A populous intermediate-age open cluster and evidence of an embedded cluster among the FSR globular cluster candidates

E. Bica and C. Bonatto

1 Departamento de Astronomia, Universidade Federal do Rio Grande do Sul
Av. Bento Gonçalves 9500, Porto Alegre 91501-970, RS, Brazil; charles@if.ufrgs.br; bica@if.ufrgs.br

2 February 2008

ABSTRACT
We study the nature of the globular cluster (GC) candidates FSR 1603 and FSR 1755 selected from the catalogue of Froebrich, Scholz & Raftery (2007). Their properties are investigated with 2MASS field-star decontaminated photometry, which is used to build colour-magnitude diagrams (CMDs), and stellar radial density profiles (RDPs). FSR 1603 has the open cluster (OC) Ruprecht 101 as optical counterpart, and we show it to be a massive intermediate age cluster (IAC). Relevant parameters of FSR 1603 are the age $\approx 1$ Gyr, distance from the Sun $d_\odot \approx 2.7$ kpc, Galactocentric distance $R_{GC} \approx 6.4$ kpc, core radius $R_C \approx 1.1$ pc, mass function slope $\chi \approx 1.8$, observed stellar mass (for stars with mass in the range $1.27 M_\odot \leq m \leq 2.03 M_\odot$) $M_{\text{obs}} \approx 500 M_\odot$, and a total (extrapolated to $m = 0.08 M_\odot$) stellar mass $M_{\text{tot}} \approx 2300 M_\odot$. FSR 1755, on the other hand, is not a populous cluster. It may be a sparse young cluster embedded in the H II region Sh2-3, subject to an absorption $A_V \approx 4.1$, located at $d_\odot \approx 1.3$ kpc. Important field-star contamination, spatially-variable heavy dust obscuration, even in $K_s$, and gas emission characterise its field. A nearly vertical, sparse blue stellar sequence shows up in the CMDs.

Key words: (Galaxy:) open clusters and associations; Galaxy: structure

1 INTRODUCTION
A catalogue containing 1021 star cluster candidates for Galactic latitudes $|b| < 20^\circ$ and all longitudes was recently published by Froebrich, Scholz & Raftery (2007). Their targets (hereafter FSR objects) were detected by means of an automated algorithm that basically identified regions with stellar overdensities, applied to the 2MASS database. The overdensities were classified according to a quality flag, '0' and '1' representing the most probable star clusters, while the '5' and '6' flags may be related to field fluctuations.

By means of a combination of three parameters, the number of cluster stars corrected to a common magnitude limit, the core radius and the central star density, Froebrich, Scholz & Raftery (2007) could discriminate known GCs from OCs. When applied to the catalogue, this criterion led them to classify 1012 targets as OC candidates and 9 as GC candidates that should be explored in followup studies. Among the latter are FSR 1603 and FSR 1755.

Several works have already explored the FSR catalogue with varying depths and different approaches, with results that reflect the importance of such catalogue. The recently discovered GCs FSR 1735 (Froebrich, Meusinger & Scholz 2007) and FSR 1767 (Bonatto et al. 2007), and the probable GCs FSR 584 (Bica et al. 2007) and FSR 190 (Froebrich, Meusinger & Davis 2007), are clear examples of the fundamental rôle played by the FSR catalogue to improve the statistics of very old star clusters. Indeed, FSR 1735 and FSR 1767 are the most recent additions to the Galactic GC population, a number that presently amounts to $\sim 160$ members (e.g. Bonatto & Bica 2007c).

Besides the obvious importance of finding new star clusters of any age throughout the Milky Way, the identification of the IACs FSR 31, FSR 89 and FSR 1744, projected towards the centre of the Galaxy (Bonatto & Bica 2007a), has provided as well important information on cluster disruption processes and survival rates in those regions. In this context, derivation of astrophysical parameters of new star clusters can be used in studies related to the star formation and evolution processes, dynamics of N-body systems, cluster disruption time scales, the geometry of the Galaxy, among others.

Central to the problem of identifying the nature of cat-
ologue stellar overdensities is the availability of a field-star decontamination algorithm to disentangle physical CMD sequences from field fluctuations. Low-noise stellar radial-density profiles (RDPs) spanning a wide radial range are essential as well, especially for objects projected against dense stellar fields (e.g. Bonatto & Bica 2007b). For instance, based on such premises and working with the decontamination algorithm described in Bonatto & Bica (2007b) applied to 2MASS photometry, Bonatto & Bica (2007a) found that the GC candidate FSR 89 is rather a well-defined IAC.

Most of the FSR catalogue remains to be further explored. As another step in the direction of classifying FSR candidates — taking into account CMD and RDP properties — we show in the present work that the candidates FSR 1603 and FSR 1755 are not GCs. Instead, FSR 1603 is a massive IAC projected against the bulge stars, strong absorption by dust lanes and Hα emission, clearly seen in the 12′ × 12′ XDSS R image (Fig. 1 left panel). Nevertheless, a few bright stars appear to stand out around the image centre over a rather uniform stellar background.

The field of FSR 1755, on the other hand, presents a complex structure that includes important contamination by bulge stars, strong absorption by dust lanes and Hα emission, seen in the 12′ × 12′ XDSS R image (Fig. 1 left panel). These features show up as well in the near IR, as can be seen in the 2MASS Ks image (Fig. 3 right panel), in two different spatial scales. Notice the presence of a bright O star about 2 arcmin to the south of the central coordinates of FSR 1755 (Sect. 3.2).

### 3 PHOTOMETRY AND ANALYTICAL TOOLS

In this section we briefly describe the photometry and outline the methods we apply in the CMD analyses.

#### 3.1 2MASS photometry

In both cases, J, H and Ks 2MASS photometry was obtained in a relatively wide circular field of extraction radius \( R_{\text{ext}} = 50′ \) centred on the coordinates provided by Froehlich, Scholz & Raftery (2007) (cols. 2 and 3 of Table 1) using VizieR4. Wide extraction areas can provide the required statistics, in terms of magnitude and colours, for a consistent field star decontamination (Sect. 3.2). They are essential as well to produce stellar RDPs with a high contrast with respect to the background (Sect. 3.3). In the case of FSR 1603, the RDP resulting from the original FSR coordinates presented a dip at the centre. Thus, we searched for new coordinates to maximise the star-counts in the innermost RDP bin. The optimised central coordinates are given in cols. 2 and 3 of Table 1. The offset with respect to the original coordinates is relatively small, \( \Delta \alpha = -6.0′\) and \( \Delta \delta = -32.2″\).

As a photometric quality constraint, the 2MASS extractions were restricted to stars with errors in J, H and Ks smaller than 0.25 mag. A typical distribution of uncertainties as a function of magnitude, for objects projected towards the central parts of the Galaxy, can be found in Bonatto & Bica (2007b). About 75% – 85% of the stars have errors smaller than 0.06 mag.

#### 3.2 Colour-magnitude diagrams and field-star decontamination

The CMD morphology is an essential tool to unveil the nature of the stellar overdensities. In the present cases we use 2MASS J × (J – H) and J × (J – Ks) CMDs extracted from a central region that, in the case of star clusters, should provide high-contrast CMDs. However, features present in the central CMDs and in the respective comparison field, show that field stars are an important component in the CMDs (Sect. 4). Thus, it is essential to quantitatively assess the relative densities of field stars and potential cluster sequences.

To objectively quantify the field-star contamination in the CMDs we apply the statistical algorithm described in Bonatto & Bica (2007b). It measures the relative number-densities of probable field and cluster stars in cubic CMD cells whose axes correspond to the magnitude J and the colours (J – H) and (J – Ks). These are the 2MASS colours that provide the maximum variance among CMD sequences for OCs of different ages (e.g. Bonatto, Bica & Girardi 2004). The algorithm (i) divides the full range of CMD magnitude and colours into a 3D grid, (ii) computes the expected number-density of field stars in each cell based on the number of comparison field stars with similar magnitude and colours as those in the cell, and (iii) subtracts the expected number of field stars from each cell. By construction, the algorithm is sensitive to local variations of field-star contamination with colour and magnitude. Typical cell dimensions...
Figure 1. Left panel: 12′ × 12′ DSS B image of FSR 1603. Right panel: 12′ × 12′ XDSS R image of FSR 1755, where gas emission and strong dust absorption are conspicuous. Images centred on the FSR coordinates (cols. 2 and 3 of Table 1).

Table 1. Data from Froebrich, Scholz & Raftery (2007)

| Object   | α(2000)     | δ(2000) | ℓ  | b  | R_C | R_t | Classification | Quality flag | N_c (H = 15) |
|----------|--------------|---------|-----|----|-----|-----|----------------|--------------|---------------|
| (1)      | (2)          | (3)     | (4) | (5) | (6) | (7) | (8)           | (9)          | (10)          |
| FSR 1603 | 12:09:45     | −62:59:49 | 298.22 | −0.51 | 1.1 | 29.6 | Probable      | 0            | 1842          |
| FSR 1755 | 17:12:20     | −38:27:44 | 348.25 | +0.48 | 3.2 | 6.4  | Probable      | 2            | 90            |

Table Notes. Cols. 2-3: Central coordinates. Cols. 4-5: Corresponding Galactic coordinates. Cols. 6 and 7: Core and tidal radii derived from King fits to the 2MASS H images. Col. 8: Both candidates have been considered as probable star clusters. Col. 9: FSR quality flag. Col. 10: Number of prospective cluster members, corrected to H = 15.

are ∆J = 0.5, and ∆(J − H) = ∆(J − K_s) = 0.25, which are large enough to allow sufficient star-count statistics in individual cells and small enough to preserve the morphology of different CMD evolutionary sequences. As comparison field we use the region R_{lim} < R < R_{ext} around the cluster centre to obtain representative background star-count statistics, where R_{lim} is the limiting radius (Sect. 3.5). Further details on the algorithm, including discussions on subtraction efficiency and limitations, are given in Bonatto & Bica (2007b). The algorithm also gives the parameter N_{1σ}, which, for a given extraction, corresponds to the ratio of the number of stars in the decontaminated CMD with respect to the 1σ Poisson fluctuation measured in the observed CMD. CMDs of star clusters should have N_{1σ} significantly larger than 1.

2MASS J, H and K_s filters\(^5\) The 2MASS transmission filters produced isochrones very similar to the Johnson-Kron-Cousins (e.g. Bessell & Brett 1988) ones, with differences of at most 0.01 in (J − H) (Bonatto, Bica & Girardi 2004).

The isochrone fit gives the age and the reddening E(J − H), which converts to E(B − V) and A_V through the transformations A_J/A_V = 0.276, A_H/A_V = 0.176, A_K_s/A_V = 0.118, and A_J = 2.76 × E(J − H) (Dutra, Santiago & Bica 2002), assuming a constant total-to-selective absorption ratio R_V = 3.1. We also compute the distance from the Sun (d_⊙) and the Galactocentric distance (R_{GC}), based on the recently derived value of the Sun’s distance to the Galactic centre R_⊙ = 7.2 kpc (Bica et al. 2006). Age, A_V, d_⊙ and R_{GC} are given in cols. 5 to 8 of Table 2 respectively.

3.3 Fundamental parameters

Fundamental parameters are derived with solar-metallicity Padova isochrones (Girardi et al. 2002) computed with the \(^5\) stev.oapd.inaf.it/~lgirardi/cgi-bin/cmd
3.5 Stellar radial density profiles

Star clusters usually have RDPs that follow some well-defined analytical profile. The most often used are the single-mass, modified isothermal sphere of King (1962), the modified isothermal sphere of Wilson (1975), and the power-law with a core of Elson, Fall & Freeman (1987). Each function is characterised by different parameters that are somehow related to cluster structure. However, considering that error bars in the present RDPs are significant (see below), and that our goal here is basically to determine the nature of the targets, we decided for the analytical profile $\sigma(R) = \sigma_b + \sigma_0/(1 + (R/R_c)^2)$, where $\sigma_b$ is the residual background density, $\sigma_0$ is the central density of stars, and $R_c$ is the core radius. This function is similar to that introduced by King (1962) to describe the surface brightness profiles in the central parts of globular clusters.

The stellar RDPs are built with colour-magnitude filtered photometry (Sect. 3.4). Minimisation of the presence of non-cluster stars by the colour-magnitude filter results in RDPs with a significantly higher contrast with the background (e.g. Bonatto & Bica 2007b). To avoid oversampling near the centre and undersampling at large radii, RDPs are built by counting stars in rings of increasing width with distance to the centre. The number and width of the rings are adjusted to produce RDPs with adequate spatial resolution and as small as possible $1\sigma$ Poisson errors. The residual background level of each RDP corresponds to the average number of colour-magnitude filtered stars measured in the comparison field. The $R$ coordinate (and respective uncertainty) of each ring corresponds to the average position and standard deviation of the stars inside the ring.

We also compute the density contrast parameter $\delta_c = 1 + \sigma_b/\sigma_0$, that measures the intrinsic contrast of a cluster RDP (in the central region) with the background. In general terms, $\delta_c$ is a measure of the detectability of clusters by means of star counts. Obviously, the presence of O stars in very young clusters may improve the detectability, even for low-$\delta_c$ cases. As a caveat we note that $\delta_c$ values measured in colour-magnitude filtered RDPs do not necessarily correspond to the visual contrast produced by optical/IR images. The minimisation of field star contamination produces RDPs with higher contrast than those resulting from the raw photometry (e.g. Bica et al. 2006a).

As a measure of the cluster size, we also derive the limiting radius and uncertainty, which are estimated by comparing the RDP (taking into account fluctuations) with the background level. $R_{\text{lim}}$ corresponds to the distance from the
cluster centre where RDP and background become statistically indistinguishable. For practical purposes, most of the cluster stars are contained within \( R_{\text{lim}} \) (Fig. 4). The limiting radius should not be mistaken for the tidal radius; the latter is usually derived from King (or other analytical functions) fits to RDPs, which depend on wide surrounding fields and as small as possible Poisson errors (e.g., Bonatto & Bica 2007). In contrast, \( R_{\text{lim}} \) comes from a visual comparison of the RDP and background levels.

The empirical determination of a cluster-limiting radius depends on the relative levels of RDP and background (and respective fluctuations). Thus, dynamical evolution may indirectly affect the measurement of the limiting radius. Since mass segregation preferentially drives low-mass stars to the outer parts of clusters, the cluster/background contrast in these regions tends to lower as clusters age. As an observational consequence, smaller values of limiting radii should be measured, especially for clusters in dense fields. However, simulations of King-like OCs (Bonatto & Bica 2007) show that, provided not exceedingly high, background levels may produce limiting radii underestimated by about 10–20%. The core radius, on the other hand, is almost insensitive to background levels (Bonatto & Bica 2007). This occurs because \( R_C \) results from fitting the King-like profile to a distribution of RDP points, which minimises background effects.

4 DISCUSSION

4.1 The IAC nature of FSR 1603

CMDs of the central \((R < 3' \sim 2 \times R_C)\) region of FSR 1603 are presented in Fig. 3 (top panels). This extraction contains the bulk of the cluster stars (Fig. 4). Features that stand out are a cluster-like population corresponding to a populous MS \((0.2 \lesssim (J - H) \lesssim 0.6 \text{ and } 12.5 \lesssim J \lesssim 16)\), a giant clump \((0.6 \lesssim (J - H) \lesssim 0.7 \text{ and } 12.2 \lesssim J \lesssim 11)\) and a giant branch \((0.7 \lesssim (J - H) \lesssim 1.0 \text{ and } J \lesssim 11)\), together with a redder sequence \((J - H) \gtrsim 0.8\). Some of these features (especially around the MS and the red component) are present as well in the equal-area comparison field (middle panels), extracted from a ring near 30′, which suggests some contamination by disk and bulge stars. However, the central and comparison field extractions present significant differences in terms of CMD densities. Besides, the giant clump and giant branch are not present in the comparison field. Similar features are present in the \(J \times (J - K_s)\) CMDs (right panels). The qualitative discussion above strongly suggests that FSR 1603 is an intermediate-age OC.

The resulting field star decontaminated CMDs of FSR 1603 are shown in the bottom panels of Fig. 3. The comparison field was taken from the region \(20' < R < 50'\). Bulge and disk contamination have been properly taken into account, except for about 40 red stars that remain in the decontaminated CMDs. Considering that the original red component contains about 214 stars (top panels), the statistical significance of the leftovers represent \(N_{1\sigma} = 2.7\), significantly lower than that of stellar sequence identified with FSR 1603 (Table 1). As shown in Bonatto, Bica, & Camargo (2007), such low values of \(N_{1\sigma}\) are typical of field fluctuations detected as overdensities by Froebrich, Scholz, & Raftery (2007). What emerges from the \(N_{1\sigma} = 6.1 \pm 0.8\) decontaminated CMDs are conspicuous sequences, especially the giant clump and the MS, typical of a relatively populous Gyr-class OC.

Indeed, the decontaminated CMD morphology of FSR 1603 is well represented by the 1 Gyr Padova isochrone, with a distance modulus \((m - M)_V = 12.6 \pm 0.1\), and a reddening \(E(J - H) = 0.17 \pm 0.01\), which corresponds to \(E(B - V) = 0.54 \pm 0.04\) and \(A_V = 1.69 \pm 0.12\). Such values imply a distance from the Sun \(d_0 = 2.7 \pm 0.1\) kpc and a Galactocentric distance \(R_{GC} = 6.4 \pm 0.2\) kpc. At this distance, the scale is 1′ = 0.774 pc. The isochrone fit to FSR 1603 is shown in the bottom panels of Fig. 3.

Figure 4 shows the stellar RDP of FSR 1603. Besides the RDP resulting from the colour-magnitude filter, we also show, for illustrative purposes, that produced with the observed (raw) photometry. In both cases, the central region presents a significant density contrast with respect to the background, especially the colour-magnitude filter RDP, with \(\delta_c = 3.0 \pm 0.4\). The adopted King-like function describes well the latter RDP throughout the full
radii range, within uncertainties. We derive a core radius \( R_C = 1.1 \pm 0.2 \text{ pc} = 1.4' \pm 0.3' \) and a limiting radius \( R_{\text{lim}} = 10 \pm 1 \text{ pc} = 13' \pm 1.3' \). The central density of stars \( \sigma_0 = 20 \pm 4 \text{ stars pc}^{-2} \) and the core radius \( (R_C) \) are derived from the RDP fit, while the background level \( \sigma_{bg} = 10 \pm 0.3 \text{ stars pc}^{-2} \) is measured in the respective comparison field. The best-fit solution is superimposed on the colour-magnitude filtered RDP (Fig. 4). Because of the 2MASS photometric limit, which for FSR 1603 corresponds to a cut-off for stars brighter than J\_phot, the number of observed MS stars, fitted with \( \phi(m) \propto m^{-2.8} \).

We also build the mass function (MF) \( \phi(m) = \frac{dN}{dm} \) for the MS stars following the methods discussed in Bonatto & Bica (2005). To maximise the statistical significance of field-star counts we take as the comparison field the region at \( 15 \leq R(\text{pc}) \leq 39 \), that lies \( \geq 5 \text{ pc} \) beyond the limiting radius. First we apply the colour-magnitude filter (Fig. 3) to the stars located inside the limiting radius, which eliminates most of the field stars, leaving a residual contamination. We deal with this statistically by building the luminosity functions (LFs) for the cluster and comparison field separately. J, H and K\_a LFs are built by counting stars in magnitude bins from the respective faint magnitude limit to the TO. To avoid undersampling near the turn-off and oversampling at the faint limit, magnitude bins are wider in the upper MS than in the lower MS. Correction is made for the different solid angles of the comparison field and cluster region. The intrinsic cluster LF is obtained by subtracting the offset-field LF. Finally, the intrinsic LF is transformed into MF using the mass-luminosity relation obtained from the 1 Gyr Padova isochrone and the observed distance modulus \( (m - M)_J = 12.6 \). These procedures are applied independently to the three 2MASS bands. The final MF is produced by combining the J, H and K\_a MFs. Further details on MF construction are given in Bonatto et al. (2006a). The resulting MF, covering the mass range \( 1.27 M_\odot \leq m_{\text{MS}} \leq 2.03 M_\odot \), is shown in the inset of Fig. 4, where we also include the fit with the function \( \phi(m) \propto m^{-3(1+\chi)} \). Within the uncertainty, the slope \( \chi = 1.8 \pm 0.4 \) is similar to \( \chi = 1.35 \) of the Initial Mass Function (IMF) of Salpeter (1955).

Finally, with the above MF we can estimate the total stellar mass in FSR1603. For masses below the observed lower limit of \( 1.27 M_\odot \), we extrapolate the observed MF down to the H-burning mass limit \( (0.08 M_\odot) \) using the universal IMF of Kroupa (2001). The latter IMF assumes the slopes \( \chi = 0.3 \pm 0.5 \) for the range \( 0.08 \leq m(M_\odot) \leq 0.5 \) and \( \chi = 1.3 \pm 0.3 \) for \( 0.5 \leq m(M_\odot) \leq 1.0 \). With such considerations, the total (extrapolated MS + evolved) mass amounts to \( M_{\text{tot}} = (2.3 \pm 0.9) \times 10^5 M_\odot \), which implies the average mass density \( \rho = 0.55 \pm 0.22 M_\odot \text{ pc}^{-3} \) and the projected density \( \sigma = 7.3 \pm 2.9 M_\odot \text{ pc}^{-2} \).

As a caveat we note that the total mass estimates should be taken as upper limits, since because of dynamical evolution, significant fractions of the low-mass content may have been lost to the field (e.g. Bonatto & Bica 2007a).

### 4.2 The Possible Embedded Cluster FSR 1755

The images of FSR 1755 (Figs. 1 and 2) clearly indicate that this object is a complicated case. Indeed, the differential absorption due to the dust clouds produces conspicuous variations in the stellar number-density, as can be seen in Fig. 6.

According to SIMBAD\(^6\), the bright star at \( \approx 2' \) south of the central coordinates of FSR 1755 is the O star \( CD - 38^\circ 11636 \).

FSR 1755 appears to be spatially associated with the HII region Sh 2-3 (Sharpless 1959), located at \( \alpha(J2000) = 17 : 12 : 21 \) and \( \delta(J2000) = -38 : 27 : 

---

\(^6\) http://simbad.u-starsbg.fr/simbad/
00, also known as Gum 58 (Gum 1953) and RCW 120 (Rodgers, Campbell & Whiteoak 1960, Russell 2003) provides the radial velocity $v_r = 12.0 \, \text{km} \, \text{s}^{-1}$, and the kinematic distance $d_0 = 1.8 \pm 0.7 \, \text{kpc}$ for Sh 2-3. According to the spatial distribution of the spiral arms (Russell 2003), Sh 2-3 appears to be related to the Sagittarius-Carina arm. Sh 2-3 is an optical H II region of dimensions $\sim 7''$ (EW) $\times 10''$ (NS), excited by the O 8V star $CD - 38^\circ 11636$ (LSS 3959), at $\alpha(2000) = 17 : 12 : 20.6$ and $\delta(2000) = -38 : 29 : 26$. It was identified spectroscopically by Georgelin & Georgelin (1970), Voge & Moffat (1972) provide $d_0 = 1.7 \, \text{kpc}$ as the photometric distance to this star. $CD - 38^\circ 11636$ has the apparent magnitudes $B = 11.93$ and $V = 10.79$ (Zavagno et al. 2007), $J = 8.013 \pm 0.021$, $H = 7.708 \pm 0.036$, and $K_s = 7.523 \pm 0.020$ (2MASS). Based on the optical photometry of $CD - 38^\circ 11636$, Zavagno et al. (2007) compute $A_V = 4.36$ and estimate the distance to this star as $d_0 = 1.34 \, \text{kpc}$, which agrees with their kinematic distance of $d_0 = 1.35 \, \text{kpc}$. With the 2MASS photometry of $CD - 38^\circ 11636$ and the absolute $J$ and $H$ magnitudes of an O 8V synthetic star (Martins & Plez 2006) we compute $d_0 = 1.35 \, \text{kpc}$, which agrees with the previous values. We also derive $E(J - H) = 0.4$, $A_J = 1.14$, $A_V = 4.15$, and $(m - M)_0 = 11.9$.

In Fig. 5 (top panels) we show the $J \times (J - H)$ CMD extracted from the $R = 3'$ central region of FSR 1755. An almost vertical, blue ($0.05 \lesssim (J - H) \lesssim 0.5$, $8 \lesssim J \lesssim 15$) sequence — typical of very young populations — appears to merge into a dominant concentration of red stars. The strong differential reddening in the field of FSR 1755 hinders the quantitative use of the decontamination algorithm. However, it can be applied as a qualitative probe on CMD features, for different choices of the comparison field. Two cases are examined, one taking field stars from the region $5' \lesssim R \lesssim 8'$, that basically corresponds to the deep RDP depression (Fig. 5), and the other from an external region $25' \lesssim R \lesssim 50'$ away from the centre. For visual purposes only, we characterise the field contamination on the $R = 3'$ central CMDs, resulting from both choices of comparison field, by means of the equal-area extractions $6.32' \lesssim R \lesssim 7'$ and $29.85' \lesssim R \lesssim 30'$, respectively. They are shown in the middle panels of Fig. 5. For statistical representativity of the field stars, the decontamination algorithm uses the full radial scale of the adopted comparison fields, $5' \leq R \leq 8'$ and $25' \leq R \leq 50'$, respectively. In both cases, the stellar distributions are similar in terms of colour and magnitudes, but they differ significantly in density.

Consequently, the resulting decontaminated CMDs also present differences, especially in the remaining field-star distribution. However, the blue sequence consistently remains in both CMDs.

Assuming that FSR 1755 is associated with Sh 2-3, we apply to the decontaminated CMDs the 3 Myr Padova isochrone as representative of the young age, together with the pre-MS (PMS) tracks of Siess, Dufour & Forestini (2000) with the ages 1 Myr and 5 Myr, set for $d_0 = 1.35 \, \text{kpc}$ and $E(B - V) = 1.3$. What results in both cases is consistent with a sparse embedded cluster. Thus, most of what remains in the CMDs as the red component results from the strong differential reddening in the rich field. However, because of the strong differential absorption, we cannot exclude the possibility that some fraction of the red component is composed of very reddened PMS stars.

Finally, in Fig. 5 we present the RDPs of FSR 1755. The deep RDP depression, which is due to dust absorption, associated with the large number of stars related to the red component, creates the impression of a high central stellar concentration and large core radius. Taken together, these features match the GC criterion established by Froebrich, Scholz & Raftery (2007). Indeed, the RDP dip (Fig. 5) coincides with the tidal radius computed by Froebrich, Scholz & Raftery (2007).

On the other hand, most of the above features are absent in the colour-magnitude filtered RDP, which has a low-level central concentration of stars typical of a poorly populated star cluster, and a small bump at $R \approx 2.5'$ that coincides with the radial distance of $CD - 38^\circ 11636$.

From the above we conclude that the potentially populous cluster FSR 1755 is in fact an artifact produced by the highly spatially variable star-count density and absorption across the field. However, we cannot exclude the possibility of a sparse young cluster embedded in the H II region Sh 2-3.
5 SUMMARY AND CONCLUSIONS

In this paper we investigated the nature of the GC candidates FSR1603 and FSR1755, taken from the Froebrich, Scholz & Raftery (2007) catalogue, by means of decontaminated J H and Ks 2MASS CMDs and stellar RDPs. Both objects were originally classified as GC candidates by Froebrich, Scholz & Raftery (2007) based essentially on the number of cluster stars, the core radius and the central star density. Basically, what results from the present work is that neither object is in fact a globular cluster: FSR1603 is a populous intermediate-age open cluster and FSR1755 may consist of a sparse young cluster embedded in a complex H II region.

FSR1603 corresponds to the OC Ruprecht 101, for which cluster parameters were derived for the first time. It is a massive IAC, with age = 1.0 ± 0.1 Gyr, located at d0 = 2.7±0.2 kpc from the Sun and Galactocentric distance RGC = 6.3±0.3 kpc, reddening E(B − V) = 0.54±0.04, core and limiting radii RC = 1.1±0.2 pc and Rlim = 10±1 pc, respectively. The mass stored in the observed stars is Mobs ≈ 500 M⊙; extrapolation to the low-MS stars (∼ 0.08 M⊙) increases the mass to Mtot ≈ 2300 M⊙. Ru101 was probably misclassified as a GC candidate because it is a populous OC.

FSR1755 is related to the optical H II region Sh 2-3, located at d0 ≈ 1.4 kpc. The object is surrounded both by Hα emission and dust absorption even in the Ks band. A nearly vertical, blue CMD sequence, that includes the O8V star CD − 38° 11636, appears to define FSR1755 as a sparse embedded cluster. Because of the strong differential reddening in the surroundings, a large number of red stars show up in the CMDs, which probably produced the stellar enhancement that was taken as GC candidate by Froebrich, Scholz & Raftery (2007). We conclude that the GC identification of FSR1755 is a dust-absorption artifact in a very rich stellar field.

Systematic surveys such as that of Froebrich, Scholz & Raftery (2007) are important to detect new star cluster candidates throughout the Galaxy. Nevertheless, works like the present one, that fine tune the analysis by means of field-star decontaminated CMDs and stellar radial profiles, turn out to be fundamental to probe the nature of such candidates, especially those projected against dense stellar fields.

ACKNOWLEDGEMENTS

We thank the anonymous referee for suggestions. We acknowledge partial support from CNPq (Brazil). This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France, as well as of data products from the Two Micron All Sky Survey (2MASS), which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science Foundation. We employed Digitized Sky Survey images from the Space Telescope Science Institute (U.S. Government grant NAG W-2166) obtained using the extraction tool from CADC (Canada). We also made use of the WEBDA database, operated at the Institute for Astronomy of the University of Vienna.

REFERENCES

Bessell, M.S. & Brett, J.M. 1988, PASP, 100, 1134
Bica, E., Bonatto, C. & Blumberg, R. 2006a, A&A, 460, 83
Bica, E., Bonatto, C., Barbay, B. & Ortolani, S. 2006, A&A, 450, 105
Bica, E., Bonatto, C., Ortolani, S. & Barbay, B. 2007, A&A, 472, 483
Bica, E., Bonatto, C. & Camargo, D., 2007, MNRAS, in press, (astro-ph/0712.0762)
Binney, J. & Merrifield, M. 1998, in Galactic Astronomy, Princeton, NJ: Princeton University Press. (Princeton series in Astrophysics)
Bonatto, C., Bica, E. & Girardi, L. 2004, A&A, 415, 571
Bonatto, C., Bica, E. & Santos Jr., J.F.C. 2005, A&A, 433, 917
Bonatto, C. & Bica, E. 2005, A&A, 437, 483
Bonatto, C. & Bica, E. 2007a, A&A, 473, 445
Bonatto, C. & Bica, E. 2007b, MNRAS, 377, 1301
Bonatto, C. & Bica, E. 2007c, A&A, accepted, (astro-ph/0711.1434)
Bonatto, C., Bica, E., Ortolani, S. & Barbuy, B. 2007, MNRAS, 381, L45
Dutra, C.M., Santiago, B.X. & Bica, E. 2002, A&A, 383, 219
Elson, R.A.W., Fall, S.M. & Freeman, K.C. 1987, ApJ, 323, 54
Froebrich, D., Meusinger, H. & Scholz, A. 2007, MNRAS, 377, L54
Froebrich, D., Scholz, A. & Raftery, C.L. 2007, MNRAS, 374, 399
Froebrich, D., Meusinger, H. & Davis, C.J. 2007, MNRAS, in press (astro-ph:0710-2030)
Georgelin, Y.P. & Georgelin, Y.M. 1970, A&ASS, 3, 1
Girardi, L., Bertelli, G., Bressan, A., et al. 2002, A&A, 391, 195
Gum, C.S. 1955, MmRAS, 67, 155
Hurley, J. & Tout, A.A. 1998, MNRAS, 300, 977
Kerber, L.O., Santiago, B.X., Castro, R. & Valls-Gabaud, D. 2002, A&A, 390, 121
King, I. 1962, AJ, 67, 471
King, I. 1966, AJ, 71, 64
Kroupa, P. 2001, MNRAS, 322, 231
Martins, F. & Plez, B. 2006, A&A, 457, 637
Mermilliod, J.C. 1996, in The Origins, Evolution, and Destinies of Binary Stars in Clusters, ASP Conference Series, eds. E.F. Milone & J.-C. Mermilliod, 90, 475
Rodgers, A.W., Campbell, C.T. & Whiteoak, J.B. 1960, MNRAS, 121, 103
Russeil, D. 2003, A&A, 397, 133
Salpeter, E. 1955, ApJ, 121, 161
Sharpless, S. 1959, ApJS, 4, 257
Siess, L., Dufour, E. & Forestini, M. 2000, A&A, 358, 593
Vogt, N. & Moffat, A.F.J. 1975, A&A, 45, 405
Wilson, C.P. 1975, AJ, 80, 175
Zavagno, A., Pomerès, M., Deharveng, L., Hosokawa, Y., Russeil, D. & Caplan, J. 2007, A&A, 472, 835