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Searching for globular clusters in NGC 253

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Abstract. The preliminary results of a search for globular clusters candidates in the spiral galaxy NGC 253 are presented. We have used B,V, and I-band photometric observations carried out at the ESO 2.2m telescope. According to various morphological criteria, 380 candidate clusters have been selected for follow-up studies.

Key words. globular cluster – galaxies: individual: NGC 253

1. Introduction

Globular clusters (GCs) are among the oldest readily observable objects in the universe and have been detected in all morphological types of massive galaxies and in many dwarfs galaxies (e.g. Harris (2001)). GCs provide important clues to the understanding of the formation and evolution of their parent galaxies, and to probe the mass distribution of the halos of galaxies. Much attention has been dedicated to globular cluster systems in elliptical galaxies, which are typically more populous than in spirals (Harris (2001); Ashman & Zepf (1998)). In comparison, relatively little work has been done for spiral galaxies, with the exception of M31 and, of course, the Milky Way. The better studied GC systems, those in the Milky Way and M31, seem to share the same physical and dynamical characteristics. In particular, they define at least two spatial and kinematical subsystems which overlap significantly in [Fe/H] (Zinn (1985); Harris (2001)), i.e. the disk clusters, more metal-rich, with rapid rotation and with relatively small velocity dispersion, and the halo clusters which are generally more metal-poor, rotate slowly and have a larger velocity dispersion. However, the identification of the clusters remains the first step before any further investigation.
NGC 253 is the most massive member of the Sculptor group (Puche et al. (1991)), and it is probably the nearest large spiral (Sc) galaxy outside the Local Group known to contain GCs. We will adopt a distance of 2.88 Mpc (average of various methods) and a total integrated magnitude of M_V^T=–21.

The total cluster population in a galaxy is related to the specific frequency S_N, the number of clusters per galaxy luminosity unit, via the relation: $S_N = N_T\ 10^{0.4(M_V^T+15)}$, where M_V^T is the integrated absolute magnitude of the host galaxy and N_T is the total number of clus-

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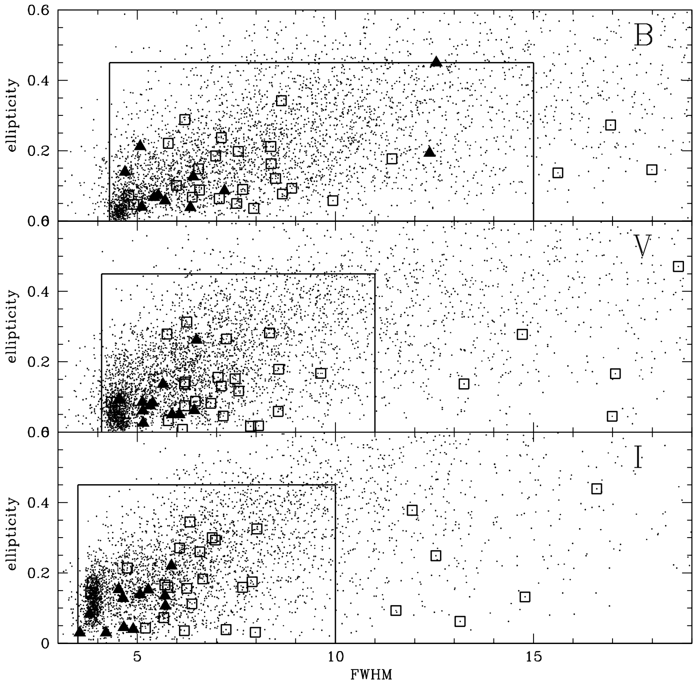

Fig. 1. Ellipticity vs. FWHM (B,V,I) for all the objects found from SExtractor in a 34' x 33' field centered on NGC 253 (squares: confirmed galaxies, triangles: confirmed globular clusters). The rectangles show the ellipticity and the FWHM limits adopted to eliminate possible background galaxies from the sample.

ters (Harris & Van den Bergh (1981); Harris (2001)). Spiral galaxies tend to have the smallest population ($S_N \leq 2$), while normal ellipticals rank somewhat higher systems ($S_N \geq 2$). Using the typical $S_N \sim 0.5 \pm 0.2$ for Sc/Irr type galaxies (Harris (1991)) we estimate $N_T \sim 150$ for NGC 253. Previous studies of the NCG 253 GC system include the photometric searches performed by Liller & Alcaino (1983) which produced 70 candidates, by Blecha (1986) which produced a list of 25 "reliable" candidates, and by Beasley & Sharples (2000) which produced a list of 91 candidates. Of all these candidates, 54 objects selected from the lists of Liller & Alcaino (1983) and Blecha (1986) were observed spectroscopically by Beasley & Sharples (2000), who confirmed only 14 globular clusters.

2. Observations

Observations of NGC 253 were carried out on 1999 July 22-23, with the Wide-Field Imager (WFI) at the 2.2m ESO telescope in La Silla, Chile. The WFI consists of eight 2048 x 4096 CCDs with a total field of view of 34' x 33', and a scale of 0.238 "/px. We imaged the galaxy in three broadband filters: B,V,I. The seeing varied between 0.8 and 1.1 arcsec. The data were reduced using the IRAF package MSCRED (Valdes (1998)), which is especially designed for the reduction of CCD mosaic images and the package WFPRED, developed at the Padova Observatory.

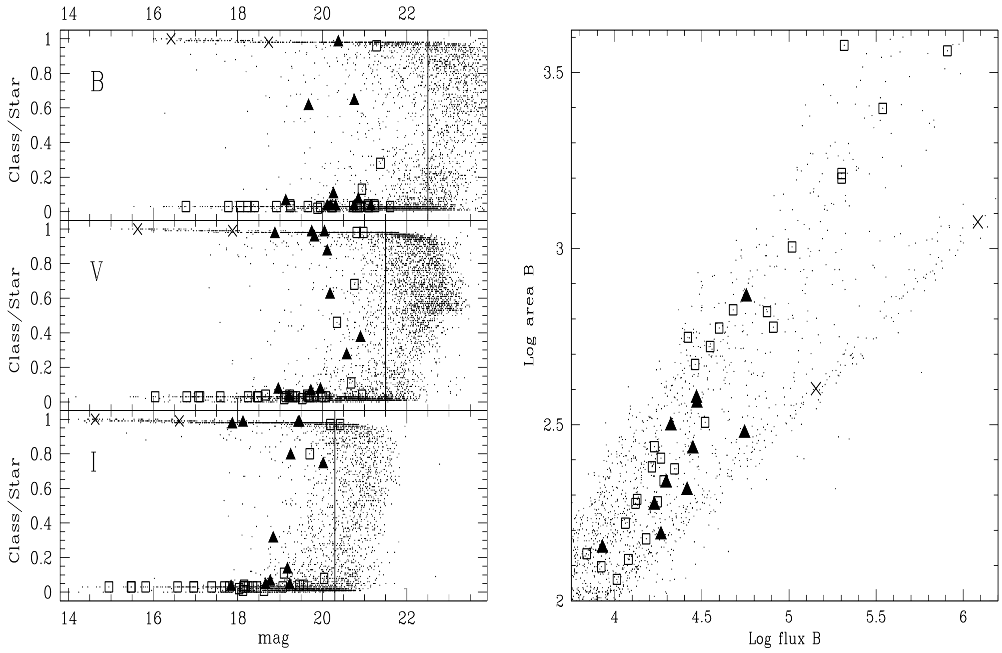

Fig. 2. *Left panel*. From top to bottom: SExtractor stellarity index vs B,V,I magnitudes (triangles: confirmed globular clusters, squares: confirmed galaxies, crosses: confirmed stars). In each panel the limit magnitude adopted is evidenced. *Right panel*. Log(isophotal area) vs Log(B isophotal flux). The symbol types are as in the left panel.

3. Detection and Selections

The detection, measure and classification of the objects have been performed with the program SExtractor (Bertin & Arnouts (1996)). Objects were searched for using a threshold of 3σ above the sky level. The magnitudes produced by SExtractor are given by an adaptive aperture photometry routine based on the Kron "first moment" algorithm (Kron (1980), for more details see Bertin & Arnouts (1996)).

A total of 5572 sources were extracted from the B,V,I frames. We have used photometric information, morphological parameters and visual inspection to survey globular cluster candidates.

At the NGC 253 distance, a typical MW globular cluster size (~20-25 pc) corresponds to FWHM of ~6-8 pixels. On our B,V,I images the measured FWHM of the previously confirmed NGC 253 GCs are slightly larger than those of the point sources. To eliminate possible background galaxies from the sample, we first excluded the candidates with ellipticity > 0.45, then we selected the objects whose B,V,I FWHM fulfil the following relations: 4.3px$<FWHM_B<$15px, 4.1px$<FWHM_V<$11px, and 3.5px$<FWHM_I<$10px. In Fig. 1 ellipticity vs. FWHM is plotted for all the measured objects: the rectangles show the limits for both parameters. The adopted restrictions eliminate from our sample part of the previously confirmed galaxies (squares), whereas the confirmed globular clusters (triangles) are retained. After this selection, we remain with a total of 3551 candidates.

SExtractor classifies the objects with a "stellarity" index (CLASS/STAR, C/S) that varies between 0 (extended source) and 1 (point source). Fig. 2 (left) shows the stellarity index as a function of magnitude, and the limits of the classifications we have assumed (B<22.5, V<21.5 and I<20.3). We note that most of the confirmed globular clusters (triangles) are classified as galaxies or as non-stellar objects (C/S ∼0.5) and that some of them lie near the point sources locus; so we excluded the objects with C/S >0.99 to eliminate point sources from the sample. Fig. 2 (right) shows the logarithm of the isophotal area versus the logarithm of the isophotal flux. Extended objects show an excess of area at a given flux. We have then excluded from our sample the objects falling on the stellar sequence, and were left with a total of 313 candidate globular clusters. This selection criterium, however, may be rather severe and may eliminate possible compact globular clusters. Therefore, relatively bright, isolated stellar objects were used to create the PSF model, which was then fitted to all the subtracted objects, and residual images were created. Inspection of these residuals showed that globular clusters were oversubtracted in the center and undersubtracted in the wings, whereas true stars left nearly flat residuals. In this way we were able to recover 67 fairly compact objects and retain them as candidate globular clusters, for a total of 380 objects.

4. Summary and future prospects

We have identified 380 candidate globular clusters in a 34’ x 33’ field centered on NGC 253. We have developed a method of analysis which is able to efficiently separate clusters from stars, and partly from background galaxies. A comparison with the color distribution of M31 globular clusters (0.4 ≤(B-V)≤ 1.7; 0.6 ≤(V-I)≤ 2) shows that ∼300 candidates are in this range. Only spectroscopic observations will be able to distinguish these objects from background galaxies or foreground stars, and provide a definitive identification. We have been granted observing time with VIMOS during ESO Period 71 for this purpose.

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