The low-luminosity galaxy population in the NGC 5044 Group

Sergio A. Cellone[1] and Alberto Buzzoni[2]

[1] Fac. de Cs. Astronómicas y Geofísicas (UNLP), Paseo del Bosque, B1900FWA La Plata, Argentina scellone@fcaglp.unlp.edu.ar
[2] INAF – Osservatorio Astronomico di Bologna, Via Ranzani 1, Bologna, Italy alberto.buzzoni@bo.astro.it

Summary. Detailed surface photometry for 79 (mostly dwarf) galaxies in the NGC 5044 Group area is analysed, revealing the existence of different morphologies among objects originally classified as early-type dwarfs. Particularly, a significant fraction of bright dwarf "ellipticals" show a distinct bulge+disc structure; we thus re-classify these objects as dwarf lenticulars (dS0). Our finding points at a possible scenario where these systems are the remnants of "harassed" disc galaxies. This is emphasized by the discovery of a few objects with hints for very low-surface brightness spiral-like structure. The colours, structure, and spatial distribution of the different galaxy types suggest that our classification may indeed be separating objects with different origins and/or evolutionary paths.

1 Introduction and observational material

Due to their low luminosities and sizes, a detailed classification of dwarf ($M_B \geq -18$) galaxies is not easy, thus leading to a deceptively simple picture: those objects showing conspicuous signatures of present/recent star formation and interstellar material are called dwarf irregulars (dI), while the remaining smooth-looking, gas-poor objects fall within the dwarf elliptical (dE) designation[3]. However, there is growing evidence for a morphological diversity among dwarfs; in particular, embedded disc structure and/or rotation were discovered within a fraction of dEs [12, 15, 17, 8, 10], which seems to favor the idea that a fraction of the dEs may be remnants of "harassed" disc galaxies [14]. Whether these objects are related to the still poorly known class of dwarf lenticulars (dS0) or not, is still matter of debate [1, 13].

Aiming at a comprehensive study of the low-luminosity galaxy population in the NGC 5044 Group ($m - M = 31.9$) [9] we have gathered multicolour surface photometry for a representative sample, comprising 40 galaxies with Gunn system *griz* imaging data, observed with the ESO 3.6-m telescope (1999–2000), and 57 galaxies observed at CASLEO, Argentina (1996–1999) in V and B or $R_{\rm C}$ with a 2.1-m telescope. There are 18 objects in common between both subsamples, hence we have a total of 79 different galaxies on

[3] Blue compact dwarfs (BCD), at least in groups and clusters, are rare objects, and will not be treated here.

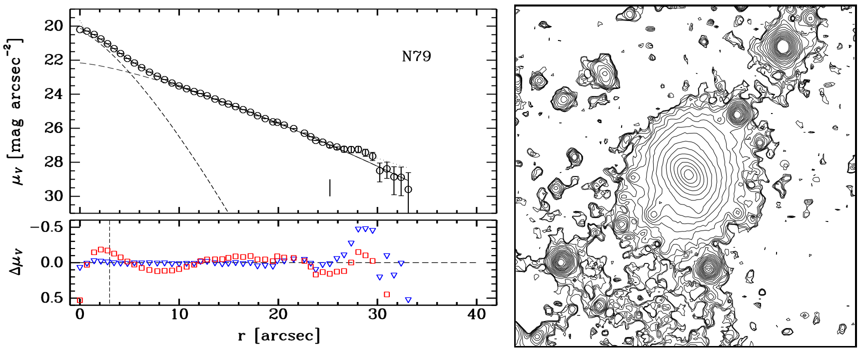


Fig. 1. *Left* - Surface brightness profile for N79 (dS0) showing Sérsic fits to the whole profile and to bulge and disc components (dashed lines); the solid line is the B+D fit. The lower panel shows residuals from a Sérsic fit to the whole profile (squares) and from the B+D fit (triangles). *Right* - Contour plot for N79.

the NGC 5044 Group area, observed at least in one photometric band. Of these, 74 galaxies have at least one colour information. A subsample of 13 galaxies was also observed spectroscopically at ESO. First results, involving nearly 50% of these data, have been already presented [5, 6, 7].

2 Classification

Background objects were identified by means of morphological criteria when a redshift was not available (see [7]). Group members were classified mostly relying on the behaviour of their surface brightness profiles (SBP), with the aid of colour information and morphological appearance. We were able to assign any individual Group member into one of the following classes:

dE: A Sérsic law [16] gives very good fits to their SBPs. Generally, these galaxies show no isophote twisting.

dE/dS0: These objects are well fit by bulge+disc (B+D) models. They usually show isophote twisting, ellipticity gradients, and/or colour gradients.

dI/dE: Very low surface brightness (LSB) objects, with very extended and nearly exponential SBPs (Sérsic index $n \simeq 1$).

Im: "Magellanic" irregulars.

dSph: Objects (mostly new ones) with $M_g \geq -12$ and central surface brightnesses $\mu_0 \geq 24$ mag arcsec^{-2}.

As an example, Fig. 1 shows the SBP and contour plot for an object (N79) we re-classify as dS0. Trying a single Sérsic fit to the whole useful profile leaves both positive and negative systematic residuals ("wave pattern," see [2]). The contour plot (right) clearly shows this galaxy's isophote twisting.

The dI/dE class, in turn, includes a few objects with LSB outer spiral arms [7].

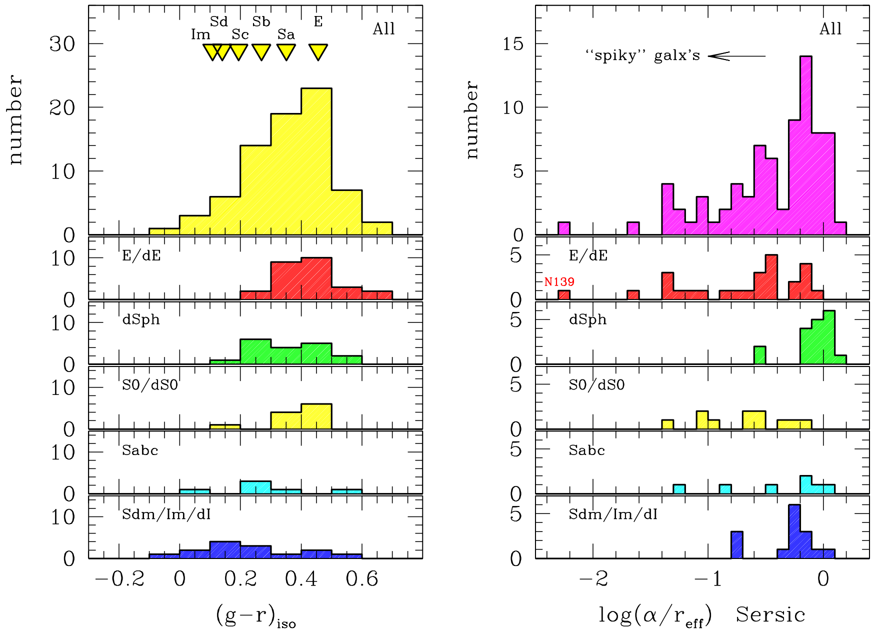


Fig. 2. *Left* - Galaxy colour distribution for the whole sample (top) and for each morphological type. The integrated $(g-r)$ colour refers to g and r galaxy luminosity collected within a $\mu(g) = 27$ mag arcsec^{-2} isophotal aperture. The 15 Gyr template galaxy models from [3, 4] are compared for reference (top triangle markers, as labeled in the upper panel). *Right* - Same as left for the "compactness" parameter $\log(\alpha/r_{\rm eff})$, defined as the ratio between Sérsic pseudo scale-length and galaxy effective radius; compactness increases from right to left. Note the outstanding case of galaxy N139, likely a background cD at $z \sim 0.4$.

3 Photometric properties

The galaxy colours in our sample show the usual trend with morphological type, with later types having bluer mean colours (Fig. 2, left). The blueing from dE's to dSph's, in turn, is most probably due to a luminosity–metallicity relation. Dwarf spheroidals display a flat and mildly broad distribution, due in part to photometric errors (worse for these faint objects), but probably also reflecting an intrinsic scatter in their origins and star formation histories, as is known for their Local Group counterparts (see e.g. [11]). Also the latest types have a broad color distribution, although in this case the cause may be internal reddening.

Structural differences between morphological types may be tested by means of a compactness parameter defined as $\alpha/r_{\rm eff}$, where α is the pseudo scale-length in Sérsic's formula, and $r_{\rm eff}$ is the effective radius. Fig. 2 (right) shows the distributions of $\log(\alpha/r_{\rm eff})$ for each morphological type. The dSph

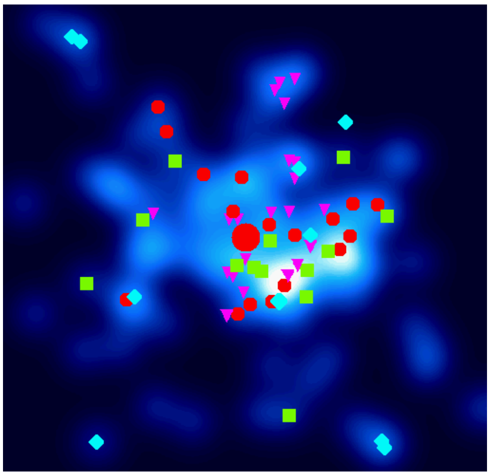
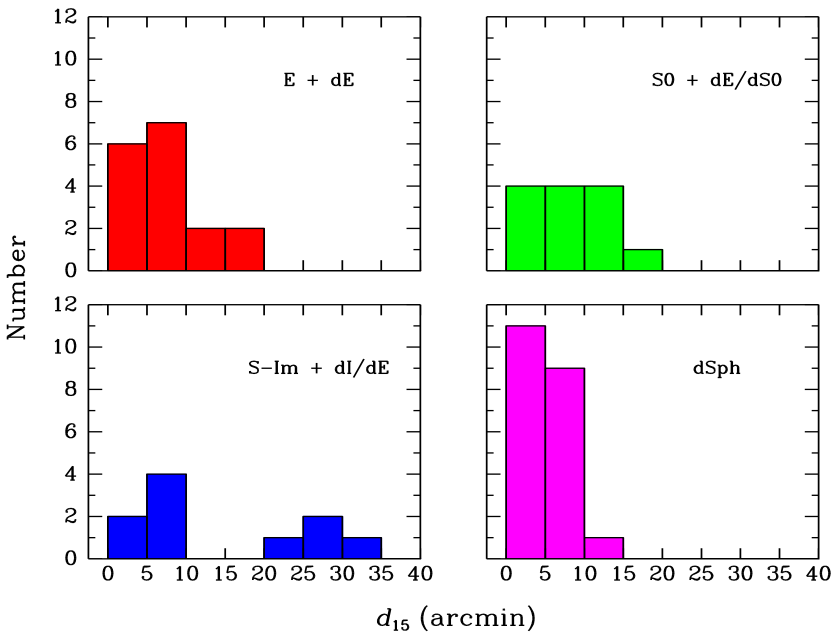


Fig. 3. *Left panel* - Projected number-density map, considering only definite and likely member galaxies from [9]. Superposed is the galaxy distribution from our sample: E+dE (circles); S0+dE/dS0 (squares); S–Im+dI/dE (diamonds); dSph (triangles). The big central dot is NGC 5044. *Lower panels* - Galaxy distribution for different morphological types against distance to the nearest bright ($B_{\rm T}$ < 15 mag) galaxy. Note the striking spatial segregation of dwarf spheroidals, preferentially located around bright group members.



galaxy class is characterized by a shallow SBP, clearly distinct from the dE one (but see [7] for possible selection effects). Among the latter, N139 (the most compact object labelled on Fig. 2) stands out for its extremely "spiky" SBP; our photometric redshift estimate locates this (likely cD) galaxy in the far background at $z \simeq 0.4$.

4 Projected spatial distribution

There is evidence for a morphology – density relation within the NGC 5044 Group, as shown in Fig. 2. While the S0+dE/dS0 galaxies are intermediate between E+dE (more concentrated) and late-type objects (less concentrated), dSph's seem to prefer the highest density regions in the Group. Differences between galaxy types become marginally more significant when the distance to the nearest bright ($B_{\mathrm{T}} < 15$ mag) neighbour is considered instead of local number density (see lower panels in Fig. 2). In fact, dSph's are only found in the (projected) vicinity of brighter member galaxies.

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