Wide field photometry of the M104 globular cluster system

Alessia Moretti\textsuperscript{1,2}, Enrico V. Held\textsuperscript{1}, Luca Rizzi\textsuperscript{1,2}, Vincenzo Testa\textsuperscript{3}, Luciana Federici\textsuperscript{4}, and Carla Cacciari\textsuperscript{4}

\textsuperscript{1} INAF-Osservatorio Astronomico di Padova, 35122 Padova, Italy
\textsuperscript{2} Dipartimento di Astronomia, Università di Padova, I-35122 Padova, Italy
\textsuperscript{3} INAF-Osservatorio Astronomico di Roma, 00040 Monte Porzio Catone, Italy
\textsuperscript{4} INAF-Osservatorio Astronomico di Bologna, 40127 Bologna, Italy

Abstract. We present preliminary results of a wide field study of the globular cluster system of NGC 4594, the Sombrero galaxy. The galaxy was observed in B, V, and R using the Wide Field Imager on the ESO 2.2m telescope. Using color and shape criteria to select a sample of highly probable globular cluster candidates, we measured the radial density profile of clusters out to 40′ (100 Kpc) in the galaxy halo. The colors are consistent with the bimodal color distribution observed in previous studies. The red cluster candidates show a clear central concentration relative to the blue clusters. The population of red clusters does not appear significantly flattened, thus indicating that they are associated to the galaxy bulge rather than to the disk.

1 Observations and reduction

Wide field imaging of M 104 was taken in April 2000 using the ESO/MPG 2.2m telescope at La Silla. The typical exposure time was 35 min in each of the B, V, and R bands. Pre-reduction was performed using the IRAF package MSCRED, while distortion correction, image alignment onto a common sky reference system, co-adding and mosaicing were obtained using a dedicated IRAF package (Rizzi & Held 2002, in prep.). The combined images in each passband were then suitably processed to subtract the galaxy’s diffuse light. The ring median filtering in IRAF was used to this purpose. Finally, DAOPHOT aperture photometry was obtained on the sum images, and a catalog was built of objects detected in all passbands at the 4\(\sigma\) level. From this master catalog, a sample of candidate globular clusters was selected based on the object color and shape. As a simple shape parameter we used the difference between two aperture magnitudes with different radii of 2 and 4 pixels (the typical size of stellar images being 4-5 pixels FWHM). This simple method proved to be quite effective in discriminating star-like images from diffuse objects (i.e. background galaxies) (Fig. \ref{fig:1}, right panel).

The color-magnitude diagram of star-like objects around M104 clearly shows the presence of a conspicuous globular cluster population (see Fig. \ref{fig:1}, left panel). The color and magnitude selection outlined in Fig. \ref{fig:1} was used to define our final sample of high-probability globular cluster candidates. The adopted limits were modeled on the properties of globular clusters in M31 \cite{1}. Using this combined
color and shape selection, contamination by foreground stars and background galaxies in expected to be very low.

2 Spatial distribution

Wide field CCD imaging provides the possibility of detecting bona-fide globular clusters out to large distances from the galaxy center. Figure 2 shows the surface density profile of candidates within 15′ (nearly 40 Kpc at the distance of M 104) from the galaxy center. We have used the outer regions (beyond 16.5 arcmin from the center) to estimate and statistically subtract an approximate background level. The cluster distribution appears to be more extended than the galaxy light, confirming the result of the photographic study of W. Harris and coll. [4]. There is also a hint of flattening in the inner region, which is consistent with a two-slopes fit.

3 Colors and metallicities

The sample of bona-fide candidates was also used to derive the color distribution of globular clusters in the halo of the Sombrero galaxy. Figure 3 suggests a bimodal metallicity distribution, with peaks at $B - R = 1.15$ and 1.35, corresponding to $[\text{Fe/H}] = -1.4$ and $-0.6$ by adopting the transformation of [1]. The metallicities measured from colors and spectroscopy ([5]; Held et al., this volume) are in good agreement. These results agree with those derived by Larsen.
Fig. 2. The radial density profile of bona-fide globular cluster candidates in M 104. A linear fit to the density profile between 2.5 and 12.5 arcmin is also shown, yielding a power-law exponent $-1.92$.

and coll. [5] from the $V - I$ colors of an HST inner cluster sample. These metallicities are very similar to those of globular clusters in our Galaxy and M 31, where the blue component is associated to a cluster sub-population which is old and metal-poor, while the red component is metal-rich and typical of the bulge/disc population [3].

4 Radial gradients

The red clusters turn out to be more centrally concentrated than the blue ones, which confirms their association with the galaxy bulge [3]. The right panel of Fig. 3 shows the radial distribution of the two sub-populations. Moving to the outer regions the blue, presumably metal-poor, component becomes predominant, and a ratio between red and blue clusters typical of spiral galaxies is reached. Interestingly, the projected two-dimensional distributions of both the
Fig. 3. Left: the $B - R$ color distribution of globular clusters in the Sombrero galaxy. Right: the radial distribution of blue ($B - R < 1.3$, corresponding to $[\text{Fe/H}] < -1$) and red ($B - R \geq 1.3$) clusters, normalized to the total number of cluster candidates in each bin.

Blue and red sub-populations exhibit a nearly spherical symmetry. As a result of our wide field multicolor study, we can conclude that the red clusters are associated to the galaxy bulge rather than to the disk.

References

1. P. Barmby, J. P. Huchra, J. P. Brodie, et al.: AJ 119, 727 (2000)
2. T. J. Bridges, D. A. Hanes: AJ 103, 3 (1992)
3. D. A. Forbes, K. L. Masters, D. Minniti, P. Barmby: A&A 358, 471 (2000)
4. W. E. Harris, H. C. Harris, G. L. H. Harris: AJ 89, 216 (1984)
5. S. S. Larsen, J. P. Brodie, B. G. Elmegreen, et al.: ApJ 556, 801 (2001)
6. S. S. Larsen, J. P. Brodie, M. A. Beasley, D. A. Forbes: AJ 124, 828 (2002)