A&A 409, 541–551 (2003)
DOI: 10.1051/0004-6361:20031121

Astronomy & Astrophysics

IC 2395 and BH 47: Only one open cluster in the Vela constellation

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Received 2 May 2003 / Accepted 18 July 2003

Abstract. We report *UBV* photoelectric photometry for 273 stars in the fields of the open clusters IC 2395 and BH 47. Our postulate is that, rather than two different clusters in this region of Vela, there is only one, which we call IC 2395 = BH 47. The cluster is centered at about $\alpha = 8^{h}42\overset{m}{.}5$, $\delta = -48°06\overset{\prime}{.}8$ (2000), its angular diameter being ∼19′. The analysis of the photometric data yields 61 probable cluster members and 16 possible members. Photometric membership probabilities show good agreement with those obtained from a proper motion study for 21 stars in common. The reddening across the cluster appears to be uniform, the mean $E(B-V)$ value being 0.09 ± 0.02. The true distance modulus is $(V - M_V)_0 = 9.52 \pm 0.10$, corresponding to a distance from the Sun of (800 ± 40) pc and 48 pc below the Galactic plane. The cluster age, determined by fitting isochrones with core overshooting, turns out to be (6 ± 2) Myr. There is a strong likelihood that IC 2395 = BH 47 is physically connected to the Vela OB1C association.

Key words. methods: observational – techniques: photometric – stars: fundamental parameters – open clusters and associations: individual: IC 2395, BH 47

1. Introduction

The photometric data reported in this paper are part of an observing project which is still ongoing at the Observatorio Astronómico de la Universidad Nacional de Córdoba (Argentina), consisting in obtaining photometric and/or spectroscopic data of southern open clusters not yet observed or with incomplete observations (see, e.g., Clariá et al. 1998, 2003; Piatti & Clariá 2002; Piatti et al. 1999, 2003). *UBV* photoelectric photometry remains a valuable tool for obtaining the fundamental parameters of star clusters with angular diameters exceeding the usual size of CCD cameras. Information on cluster membership, distance, interstellar reddening and age are obtained through the analysis of the colour–magnitude (CM) and colour–colour (CC) *UBV* diagrams.

IC 2395 (IAU designation C0839-480), also known as Collinder 192, is a medium-sized open cluster situated in the Vela constellation at $\alpha = 8^{h}41\overset{m}{.}1$, $\delta = -48°12'$ (2000.0), with Galactic coordinates $l = 266\overset{\circ}{.}57$, $b = -3\overset{\circ}{.}81$, as consigned in the WEDBA Open Cluster Catalogue (Mermilliod 2000). It was described by Ruprecht (1966) as a Trumpler (1930) class II-3p system – i.e., a detached cluster of fewer than 50 members, with little central concentration and a medium range in the brightness of the stars.

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On the other hand, BH 47 (C0841-479) was first recognized as an open cluster by van den Bergh & Hagen (1975), who estimated its angular diameter as 13′. Although BH 47, centered at $\alpha = 8^{h}42\overset{m}{.}6$, $\delta = -48°07'$ (2000.0), is considered to be a different, somewhat smaller cluster than IC 2395 in the WEBDA Open Cluster Database (Mermilliod 2000), there seems to exist some confusion in the literature about these two objects. In fact, Lyngå (1959) has observed photoelectrically in the *UBV* system 20 stars in the field of BH 47, but calls the cluster IC 2395. Photographic *UBV* photometry of about 30 stars was later obtained by Lyngå (1962) nearly in the same cluster field. He derived a colour excess $E(B-V) = 0.11$, a distance of 960 pc and a nuclear age of about 100 Myr for what he refers to as IC 2395, even though he is in fact dealing with BH 47. In their search for carbon stars in open clusters, Jørgensen & Westerlund (1988) obtained *UBVRI* photoelectric photometry of 14 stars located properly in the field of IC 2395. Since several of these stars seem to fall on the fainter portion of the cluster's CM published by Lyngå (1962), Jørgensen & Westerlund suggested that there is only one cluster with an angular diameter of about 12′ in this region of Vela. More recently, Loktin et al. (2001) published a second version of their Open Cluster Catalogue (Loktin & Matkin 1994) reviewing the fundamental parameters of 423 clusters. Their updated distances are now based on a Hyades distance modulus of 3.27, this value being 0.06 mag smaller than that found from Hipparcos parallaxes,

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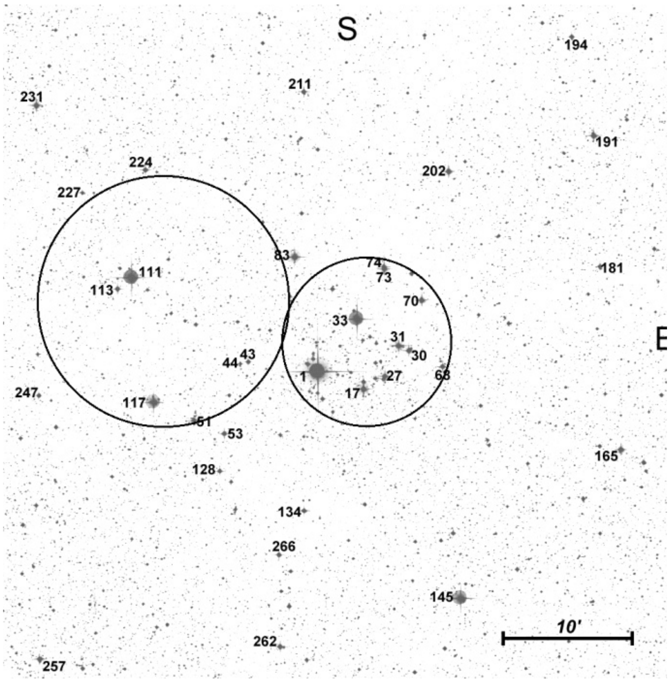

Fig. 1. Identification chart for stars observed in the fields of the open clusters IC 2395 and BH 47. The positions and approximate sizes of IC 2395 (the largest circle) and BH 47 (smaller circle) are indicated. The positions of the observed stars can be determined from the linear coordinates *X* and *Y* listed in Table 1. The zero point of these coordinates corresponds to the upper left corner and the size of the figure is 1000 × 1000 pixels. Individual equatorial coordinates Right Ascension and Declination (2000.0) for all the observed stars are given in Table 1. Only observed stars brighter than $V = 10.0$ are identified. Image taken from the Digitized Sky Survey, produced at the Space Telescope Science Institute under US Government grant NAG W-2166.

namely $(m - M)_V = 3.33 \pm 0.01$ (Perryman et al. 1998). Using the original data from Lyngå (1959, 1962), Loktin et al. (2001) derived the following parameters for IC 2395: $d = 705$ pc, $E(B - V) = 0.066$ and 16 Myr.

In the present study we report *UBV* photoelectric observations of 273 stars brighter than $V = 15.0$, distributed in an area of about $50' \times 50'$ centered at about $\alpha = 8^{\rm h}42\overset{\rm m}{.}2$ (2000), $\delta = -48°09\overset{'}{.}3$, which includes both IC 2395 and BH 47 (Fig. 1). We will use the *UBV* data to search for any evidence that the two groups of stars belong to the same cluster. We will also use the data to determine the basic parameters of this group of stars.

2. Observations and reductions

The *UBV* measurements were carried out during several observing runs between 1984 and 1987 with the 0.6-m Canadian telescope of the David Dunlap Observatory located in Las Campanas Observatory (LCO) and the 0.9-m telescope of the Cerro Tololo Inter-American Observatory (CTIO). Dry-ice cooled RCA 1P21 and Ga-As RCA 31034 photomultipliers in single channel photometers with pulse-counting electronics were used at LCO and CTIO, respectively. Mean extinction coefficients at both observatories were employed and about 12−15 standard stars taken from the lists of Cousins (1973, 1974), Landolt (1973) and Graham (1982) were observed each night to insure accurate transformations to the standard system. The dispersions in the individual measures for the observed stars yield the internal mean errors of a single *UBV* observation. These errors are $\sigma_V \leq 0.015$ mag, $\sigma_{B-V} \leq 0.010$ mag and $\sigma_{U-B} \leq 0.016$ mag for $V < 12$ mag, increasing to 0.019, 0.023 and 0.031 for $V > 12$ mag, respectively. 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 averaged external mean errors are smaller than 0.015 mag for the *V* magnitude and the $(B - V)$ and $(U - B)$ colours. All these errors are nearly similar to those in previous papers (e.g., Clariá et al. 1991). No evidence of systematic differences either in the *V* magnitude or in the colours among the stars measured in LCO and CTIO was detected. Consequently, mean *UBV* values were computed for the observed stars.

Table 1 presents the results of our photometry. The first column gives a running star number. Columns 2 and 3 refer to linear coordinates *X* and *Y* in pixels for the positions of stars in Fig. 1. The figure is 1000 × 1000 pixels and the zero point corresponds to the upper left corner. The scale on the figure is 3.1″ pixel^{-1}. Only star numbers corresponding to the observed stars brighter than $V = 10.0$ are indicated in Fig. 1. Columns 4 and 5 list the equatorial coordinates Right Ascension and Declination for the epoch 2000.0, while Cols. 6–9 give in succession the *V* magnitude, the $B - V$ and $U - B$ colours and the number of individual *UBV* photoelectric observations for each star made on different nights. Column 10 provides the HD or CD numbers (when available) as well as star numbers from Lyngå (1962) and Jørgensen & Westerlund (1988) preceded by *L* and *JW*, respectively. Column 11 lists the MK spectral types taken from Houck (1978) or Garrison et al. (1977), when available, and the last column gives an indication whether the star is believed to be a probable member (M), a possible member (PM), or a non-member (NM) of the cluster IC 2395 = BH 47 (see Sect. 5.1). Only a portion of Table 1 is shown here for guidance regarding its form and content, its whole content being available in electronic form at the CDS via anonymous ftp to `cdsarc.u-strasbg.fr (130.79.128.5)` or via `http://cdsweb.u-strasbg.fr/cgi-bin/qcat?/A+A/409/541`

3. Comparison with other *UBV* data

Eighteen stars measured in the present study have previously been observed photoelectrically by Lyngå (1959). Omitting Lyngå's stars 11 and 20 for which the two sets of observations do not agree, the average differences (Δ = previous minus present value) and standard deviations are: $\Delta V = -0.01 \pm 0.04$, $\Delta(B-V) = -0.01 \pm 0.03$, and $\Delta(U-B) = 0.01 \pm 0.06$. A comparison with Lyngå's (1962) photographic data for 29 stars measured in common shows a poorer agreement, the mean differences now being: $\Delta V = -0.13 \pm 0.14$, $\Delta(B-V) = -0.01 \pm 0.10$, and $\Delta(U-B) = -0.22 \pm 0.22$. Finally, ten stars were measured in common with Jørgensen & Westerlund (1988). Omitting their

Table 1. *UBV* photometry for stars in the fields of IC 2395 and BH 47.

Star	X	Y	α_{2000} (^{hms})	δ_{2000} ($^{\circ}\ '$)	V	$B-V$	$U-B$	n	Name(s)	Spec. type	Membership
1	464	542	8 42 15.9	–48 06.1	5.485	–0.179	–0.957	2	HD 74455, L 1	B2/3 IV-V	M, 96%
2	465	575	8 42 15.8	–48 04.4	11.696	0.291	0.144	3	L 18		M
3	472	584	8 42 17.9	–48 03.9	10.739	0.026	–0.121	3	L 15, CD –47°4253		M
4	453	573	8 42 12.2	–48 04.5	11.698	1.687	1.814	3	L 42, CD –47°4250		NM
5	450	532	8 42 11.7	–48 06.6	10.395	0.001	–0.186	4	L 43, CD –47°4247		M
6	459	525	8 42 14.6	–48 06.9	11.281	0.089	0.034	4	L 44		M
7	459	517	8 42 14.6	–48 07.3	12.531	0.680	0.126	3	L 45		NM
8	444	497	8 42 10.3	–48 08.4	12.724	0.379	0.267	3	L 48		NM

Note: Stars Nos. 153, 156, 174 and 233 are double stars. Photometry refers to the combined light of both components. Stars Nos. 170, 217 and 222 were previously reported as variables (Lapasset & Clariá 1985). Star No. 82 was found to be variable, its individual ΔV variations being ~0.3 mag. All the MK spectral types are from Houck (1978), except that of star No. 1, which is from Garrison et al. (1977).

star 14 for which the two sets of measurements do not agree, the mean differences and standard deviations from nine stars in common are: $\Delta V = 0.03 \pm 0.03$, $\Delta(B-V) = 0.03 \pm 0.03$, and $\Delta(U-B) = 0.00 \pm 0.05$.

4. Probable variables

Three stars in the observed field were previously found to be suspected variables by Lapasset & Clariá (1985), their individual V measurements differing by more than 0.1 mag. Their old numbers are 169, 215 and 220 (Lapasset & Clariá 1985), equivalent to the new ones 170, 217 and 222 (Table 1). In addition, star 82 from Table 1 is now reported as a new variable in the cluster field. A comparison of the photoelectric *UBV* data of Lyngå (1959) and Jørgensen & Westerlund (1988) with the present observations shows that for stars 27 (Lyngå No. 11), 135 (Lyngå No. 20) and 44 (Jørgensen & Westerlund No. 14), the V magnitudes differ significantly with respect to their observational errors. We believe that these stars may also be variables and have been omitted in the above mean ΔV differences.

5. Analysis and discussion of the data

5.1. The UBV diagrams: membership criteria

The CM and CC diagrams constructed with all stars measured in a field of ~50′ × 50′ around IC 2395 are presented in Fig. 2. Note that only 34 stars in this field have previously been measured photoelectrically either by Lyngå (1962) or by Jørgensen & Westerlund (1988). For comparison, the Lejeune & Schaerer (2001) Zero-Age Main Sequence (ZAMS) for solar metallicity has been plotted for $E(B-V) = 0.0$ (solid line) and $E(B-V) = 0.09$ (dashed line) in the CC diagram of Fig. 2. The *UBV* diagrams exhibit nearly the same features visible in Figs. 12 and 13 of Lyngå (1962), though the cluster sequence is much more well-defined with the new data. There is no evidence of two sequences corresponding to two different clusters. Much on the contrary, a single, well-defined sequence can be observed, typical of a young open cluster, contaminated by the presence of a substantial number of foreground and background field stars distributed over the field.

Membership in the cluster field has been determined by examining the positions of the observed stars in the CM and CC diagrams. Cluster members were selected following the criteria described by Clariá & Lapasset (1986), namely by requiring that the location of a star in the two CM diagrams corresponded to the same evolutionary stage and that the location of the same star in the CC diagram were close to the main sequence (MS) of the cluster, the maximum accepted deviation being 0.10 mag. Since many factors such as duplicity, rotation, and others contribute to increase the dispersion in the *UBV* diagrams, a star located at most 0.75 mag above the unevolved cluster MS in the (V, $B-V$) diagram, is considered to belong to it. Sixty one stars fulfilling the above mentioned requirements are considered to be probable cluster members and have been represented by filled circles in Fig. 2. The positions of 16 stars preclude us from unambiguously retaining or discarding them as probable cluster members. These stars, represented by filled triangles in Fig. 2, are thus considered to be possible members. The bright blue star 1 (HD 74455), classified as B1.5Vn by Garrison et al. (1977) and B2IV-V by Houck (1978), is the brightest probable cluster member. As shown in the *UBV* diagrams, the cluster MS consists of early-B up to late-F type stars extending from $V = 5.5$ to about $V = 14.5$ mag. We find no evidence for stars that lie on the red giant branch. This is not too surprising on account of the very short evolutionary time-scale for the red giant phase for these massive stars. All probable members brighter than $V = 10.2$ (except star 74) have MK spectral types assigned by Houck (1978), which are compatible with their membership status.

This work departs from the usual practice in that it considers the stars selected on the basis of the photometric analysis as probable members, while they are generally considered as members for the sake of simplification. Although the membership evaluation from photometry alone is generally reliable, its efficiency however depends on the density of the stellar medium surrounding the cluster. Therefore, the fulfillment of photometric criteria is a necessary condition, but not a sufficient one.

Three different kinematic studies based on proper motion membership probabilities have been recently published in the field of IC 2395. Glushkova et al. (1997) have

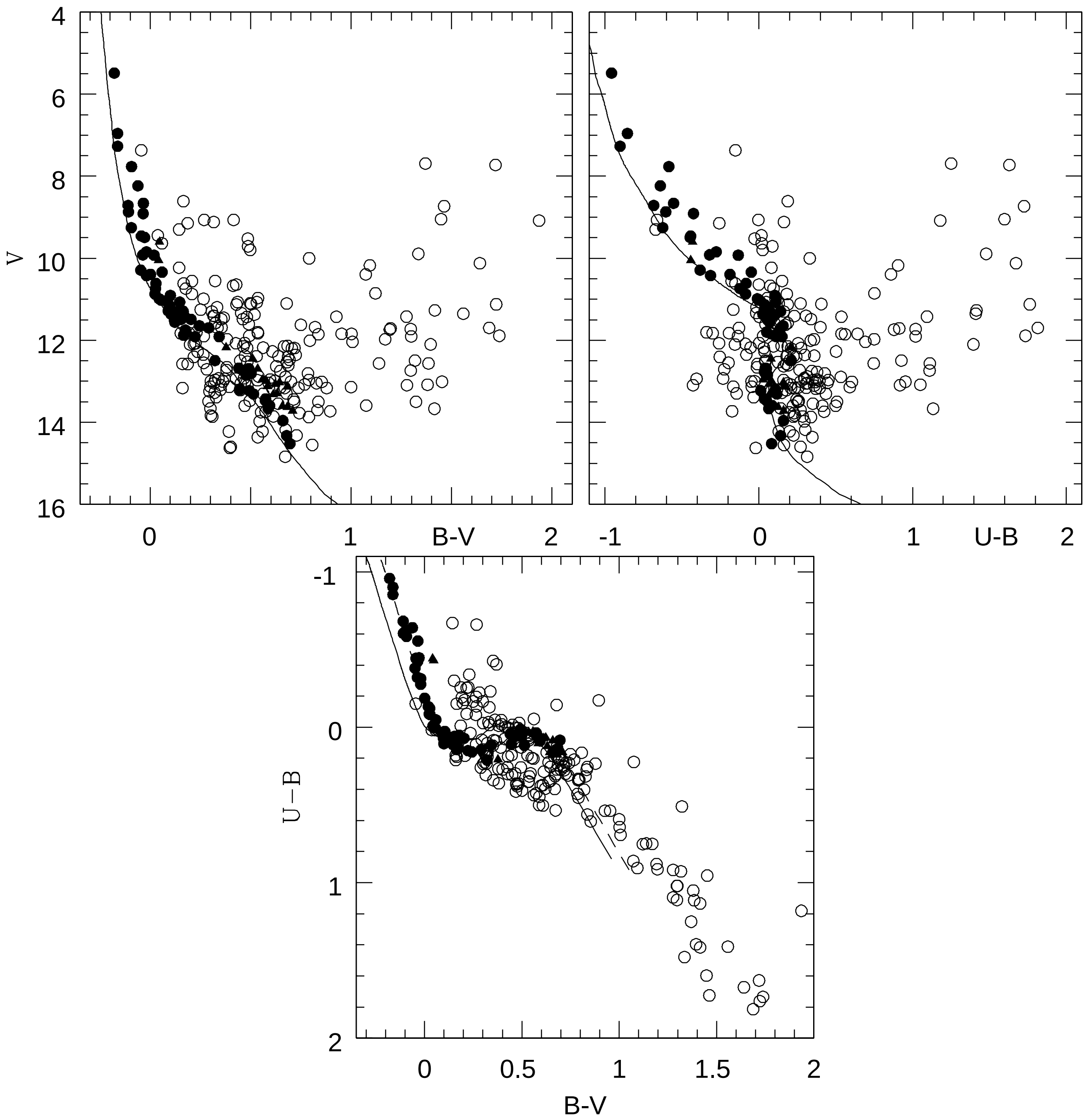

Fig. 2. The observed (V, $B-V$), (V, $U-B$) and ($U-B$, $B-V$) diagrams for stars in the fields of IC 2395 and BH 47. The ZAMS (solid line) computed by Lejeune & Scharer (2001) for solar metallicity has been adjusted to $E(B-V) = 0.09$, $E(U-B) = 0.06$ and $(m-M)_V = 9.80$ in the two CM diagrams. This ZAMS has been plotted for $E(B-V) = 0.0$ (solid line) and $E(B-V) = 0.09$ (dashed line) in the CC diagram. Filled and open circles represent photometric probable members and non members, respectively, while the triangles indicate stars considered to be possible members (Sect. 5.1).

computed absolute proper motions of stars in IC 2395 by comparing the relative proper motions of eight member stars with their absolute proper motions taken from the Four-Million Catalogue of Positions and Proper Motions compiled at the Sternberg Astronomical Institute of the Moscow State University (Gulyaev & Nesterov 1992). They found the following mean absolute proper motions in Right Ascension and Declination for IC 2395: $< \mu_{RA} > = (2.3 \pm 1.0)$ mas yr^{-1} and $< \mu_{Dec} > = (-1.8 \pm 1.0)$ mas yr^{-1}. On the other hand, using data of 11 stars from the Tycho2 catalogue, Dias et al. (2001) determined the following mean absolute proper motions: $< \mu_{RA} > = (-4.4 \pm 1.6)$ mas yr^{-1} and $< \mu_{Dec} > = (+3.9 \pm 1.6)$ mas yr^{-1}, while Baumgardt et al. (2000), using data of only one star from the Hipparcos catalogue, obtained: $< \mu_{RA} > = (-3.6 \pm 0.6)$ mas yr^{-1} and $< \mu_{Dec} > = (+2.2 \pm 0.5)$ mas yr^{-1}. Note that the mean proper motions of Glushkova et al. do not show a good agreement with those of Baumgardt et al. and Dias et al., an outcome for which we are unable to

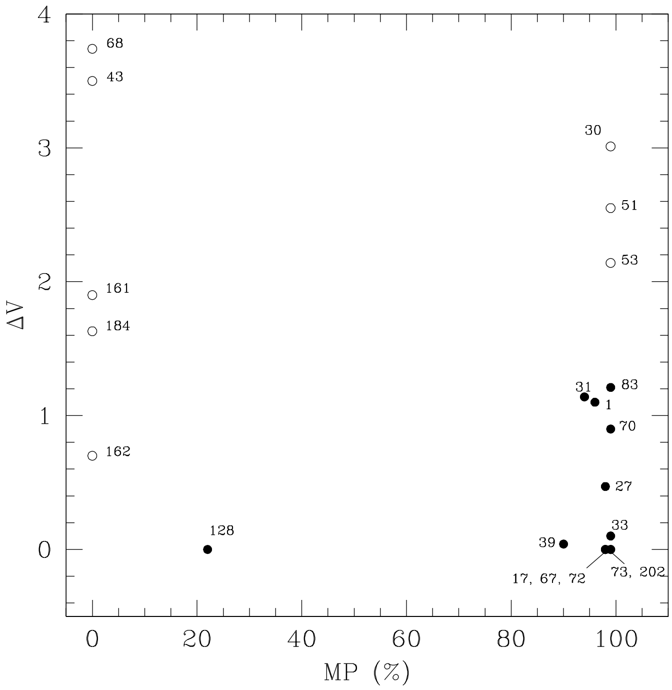

Fig. 3. Deviation ΔV from the main sequence in the $(V, B-V)$ diagram as a function of the proper motion membership probability assigned by Dias et al. (2001). Filled and open circles represent probable members and non-members, respectively, according to the photometric criteria.

offer an explanation. In the subsequent analysis, we have chosen the study of Dias et al. because it is based on a larger number of stars than those used in the other two kinematic studies. Dias et al. assigned membership probabilities (*MP*s) to individual stars in the cluster field by applying the statistical method of Sanders (1971). As shown in Fig. 3, the agreement between the photometric and kinematic *MP*s for 21 stars in common turned out be very good. In fact, 12 stars with *MP*s larger than 90% have also been considered to be probable members from the *UBV* criteria, while five stars with $MP = 0\%$ have been identified as non cluster members according to the same criteria. Only three stars with *MP*s larger than 90% were found to be photometric non-members. We believe that these are very likely field star interlopers. The only conflictive case in the present study appears to be star 128, a photometric probable member, whose proper motion *MP* is scarcely 22%. The last column of Table 1 includes the *MP*s assigned by Dias et al. (2001) besides our present adopted membership status for 21 stars in common.

There is a lack of probable members in the interval $0.34 \leq (B-V) \leq 0.44$ (Fig. 2), which does not seem to be a result of a selection effect in the list of probable members. This gap detected in the MS distribution of stars occurs between spectral types A8 and F2. The abnormal distribution of MS stars in the *UBV* diagrams is most probably due to the effects of the abrupt onset of convection in the stellar atmospheres as predicted by Böhm-Vitense (1958) and Böhm-Vitense & Canterna (1974). Similar gaps occuring at somewhat earlier spectral types have been noted in the CM diagrams of NGC 6025 (Kilambi 1975), NGC 2571 (Kilambi 1978) and NGC 1039 (Canterna et al. 1979), among other open clusters. Mermilliod (1976) also found a gap in the MS between spectral types B7 and B8 for open clusters younger than the Pleiades. This gap, however, is most likely due to the effects of the helium and hydrogen ionization zones in the stellar atmospheres and results in a weakening of the Balmer jump and the equivalent width of the Balmer lines (Mermilliod 1976).

In view of the fact that the WEBDA Open Cluster Database (Mermilliod 2000) includes two different clusters in this Vela region, we have indicated their respective positions and approximate sizes in Fig. 1. The smallest cluster containing brighter stars corresponds to BH 47 (van den Bergh & Hagen 1975). We present in Fig. 4 the observed CM and CC diagrams for all stars measured within the largest circle in Fig. 1 (IC 2395), while those for the stars measured within the smallest circle (BH 47) are shown in Fig. 5. These diagrams show no evidence for two different main sequences. Instead, there is only one sequence, defined mostly by BH 47's bright stars. As a matter of fact, after applying the same membership criteria mentioned above, 25 of BH 47's 53 observed stars lie unmistably on one MS and display similar reddenings. By contrast, only IC 2395's two brightest stars (111 and 117) seem to be affected by the same reddening as BH 47's young stars and lie on the same MS, whereas barely nine of the 49 stars observed within the largest circle (IC 2395) are located on the fainter portion of this sequence. Therefore, we propose that the stars in the two regions may belong to the same cluster, which we will refer to as IC 2395 = BH 47. However, we are some cautious here since there are only a small number of bright stars in the BH 47 region to support this claim. In Fig. 6 we plot the stars in the two regions (IC 2395 + BH 47) on the same diagram. Probable members, possible members and non-members in the region of IC 2395 are represented by filled circles, filled triangles and open circles, respectively, while filled boxes, crosses and open boxes represent probable members, possible members and non-members in the region of BH 47. It is now much more clear from Fig. 6 that the two groups of stars may belong to the same cluster.

On the basis of the adopted membership status of Table 1, we determined the cluster center by projecting the observed stellar density distributions in the *X* and *Y* directions. Figure 7 shows the resulting projected density profiles for probable members (solid lines), field stars (dashed lines) and the total number of observed stars (dotted lines). The selected bin size (50 pixels) is a compromise between the intrinsic higher spatial frequency variations and the statistical noise. Smaller intervals do not yield additional information on the projected stellar density distributions. As can be seen, the distribution of the observed field stars (dashed histograms) is almost symmetric around the cluster. Using Figs. 1 and 7 as reference, we adopted the central position $(X_C, Y_C) = (520 \pm 3, 520 \pm 3)$ for the cluster, equivalent to $(\alpha, \delta)_{2000} = (8^h42\overset{m}{.}5, -48°06\overset{\prime}{.}8)$. This central position nearly coincides with the one measured by van den Bergh & Hagen (1975) for BH 47. The first quoted coordinates for IC 2395 are located ∼15′ towards the south-east from the adopted ones.

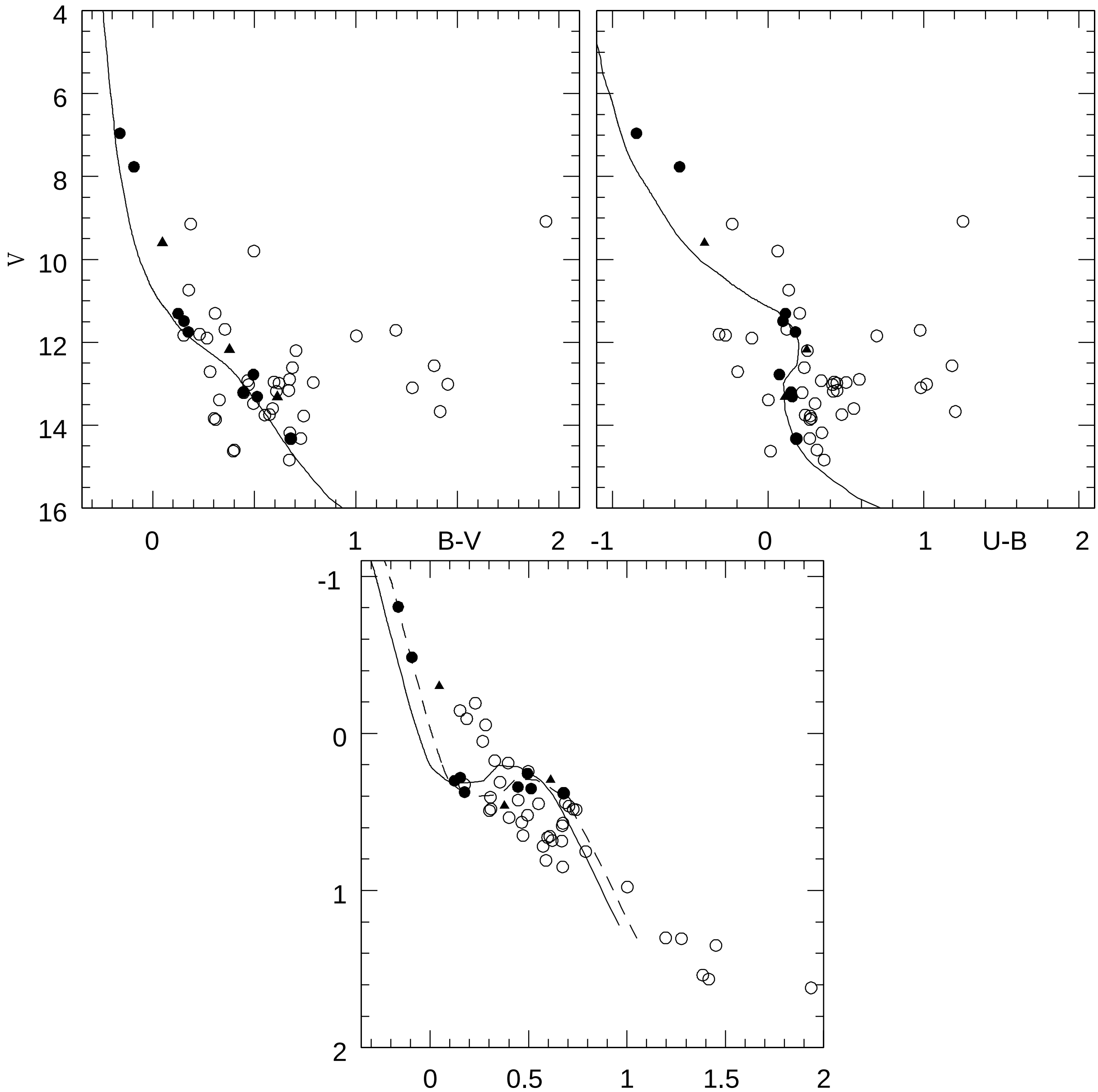

Fig. 4. The observed (V, $B - V$), (V, $U - B$) and ($B - V$, $U - B$) diagrams for all stars measured within the largest circle in Fig. 1 (IC 2395). Symbols are as in Fig. 2.

We determined the cluster radius by building its radial stellar density profile as shown in Fig. 8. The resulting radial profiles for probable members, non-members, and all the measured stars were plotted using the same line styles as in Fig. 7. IC 2395 = BH 47 appears now to be confined within 9.3′ (180 pixels), and has a corona which extends up to ∼18.6′ (360 pixels). The spatial distribution of stars considered to be probable and possible members of IC 2395 = BH 47 is shown in Fig. 9.

5.2. The foreground reddening of IC 2395 = BH 47

As can be seen in the CC diagram of Fig. 6, the interstellar reddening does not vary across the cluster in any noticeable way. According to this figure, all probable members with $(B - V) \leq 0.10$ and $(U - B) \leq 0.10$ are certainly earlier than the spectral type A2. Consequently, individual $E(B - V)$ and $E(U - B)$ colour excesses were derived for these stars using Eqs. (1) and (2) of Clariá (1977). The resulting values are displayed in Table 2, together with the MK spectral types assigned by Houck (1978) and Garrison et al. (1977), when available. The resulting mean values and standard deviations from 30 B-type probable members are: $< E(B-V) > = 0.09 \pm 0.02$, $< E(U - B) > = 0.06 \pm 0.02$. The measured full width of the observed CC diagram from the values listed in Table 2 is $\Delta E(B-V) = 0.08 \pm 0.02$, which is smaller than 0.11, the lower limit estimated by Burki (1975) for clusters with differential reddening. We thus conclude that the interstellar reddening across the cluster is uniform.

The interstellar reddening in front of IC 2395 = BH 47 was also estimated from the available MK spectral types of 14 B-type probable members (Table 2), using the

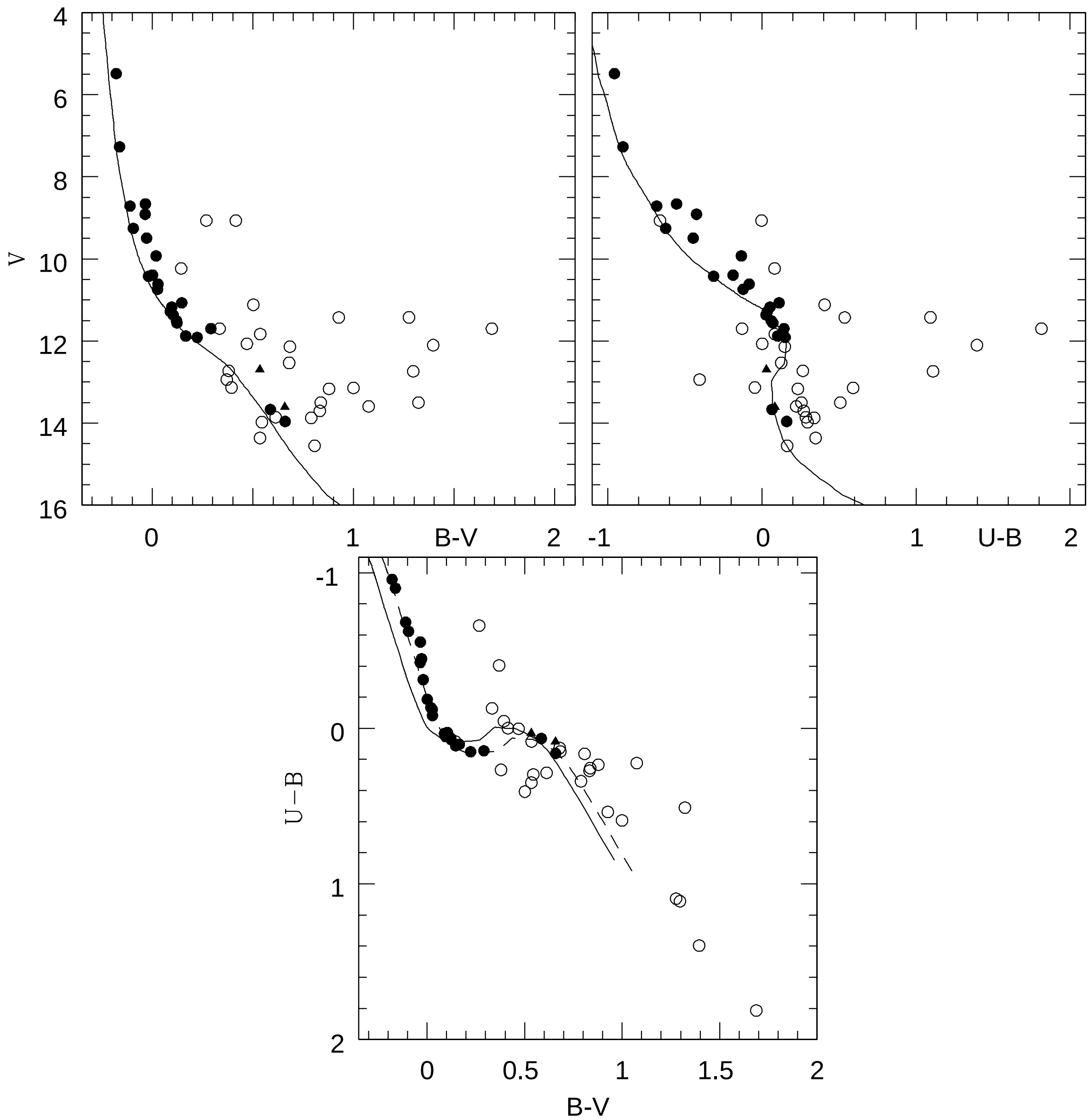

Fig. 5. The observed (V, $B - V$), (V, $U - B$) and ($B - V$, $U - B$) diagrams for all stars measured within the smallest circle in Fig. 1 (BH 47). Symbols are as in Fig. 2.

Schmidt-Kaler (1982) relation between intrinsic colours and spectral types. A mean reddening $< E(B-V)_{\rm MK} > = 0.09 \pm 0.04$ is now obtained from this procedure, in excellent agreement with the former value. Consequently, it will be used in subsequent discussions. The resulting total visual absorption is then 0.28 ± 0.06 mag, assuming that $A_V/E(B - V) = 3.1$ (Cardelli et al. 1989).

5.3. Distance and age

A rough estimate of the cluster distance may be made from the available MK spectral types of the cluster stars. Individual true distance moduli of 14 probable members, computed using individual $E(B-V)$ values and Schmidt-Kaler's (1982) calibration, are listed in Col. 5 of Table 2. The mean $(V - M_V)_0$ value turns out to be 9.55, equivalent to a distance of 813 pc. A more reliable distance, however, may be derived from a fit of the cluster sequence to the ZAMS of Lejeune & Schaerer (2001) in the two CM diagrams (Fig. 2). This procedure yields an apparent distance modulus of $(m-M)_V = 9.80$, which corresponds to a distance of 800 pc from the Sun and 48 pc below the Galactic plane. The uncertainty in the fitting to the ZAMS is estimated to be 0.10 mag and the resulting uncertainty of the distance is about 5%.

We have estimated the age of the cluster by fitting theoretical isochrones computed by Lejeune & Schaerer (2001) to the M_V vs. $(B - V)_0$ and M_V vs. $(U - B)_0$ diagrams (Fig. 10). We adopted a solar metal content ($Z = 0.02$) for the cluster, although we would have obtained a similar age if we had used Z values of 0.008 or 0.040 from the model grids. The isochrone which best fitted the cluster sequences in the above two diagrams turns out to be that for log $t = 6.80$, equivalent

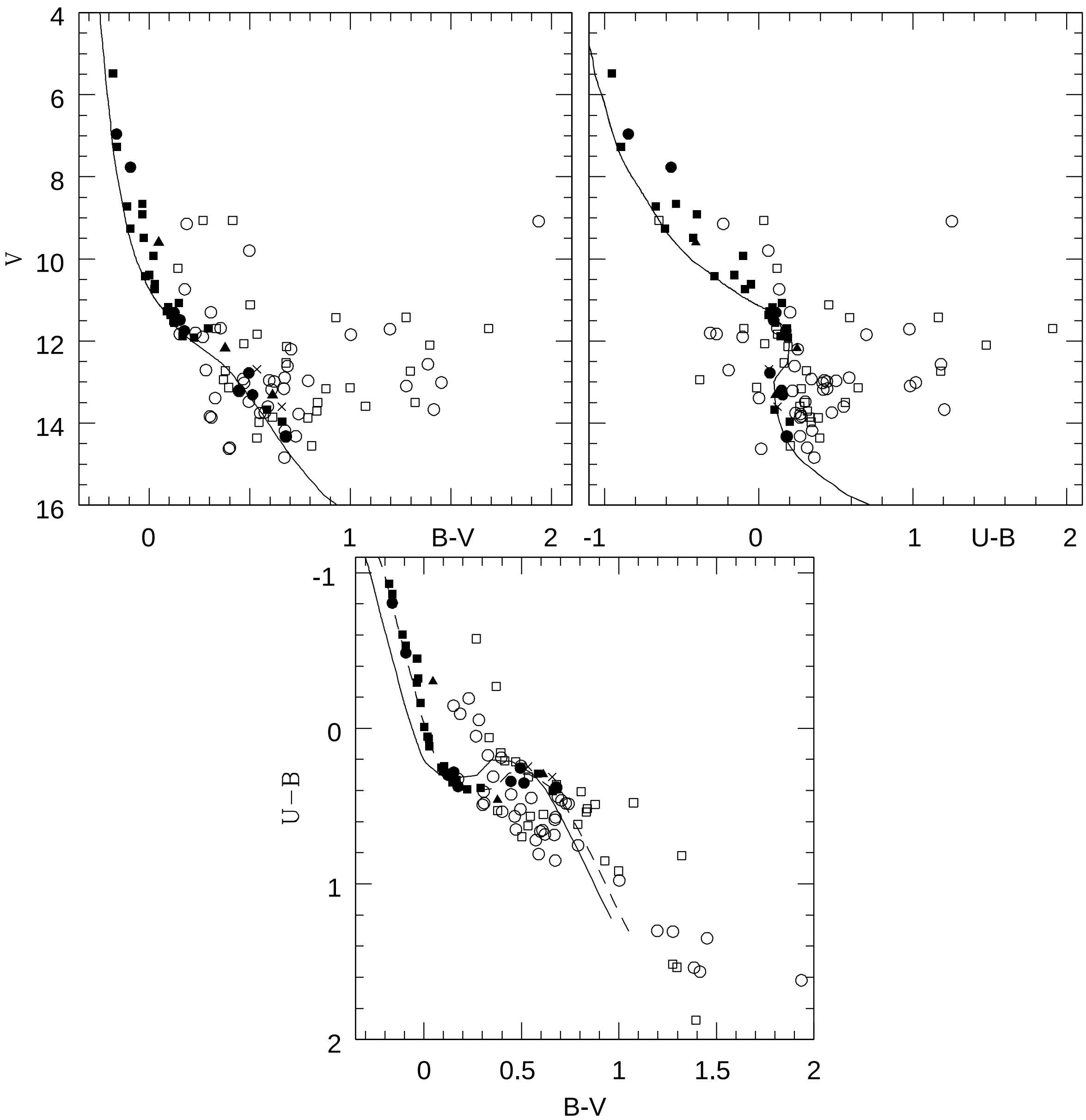

Fig. 6. CM and CC diagrams for stars in the two regions (IC 2395 + BH 47). Probable members, possible members and non-members in the region of IC 2395 are represented by filled circles, filled triangles and open circles, respectively, while filled boxes, crosses and open boxes represent probable members, possible mebers and non-members in the region of BH 47.

to 6 Myr, as shown in Fig. 10. For the fits, we assigned a higher weight to the three brightest probable members. Two additional isochrones (dashed lines) illustrate the cluster age estimation and adopted error (2 Myr).

5.4. IC 2395 = BH 47 and the Vela OB1 association

IC 2395 = BH 47 lies in the direction towards Vela OB1, one of the largest OB associations known (Humphreys 1978). Based on Humphreys's derived mean distance of 1690 pc and angular extent (l = 262° to 268°, b = −2.°7 to +1.°4, linear dimensions of some 180 by 120 pc in longitude and latitude are inferred for Vela OB1. However, three different stellar groups observed along nearly the same line of sight have been recognized by Mel'nick & Efremov (1995), who called them Vela OB1A, Vela OB1B and Vela OB1C. The latter, centered at l ∼ 266.°82, b ∼ −3.°52, lies practically in the same direction as IC 2395 = BH 47 and it is located at a distance of 700 pc from the Sun (Mel'nick & Efremov 1995), i.e., a value slightly smaller than the cluster's distance derived here. Since the age we have estimated for IC 2395 = BH 47 is also compatible with that of a young stellar association, it seems likely that IC 2395 and Vela OB1C originated from the same protostellar material.

6. Summary and conclusions

We have presented here *UBV* photometric data for stars in the fields of the southern open clusters IC 2395 and BH 47. The present study supersedes the previous photometric

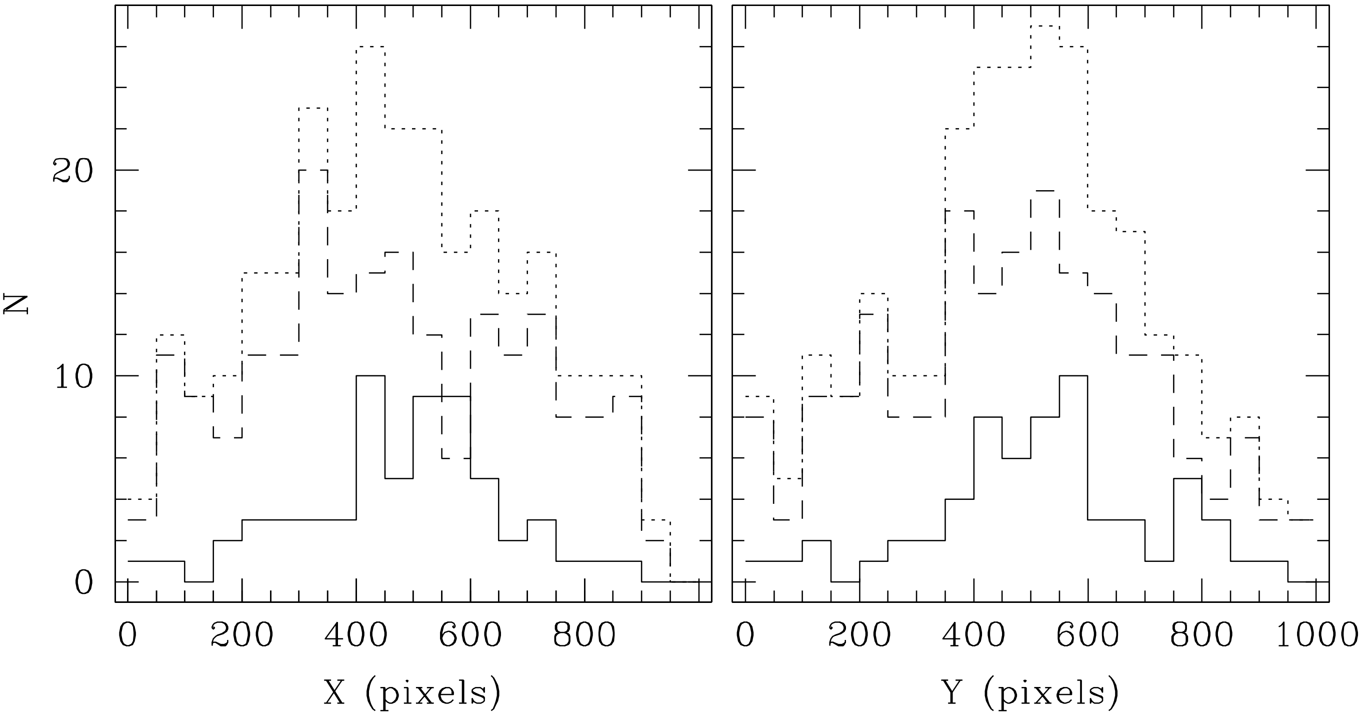

Fig. 7. Projected stellar density distributions in the *X* and *Y* directions. Solid, dashed and dotted lines correspond to probable members, field stars and total number of observed stars, respectively.

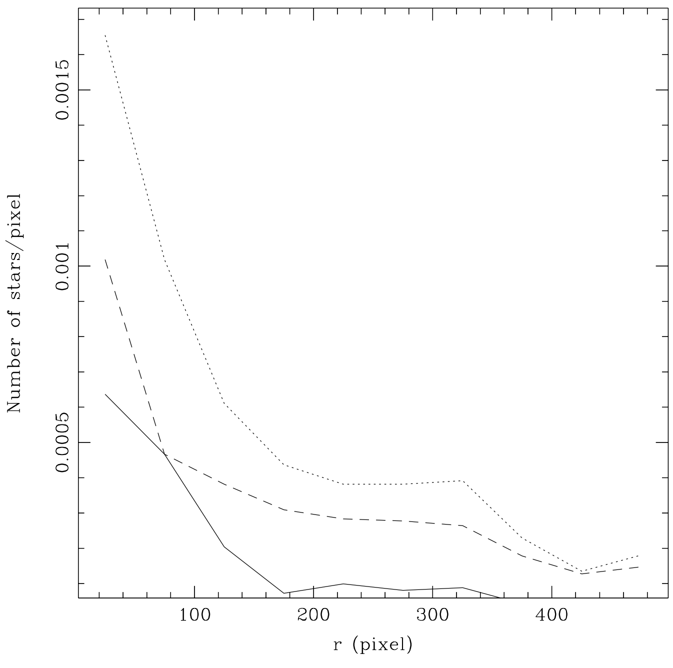

Fig. 8. Stellar density profile centred at (X_C, Y_C) = (520, 520) pixels for stars observed in the field of IC 2395 = BH 47. Lines are as in Fig. 7.

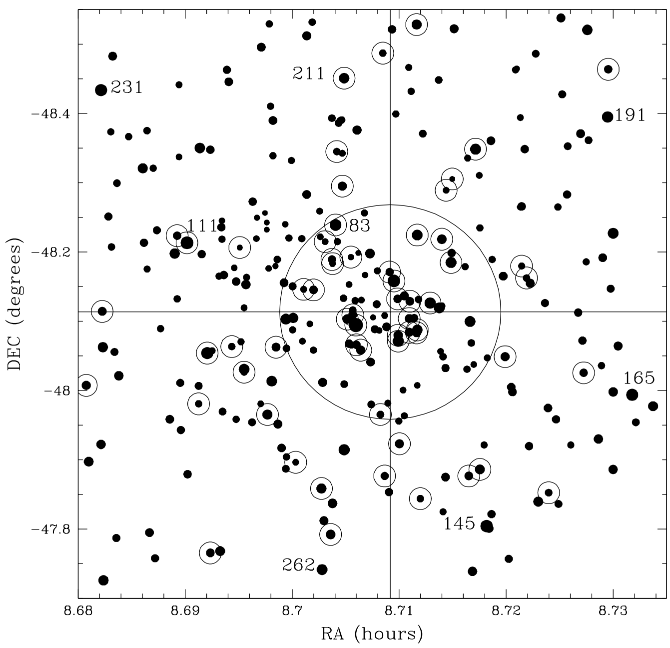

Fig. 9. Spatial distribution of stars considered to be probable and possible members of IC 2395 = BH 47. South is up and East is to the right. The sizes of the filled circles are proportional to the brightness of the stars. The cluster center and adopted radius ($r = 9.3'$) are indicated.

studies by Lyngå (1959, 1962) on account of the larger number of stars observed in the clusters field. The *UBV* CM and CC diagrams reveal the existence of only one MS, typical of a young open cluster. Consequently, we suggest that there is only one rather than two different clusters in this Vela region, which we call IC 2395 = BH 47. The cluster central position $(\alpha, \delta)_{2000}$ = ($8^h42\overset{m}{.}5$, $-48°06\overset{\prime}{.}8$) was determined by projecting the observed stellar density distributions of probable members in the *X* and *Y* directions. The cluster angular diameter derived from radial stellar density profiles is 18.6′, so that the stellar density is ~2 stars pc^{-3}. Photometric membership probabilities appear to be in good agreement with those obtained

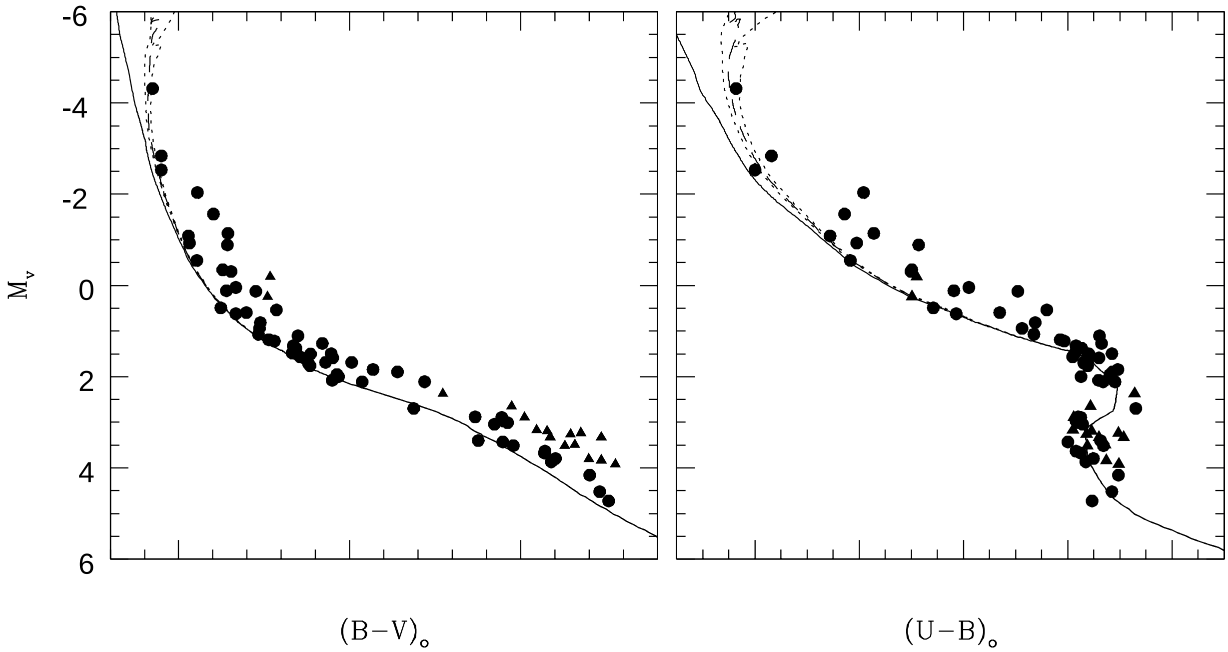

Fig. 10. M_V vs. $(B-V)_0$ and M_V vs. $(U-B)_0$ diagrams for the stars considered to be probable (circles) and possible (triangles) members of IC 2395 = BH 47. The ZAMS (solid lines) and the theoretical isochrones computed by Lejeune & Schaerer (2001) for $Z = 0.020$, log $t = 6.80$ (dashed lines) and log $t = 6.70$ and 6.90 (dotted lines) have been adjusted to $E(B-V) = 0.09$, $E(U-B) = 0.06$ and $(m-M)_V = 9.80$.

Table 2. Derived quantities for B-type probable members of IC 2395 = BH 47.

Star	MK	$E(B-V)$	$E(U-B)$	$(V-M_V)_0$
1	B1.5 Vn	0.10	0.07	8.09
3		0.07	0.05	
5		0.06	0.04	
6		0.10	0.07	
17	B3 IV-V	0.09	0.06	10.44
18		0.06	0.04	
24		0.10	0.07	
26		0.12	0.08	
27	B9 Ve	0.11	0.08	8.96
31	B3 V	0.14	0.10	9.84
33	B2 V	0.10	0.07	9.42
67		0.06	0.04	
70	B8 V	0.10	0.07	8.86
72		0.08	0.06	
73	B6/8 V	0.09	0.06	9.58
74		0.07	0.05	
83	B3 V	0.14	0.10	9.41
85		0.06	0.04	
111	B2 IV	0.08	0.06	9.82
117	B3 IV-V	0.08	0.06	9.52
128	B9 IV	0.06	0.04	9.94
129		0.10	0.07	
136		0.07	0.05	
156		0.09	0.06	
202	B3 V	0.07	0.05	10.26
211	B5 V	0.09	0.06	10.39
246		0.10	0.07	
250		0.09	0.06	
263		0.07	0.05	9.20
266	B9/A0 V	0.07	0.05	9.20

NOTE: All MK spectral types are from Houck (1978), except star 1 (Garrison et al. 1977).

from a proper motion study for 21 stars in common. The full width of the observed cluster MS in the CC diagram measured from B and early A-type stars is consistent with the cluster being uniformly reddened; the mean $E(B-V)$ value being 0.09 ± 0.03. A true distance modulus $(V-M_V)_0 = 9.52 \pm 0.10$, equivalent to a distance of (800 ± 40) pc, is derived for IC 2395 = BH 47. This value lies between the values of 960 pc and 705 pc found by Lyngå (1962) and Loktin et al. (2001), respectively, for IC 2395. However, IC 2395 = BH 47 now turns out to be much younger than previously believed. In fact, adopting a metal content of $Z = 0.02$, the isochrones for log $t = 6.80$ (6 Myr) computed from the models of Lejeune & Schaerer (2001) reproduce the upper MS quite well. The distance as well as the age here derived for IC 2395 = BH 47 support the conclusion that it is physically associated to the Vela OB1C association.

Acknowledgements. We have used an image from the Digitized Sky Survey (Fig. 1), produced at the Space Telescope Science Institute under U.S. Government grant NAG W-2166. We are gratefully indebted to CTIO and Las Campanas staff members and night assistants for their kind hospitality and support during the observing runs. We are also very grateful to Wilton S. Dias for making the results of his kinematic study in this region available for us. We also thank the referee Hans Bruntt for his valuable comments and suggestions which have contributed to improve our work. This study was supported by the Argentinian institutions CONICET, Agencia Nacional de Promoción Científica y Tecnológica (ANPCyT), Secyt (Universidad Nacional de Córdoba) and Agencia Córdoba Ciencia.

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