-Hβ photometry of A- and F-type stars. He also deduced a nearly solar metal content from photoelectric *RI* observations of the probable red cluster giants. Recently, Bica & Bonatto (2005) derived basic cluster parameters using 2MASS photometry. By fitting to the observed CMD the Girardi et al. (2002) isochrones of solar metallicity in the 2MASS *H* and *J* filters, Bica & Bonatto (2005) derived $E_{B-V} = 0.0$, a distance to the Sun $d = 1.05 \pm 0.04$ kpc and an age of 400 ± 50

Myr. Maitzen (1993) carried out a photoelectric search for peculiar stars in the cluster field using the Δa-index (Maitzen 1976), but no photometrically peculiar star was found from a sample of 42 observed stars. Mermilliod & Mayor (1989) obtained Coravel radial velocities for thirteen red giant members in the cluster field, including three spectroscopic binaries. Strobel (1989) lists [Fe/H] = 0.0 for NGC 2447, although the source of this value is uncertain. More recently, Hamdani et al. (2000) derived abundances of about 15 elements in three giants of NGC 2447 from echelle spectroscopy. The average iron abundance was found to be [Fe/H] = 0.03.

NGC 2447 is interesting on account of the number of red giant candidates it contains. In fact, the CMD of NGC 2447 reveals a relatively well populated giant branch with a clump of stars near V = 10.2. As part of a project to determine abundance of red evolved stars in southern open clusters, we present here *UBV*, *DDO* and *Washington* photometry of yellow and/or red giant candidates in the field of NGC 2447. These data are used to discuss the likelihood of membership, to determine individual color excesses and to estimate independent metal abundance parameters. In Section 2 we describe the observational material and the data reduction. Section 3 presents the analysis and discussion of the multicolor photometric data, while the summary and final conclusions of the present work are given in Section 4.

2. PHOTOMETRIC *UBV*, *DDO* AND CMT_1T_2 OBSERVATIONS

Eleven stars in the cluster field brighter than $V = 10.5$ and redder than $B-V = 0.80$, were originally selected as red giant candidates of NGC 2447 from the cluster CMD. Three yellow stars brighter than $V = 10.0$ with $0.40 < B-V < 0.50$ were also selected as probable cluster evolved stars. All these stars were observed in the *UBV*, *DDO* (McClure 1976) and *Washington* (Canterna 1976) photometric systems. Only the four primary filters of the *DDO* (41, 42, 45 and 48) and *Washington* (C, M, T_1 and T_2) systems were used because these contain enough suitable information for the present purposes.

The *UBV* and *DDO* measurements were carried out between 1986 February and 1993 January with the University of Toronto 61 cm telescope at Las Campanas Observatory (LCO) and the 1.0 m telescope of the Cerro Tololo Inter-American

Table 1. UBV photometry and Coravel radial velocities of red giant candidates in NGC 2447.

Star	CD/CPD	V	σ	$B-V$	σ	$U-B$	σ	n_1	V_r	Remarks
3.	−23 6064	8.206	0.011	1.420	0.022	1.689	0.021	5	+20.81	
4.	−23 2735	10.127	0.024	0.920	0.006	0.551	0.001	2	+23.25	
7.	−23 6076	8.373	0.014	1.400	0.017	1.558	0.049	2	+21.97	
25.	−23 6096	9.915	0.001	0.807	0.015	0.452	0.015	3	+21.96	SB (orbit)
26.	−23 6103	9.846	0.002	0.450	0.031	0.127	0.043	2	+20.90	SB
28.	−23 6102	9.888	0.028	0.930	0.008	0.663	0.023	3	+21.25	
34.	−23 2764	10.138	0.014	0.912	0.013	0.604	0.036	5	+22.08	
38.	−23 2747	9.861	0.014	0.470	0.012	0.243	0.023	2	+22.86	SB?
41.	−23 2745	10.038	0.021	0.935	0.002	0.595	0.038	2	+21.51	
42.	−23 6074	9.806	0.011	0.493	0.021	0.223	0.029	2	+15.04	SB
71.	−23 2778	10.213	0.021	0.883	0.013	0.579	0.010	4	+21.87	
85.	−23 6099	10.169	0.016	0.910	0.020	0.587	0.013	2	+20.56	
93.	−23 6086	10.436	0.009	0.890	0.020	0.507	0.037	4	+22.65	
102.	−23 2744	10.078	0.014	1.446	0.017	1.717	0.016	4	–	NM

Table 2. *DDO* photometry of late-type giant candidates in NGC 2447.

Star	$C(41–42)$	σ	$C(42–45)$	σ	$C(45–48)$	σ	n_2
3.	0.263	0.023	1.146	0.010	1.349	0.008	2
4.	0.172	0.014	0.760	0.021	1.137	0.016	2
7.	0.327	0.015	1.133	0.019	1.355	0.011	7
25.	0.151	0.022	0.667	0.025	1.106	0.020	3
26.	0.053	0.001	0.470	0.010	0.890	0.001	2
28.	0.204	0.027	0.754	0.017	1.162	0.026	5
34.	0.210	0.006	0.767	0.002	1.139	0.003	2
38.	0.071	0.004	0.477	0.014	0.899	0.009	2
41.	0.170	0.016	0.802	0.021	1.153	0.008	3
42.	0.066	0.019	0.472	0.006	0.908	0.004	2
71.	0.161	0.014	0.744	0.010	1.156	0.014	3
85.	0.173	0.009	0.756	0.016	1.145	0.009	3
93.	0.106	0.009	0.774	0.004	1.136	0.009	2
102.	0.261	0.025	1.182	0.021	1.273	0.004	2

Table 3. CMT_1T_2 photometry of late-type giant candidates of NGC 2447.

Star	$C–M$	σ	$M–T_1$	σ	$T_1–T_2$	σ	T_1	σ	n_3
3.	1.883	0.005	1.103	0.009	0.709	0.001	7.460	0.012	3
4.	1.035	0.010	0.702	0.002	0.457	0.009	9.700	0.011	3
7.	1.800	0.003	1.043	0.004	0.662	0.003	7.661	0.013	3
25.	0.870	0.011	0.649	0.019	0.443	0.006	9.450	0.011	3
26.	0.441	0.006	0.403	0.027	0.311	0.003	9.595	0.011	2
28.	1.091	0.004	0.720	0.008	0.467	0.006	9.376	0.014	2
34.	1.043	0.010	0.699	0.005	0.459	0.010	9.659	0.017	2
38.	0.460		0.419		0.333		9.622		1
41.	1.061	0.006	0.711	0.008	0.471	0.006	9.599	0.031	3
42.	0.454	0.027	0.426	0.001	0.333	0.002	9.505	0.003	2
71.	1.009	0.001	0.682	0.012	0.468	0.001	9.759	0.004	2
85.	1.027	0.012	0.703	0.001	0.462	0.001	9.686	0.017	2
93.	0.977	0.001	0.682	0.002	0.451	0.005	9.959	0.015	2
102.	1.857	0.005	1.120	0.006	0.727	0.008	9.301	0.009	2

Observatory (CTIO). Single-channel pulse-counting photometers were used in conjunction with dry-ice cooled EMI 9658 and RCA 1P21 phototubes, respectively. Mean *UBV* and *DDO* extinction coefficients for LCO and CTIO were used and nightly observations of about 12–15 standard stars from the lists of Cousins (1973, 1974) and McClure (1976) were carried out to insure accurate transformation to the standard *UBV* and *DDO* systems. No evidence of systematic differences either in the V magnitudes or in the color indices among the stars measured in LCO and CTIO was detected. Consequently, mean values were computed and listed in Tables 1 and 2 together with their mean internal errors, where n_1 and n_2 indicate the number of separate nights on which each star was measured in the *UBV* and *DDO* systems, respectively. Column (1) in both tables gives the star designation from Becker et al. (1976), while column (2) in Table 1 lists the CD or CPD number (when available).

The CMT_1T_2 measurements were performed with the CTIO 0.61 m telescope in 1993 January, using a single-channel photometer and a dry-ice cooled Hamamatsu R943-02 GaAs photomultiplier. The transformation to the standard *Washington* system was accomplished by nightly observing between 13 and 18 standard stars from the lists of Canterna (1976) and Harris & Canterna (1979). A few stars with several precise measurements carried out by Clariá & Lapasset (1985) in NGC 5822 were also used as *Washington* standard stars. Table 3 displays the new CMT_1T_2 data for the observed stars along with the standard deviations of different individual observations, and the number of nights n_3 on which each star was observed.

A comparison of the multiple observations with the observed means for the observed stars yields the internal mean errors of a single observation. On the other hand, a comparison of the observed mean values with the published ones for the standard stars yields the external mean errors of a single observation, an indication of how closely the standard system has been reproduced. The average internal and external mean errors of the different photometries are summarized in Tables 4 and 5.

Table 4. Mean errors of *UBV* and *DDO* photometry.

	UBV photometry – external mean errors		
	V	$B-V$	$U-B$
61 cm (CTIO)	0.011	0.007	0.015
61 cm (LCO)	0.012	0.011	0.018
	UBV photometry – internal mean errors		
	V	$B-V$	$U-B$
61 cm (CTIO)	0.016	0.014	0.025
61 cm (LCO)	0.012	0.016	0.025
	DDO photometry – external mean errors		
	$C(45-48)$	$C(42-45)$	$C(41-42)$
1.0 m (CTIO)	0.007	0.006	0.011
	DDO photometry – internal mean errors		
	$C(45-48)$	$C(42-45)$	$C(41-42)$
1.0 m (CTIO)	0.014	0.013	0.010

Table 5. Mean errors of CMT_1T_2 photometry.

	External mean errors			
	$C-M$	$M-T_1$	T_1-T_2	T_1
61 cm (CTIO)	0.009	0.008	0.006	0.024
	Internal mean errors			
	$C-M$	$M-T_1$	T_1-T_2	T_1
61 cm (CTIO)	0.008	0.008	0.005	0.013

3. ANALYSIS AND RESULTS

3.1. Cluster membership and interstellar reddening

The first aim of the current study is to exclude those observed stars which bear no physical connection with NGC 2447. The best way to confirm the cluster membership status of a given star is from its radial velocity. Mermilliod & Mayor (1989) obtained high precision Coravel radial velocities for 13 of the 14 stars observed in the present work. As shown in column 10 of Table 1, the radial velocities show clearly that all 13 stars are cluster members. Stars 26, 38 and 42 were found to be new spectroscopic binaries (SBs). These three stars are interpreted by Mermilliod & Mayor (1989) as being gK + dA composite stars because of their colors intermediate between those of red giants and main-sequence stars. Star 25, found peculiar or possibly non-member by Eggen (1983), is in fact a binary, and its orbit has been determined by Mermilliod et al. (1989).

As an additional check, cluster membership was also examined in NGC 2447 by applying two photometric criteria – denoted A and B – described by Clariá & Lapasset (1983) and Clariá (1985). We considered a red star to be a cluster member if one (or both) criterion implies membership, while the other indicates that the star is a probable member. If one criterion (or both) implies non-membership, the star is considered to be an object of the Galactic field. Finally, if both criteria simultaneously indicate probable membership, the star is then considered to be a probable member of the cluster.

Since no differential reddening seems to be present in the cluster area (see, e.g., Eggen 1983), criterion A can be applied by computing for each star the difference $\Delta E = |E_{B-V}(\mathrm{MS}) - E_{B-V}(\mathrm{GK})|$, where E_{B-V}(MS) is the cluster reddening derived from the main sequence stars and E_{B-V}(GK) represents the star reddening obtained from combined *UBV* and *DDO* data after applying the iterative method described by Janes (1977). In the present study, a value of $E_{B-V}(\mathrm{MS}) = 0.04$ has been adopted as the average of the previous reddening determinations performed by Becker (1959) and Eggen (1983).

To apply criterion B, the difference $\Delta L = |LC(\mathrm{predicted}) - LC(\mathrm{DDO})|$ must be computed for each star, where LC(predicted) represents the luminosity class that the star would have being a cluster member and LC(DDO) is the luminosity class derived from the reddening-corrected *DDO* colors. The latter data were determined using the present E_{B-V}(GK) values and the reddening ratios by McClure (1973). Since we are dealing with population I stars with nearly solar metallicity, the location of a star in the unreddened C_0(45–48) vs. C_0(42–45) diagram yields the spectral and luminosity classes. The accuracy of the *DDO* two-dimensional classification is comparable to that of the MK system (Yoss 1977). The predicted LC for each observed star was determined from the Straižys (1992) calibration assuming $R = A_V/E_{B-V} = 3.5$ for G–K III stars and adopting a cluster distance of 1.05 kpc (Bica & Bonatto 2005). Columns 2–8 of Table 6 display in succession the color excess E_{B-V}(GK) derived from the Janes (1977) iterative procedure, the standard deviation of the E_{B-V}(GK) color excess calculated from Equation (2) of Clariá & Lapasset (1983), the LC each star would have being a cluster member, the MK spectral type derived from the *DDO* colors using the calibration of Clariá et al. (1994) and the membership results from applying criteria A and B. Stars 25, 26, 38 and 42 are omitted in Table 6 because they fall outside the range of the *DDO* calibrations. Only one object (star 102) should be considered a field star according to the photometric criteria, while the remaining stars appear all to be very likely giant cluster members. These results are in good agreement with those found from the Coravel radial velocities. Therefore, as shown earlier (see, Clariá et al. 2003), criteria A and B lead to reliable membership results for G and K giants provided their *BV* and *DDO* photometric data are of high quality.

The giant branch of NGC 2447 in the observed V vs. B–V CMD is shown in Figure 1. The theoretical isochrone computed by Girardi et al. (2002) for $Z = 0.019$ and $\log t = 8.60$ has been adjusted to $E_{B-V} = 0.04$ (adopted value for the main-sequence stars) and $V - M_V = 10.24$ (Bica & Bonatto 2005). Figure 2 illustrates the giant branch of NGC 2447 in the reddening-corrected C_0(45–48) vs. C_0(42–45) diagram. Also included in Figure 2 are the solar vicinity loci of Clariá et al. (1994) for luminosity classes Ib, III and V. The stars considered to be giant

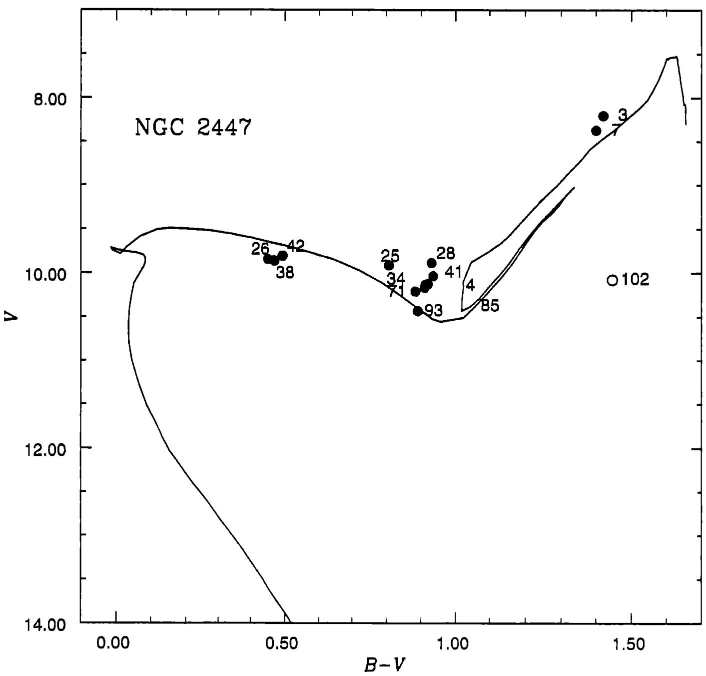

Fig. 1. The observed CMD for yellow and red evolved stars in NGC 2447. Cluster members and field stars are represented by filled and open circles (only one), respectively. The solar metallicity Padova isochrone for $\log t = 8.60$ is shown.

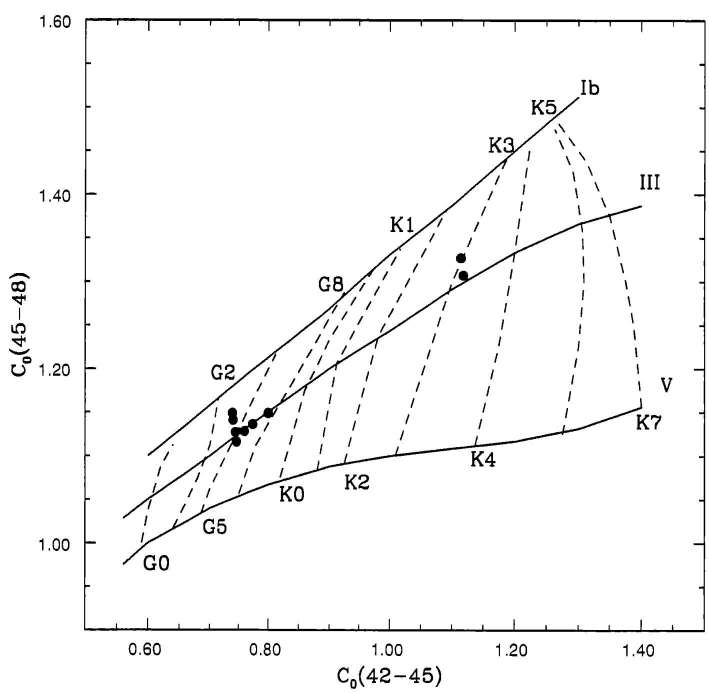

Fig. 2. Red giants in NGC 2447 plotted on the unreddened $C_0(45\text{–}48)$ vs. $C_0(42\text{–}45)$ plane. The solid lines are the solar vicinity field lines for luminosity classes Ib, III and V as given by Clariá et al. (1994).

Table 6. Results from applying two photometric membership criteria

Star	$E_{B-V}(GK)$	σ_E	LC (predicted)	$MK(DDO)$	Criteria (A) (B)	Membership
3.	0.12	0.06	II	K3 II-III	pm m	m
4.	0.06	0.05	II-III	G5/8 III	m m	m
7.	0.08	0.05	II	K3 II	m m	m
28.	0.06	0.07	II-III	G5 II	m m	m
34.	0.03	0.03	II-III	G5/8 III	m m	m
41.	0.01	0.04	II-III	G8 III	m m	m
71.	0.02	0.05	II-III	G2/5 II	m m	m
85.	0.05	0.05	II-III	G5 III	m m	m
93.	0.00	0.06	II-III	G5/8 III	m m	m
102.	0.19	0.05	II-III	K4 III-IV	nm pm	nm

Table 7. Abundance parameters for red giants in NGC 2447.

Star	ΔCN	δ(U-B)	Δ'_1	Δ'_2	Δ'_3	Δ'_4	Δ'_5
3.	–0.057	0.11	0.098	0.010	0.108	0.081	0.084
4.	0.059	–0.02	–0.051	–0.004	–0.054	–0.037	–0.037
7.	–0.007	0.00	0.094	0.007	0.100	0.088	0.091
28.		0.06	–0.033	–0.004	–0.036	–0.021	–0.021
34.	0.091	0.03	–0.051	–0.010	–0.060	–0.028	–0.030
41.	0.013	–0.02	–0.078	–0.020	–0.097	–0.044	–0.050
71.	–0.011	0.04	–0.199	–0.043	–0.161	–0.050	–0.064
85.	0.040	0.00	–0.078	–0.012	–0.089	–0.054	–0.057
93.	–0.050	–0.08	–0.087	–0.013	–0.099	–0.058	–0.061

cluster members from criteria A and B are represented by filled circles. Among the red cluster giants, there are seven clump stars at the blue end of the giant branch with a narrow range of B–V between 0.88 and 0.94 (Figure 1).

The mean reddening derived for the red cluster giants of Table 6 is $<E_{B-V}>$ $= 0.05 \pm 0.04$ (s.d.), which is in good agreement with the adopted value for the main-sequence stars, i.e., $E_{B-V}(\mathrm{MS}) = 0.04$.

3.2. DDO and UBV abundance parameters

Metallicity determination of the NGC 2447 red giants may be performed from the reddening-corrected *DDO* indices. Janes (1975) has shown that the cyanogen anomaly δCN – defined as the excess (positive δCN) or deficiency of the unreddened C(41–42) index in magnitudes over the standard value for a star of the same unreddened C(45–48) and C(42–45) indices – has a good correlation with [Fe/H]. Some inconsistencies in the definition and calculation of δCN observed by Piatti et al. (1993, hereafter PCM) enabled them to redefine the cyanogen anomaly – now denoted ΔCN – as the difference between the unreddened C(41–42) index and the standard value of this index corresponding to a star with the same temperature and surface gravity (not with the same unreddened C(45–48) and C(42–45) indices) as the star in question.

We applied the iterative procedure proposed by PCM to derive the cluster metal abundance. Column 2 of Table 7 lists the resulting new cyanogen anomalies. The mean value is $<\Delta\mathrm{CN}> = 0.01 \pm 0.02$ (σ_n), where σ_n is the standard deviation of the mean. This value implies $[\mathrm{Fe/H}]_{DDO} = -0.12 \pm 0.08$, if Equation (2) of PCM is used. We note that if the old cyanogen anomaly δCN instead of ΔCN had been used, the resulting metallicity would have been practically the same.

The metal content can also be examined from the ultraviolet excesses $\delta(U{-}B)$ of the cluster giants determined with respect to the field K giants. Before calculating $\delta(U{-}B)$, the unreddened $(U{-}B)_0$ colors were derived from Equation (9) of Janes (1979). The UV excesses were then determined by comparing the $(B{-}V)_0$ and $(U{-}B)_0$ intrinsic colors of each star with those of the typical field K-giants as given by FitzGerald (1970). These UV excesses are shown in column 3 of Table 7. The mean value $<\delta(U{-}B)> = 0.01 \pm 0.02$ (σ_n) found for the cluster giants implies δCN = 0.01, if Equation (8) of Janes (1979) is used. Adopting the relation between the old cyanogen anomaly δCN and the iron abundance given by McClure (1979), namely, [Fe/H] = 4.5δCN – 0.13, we then find $[Fe/H]_{UV} = -0.09 \pm 0.05$. Thus, as expected on physical grounds, both δCN and $\delta(U{-}B)$ provide enough evidence to reach the conclusion that NGC 2447 is slightly metal-poor.

3.3. Abundance parameters in the Washington system

Geisler et al. (1991, hereafter GCM) have calibrated five metallicity-sensitive indices of the *Washington* system as a function of high dispersion spectroscopic iron-to-hydrogen ratios and proposed an iterative procedure to derive metallicities of G and K giants. The method allows the mean cluster abundances to be easily obtained after a few iterations. GCM have defined fiducial lines for solar abundance giants in the *Washington* color-color diagrams. The first step to derive metallicity from the *Washington* colors is to correct the observed indices by reddening using the reddening ratios given by GCM. Figure 3 displays the $(C{-}M)_0$ vs. $(T_1{-}T_2)_0$, $(M{-}T_1)_0$ vs. $(T_1{-}T_2)_0$, $(C{-}T_1)_0$ vs. $(T_1{-}T_2)_0$, $(C{-}M)_0$ vs. $(M{-}T_2)_0$ and $(C{-}T_1)_0$ vs. $(M{-}T_2)_0$ color-color diagrams for the NGC 2447 cluster giants. The isoabundance relations range from [Fe/H] = +0.5 (bottom) to –3.0 (top), in steps of 0.5 dex, except for the $(M{-}T_1)_0$ vs. $(T_1{-}T_2)_0$ diagram where the range is from +0.4 to –0.8 in steps of 0.4 dex. According to GCM, the abundance-sensitive index Δ is the difference between the observed color and the solar-abundance color at the observed $(T_1{-}T_2)$ (or $M{-}T_2)$], where all colors refer to unreddened values. GCM described a procedure for correcting the decrease in abundance sensitivity with temperature and established empirical calibrations of the abundance indices Δ'_1 – Δ'_5 with [Fe/H], where Δ'_1 – Δ'_5 refer respectively to $\Delta'(C{-}M)_{T1-T2}$, $\Delta'(M{-}T_1)_{T1-T2}$, $\Delta'(C{-}T_1)_{T1-T2}$, $\Delta'(C{-}M)_{M-T2}$ and $\Delta'(C{-}T_1)_{M-T2}$. These Δ'_i indices can be calculated from the Δ_i indices using GCM's Equation (2). Note that $\Delta'_i = \Delta_i$ for all the stars in NGC 2447, except for the bright giant stars 3 and 7. The derived *Washington* abundance indices for the cluster giants are given in columns 4-8 of Table 7. The resulting mean values and standard deviations of the mean from nine giant members are: $< \Delta'_1 > = -0.047 \pm 0.025$, $< \Delta'_2 > = -0.012 \pm 0.005$, $< \Delta'_3 > = -0.058 \pm 0.029$, $< \Delta'_4 > = -0.023 \pm 0.018$ and $< \Delta'_5 > = -0.026 \pm 0.020$. Finally, the following values and corresponding standard deviations of the mean were derived from the GCM's calibrations: $[Fe/H]_1 = -0.10 \pm 0.07$, $[Fe/H]_2 = -0.13 \pm 0.04$, $[Fe/H]_3 = -0.11 \pm 0.06$, $[Fe/H]_4 = -0.06 \pm 0.07$ and $[Fe/H]_5 = -0.06 \pm 0.07$. The unweighted average of the five *Washington* abundance estimates turns out to be $< [Fe/H]_W > = -0.09 \pm 0.06$, in good agreement with the two previous estimates. Considering the three independent metallicity determinations, we finally adopted [Fe/H] = –0.10 ± 0.08 for NGC 2447. This value shows a reasonably good agreement with the value derived by Hamdani et al. (2000) from echelle spectroscopy of only three cluster giants, thus confirming the nearly solar metal abundance of NGC 2447.

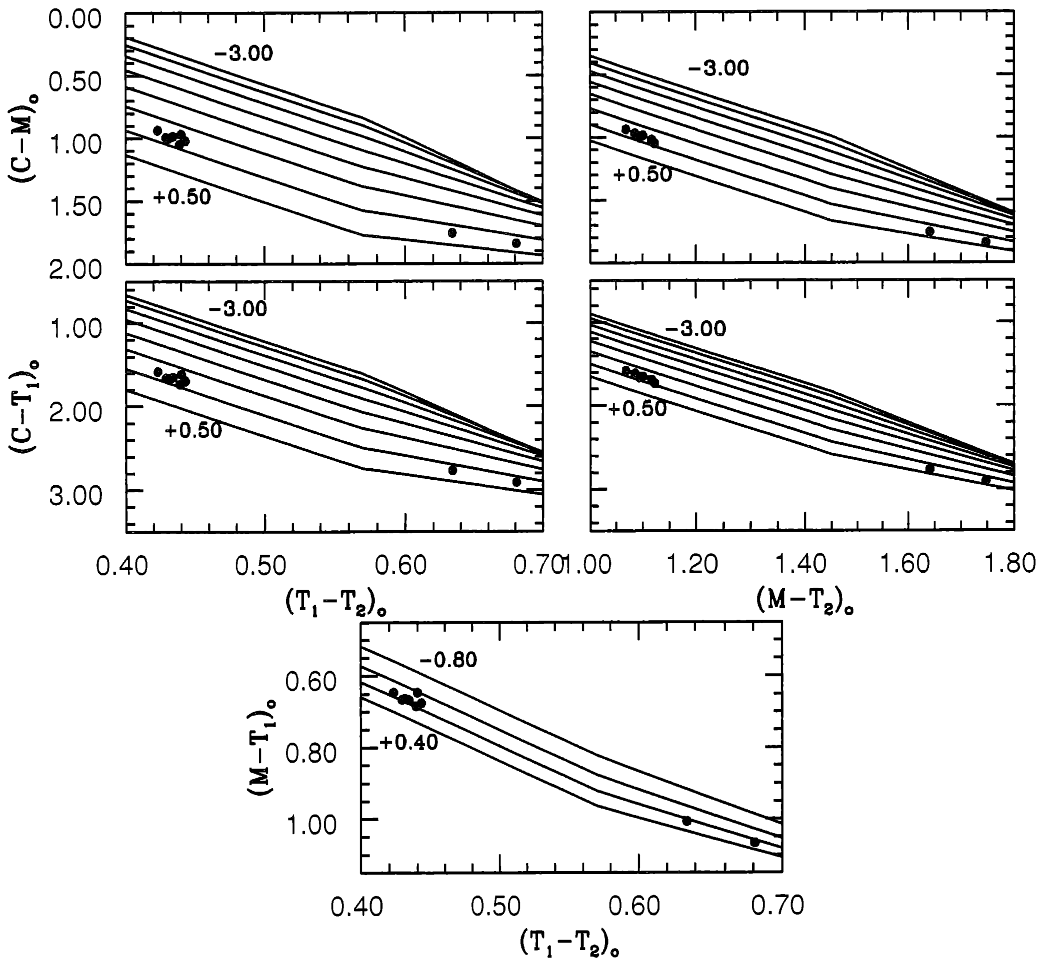

Fig. 3. Unreddened Washington color-color diagrams for red cluster giants of NGC 2447 confirmed from Coravel radial velocity data. Isoabundance relations from GCM are shown.

4. SUMMARY AND CONCLUSIONS

In summary, we have used new photoelectric *UBV*, *DDO* and CMT_1T_2 data of high accuracy for 14 late-type giant candidates in the field of the southern open cluster NGC 2447 with the purpose of evaluating cluster membership and deriving cluster reddening and metallicity. The distribution of stars in the CM diagram allows us to identify eight clump stars in the core helium burning stage of evolution. The likelihood of membership for each observed star was evaluated by applying two independent photometric criteria, based on combined *UBV* and *DDO* data. It was found that nine red evolved stars are clearly members, while only one is most probably a red field star. These results are in good agreement with those derived from the published high precision Coravel radial velocities. This fact demonstrates that when the photometric data are of high quality, the application of the above criteria leads to reliable results. A mean cluster reddening E_{B-V} = 0.05 ± 0.04 was found. The mean ultraviolet excess, mean cyanogen anomaly and mean *Washington* abundance indicators all support the conclusion that the cluster giants are only slightly metal-poor ([Fe/H] = −0.10).

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REFERENCES

Archinal B. A., Hynes J. J. 2003, *Star Clusters*, Willmann-Bell, Inc.

Becker W. 1959, Z. f. Astrophys., 48, 279

Becker W., Svolopoulos S. N., Fang C. 1976, *Kataloge photographisher und photoelektrisher Helligkeiten vos 25 galaktischen Sternhaufen im RGU- und $U_C BV$ System*, Univ. Basel

Bica E., Bonatto C. 2005, A&A, 431, 943

Canterna R. 1976, AJ, 81, 228

Clariá J. J. 1985, A&AS, 59, 195

Clariá J. J., Lapasset E. 1983, J. Astrophys. Astron, 4, 117

Clariá J. J., Lapasset E. 1985, MNRAS, 214, 229

Clariá J. J., Piatti A. E., Lapasset E. 1994, PASP, 106, 436

Clariá J. J., Piatti A. E., Lapasset E., Mermilliod J.-C. 2003, A&A, 399, 543

Collinder P. 1931, Medd. Lund Obs. 2

Cousins A. W. J. 1973, Mem. RAS, 77, 22

Cousins A. W. J. 1974, Mon. Notes Astron. Soc. S. Africa, 33, 149

Crawford D. L. 1978, AJ, 83, 48

Eggen O. J. 1983, AJ, 88, 184

FitzGerald M. P. 1970, A&A, 4, 234

Geisler D., Clariá J. J., Minniti D. 1991, AJ, 102, 1836 (GCM)

Girardi L., Berteli G., Bressan A., Chiosi C., Groenewegen M. A. T., Marigo P., Salasnich B., Weiss A. 2002, A&A, 391, 195

Hamdani H., North P., Mowlave N., Raboud D., Mermilliod J.-C. 2000, A&A, 360, 509

Harris H. C., Canterna R. 1979, AJ, 84, 1750

Janes K. A. 1975, ApJS, 29 161

Janes K. A. 1977, PASP, 89, 276

Janes K. A. 1979, ApJS, 39, 135

McClure R. D. 1973, *Spectral Classification and Multicolour Photometry*, IAU Symp. 50, Eds. C. Fehrenbach & B. E. Westerlund, Reidel, Dordrecht p. 162

McClure R. D. 1976, AJ, 81, 182

McClure R. D. 1979, *Problems of Calibration of Multicolour Photometric Systems*, ed. A. G. D. Philip, Dudley Observatory, p. 83

Maitzen H. M. 1976, A&A, 52, 223

Maitzen H. M. 1993, A&AS, 102, 1

Mermilliod J.-C., Mayor M. 1989, A&A, 219, 125

Mermilliod J.-C., Mayor M., Andersen J., Nordstrom B., Lindgren H., Duquennoy A. 1989, A&AS, 79, 11

Piatti A. E., Clariá J. J., Minniti D. 1993, J. Astrophys. Astron., 14, 135 (PCM)

Straižys V. 1992, *Multicolor Stellar Photometry*, Pachart Publishing House, Tucson, Arizona

Strobel A. 1989, Astron. Nachr., 310, 367

Yoss K. M. 1977, AJ, 82, 832