VLT Observations of Dwarf Elliptical Galaxies in the Virgo Galaxy Cluster

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1 Dwarf Elliptical Galaxies

Previous surveys of clusters of galaxies have shown that dwarf ellipticals are the most numerous species of galaxies in dense regions, reinforcing the well known morphology-density relation for galaxies. Dwarf ellipticals are believed to be old, to contain no gas and to have almost no inner structure except - in most cases - a central nucleus (dEN). In general dE's are of low luminosity and they can be distinguished from late-type galaxies by their smooth surface brightness profiles (see also Ferguson and Binggeli 1994).

2 Sample and Strategy

We are carrying out a detailed photometric analysis of a sample of 22 dwarf ellipticals (mostly nucleated), which were observed in B and R in two runs at the VLT with the FORS1 multi-mode instrument with a seeing of $0.7''$. The exposure times were $400s$ in B and $3 \times 400s$ in R.

We derive mean surface brightness profiles in B and R and fit Sérsic laws to them (Sérsic 1968). Applying an ellipse-fit procedure within MIDAS we determine ellipticities and position angles. A subsequent Fourier analysis of the departures of the ellipses from the isophotes yields the isophotal shape parameter a_4 (Bender and Möllenhoff 1987). A first overview shows that in most cases the brightness profiles are not so well fitted by a Sérsic law as usually thought. The dwarf ellipticals and dS0's therefore seem to be more structured than previously believed (see Fig. 1 left panel, as an example).

The extremly good quality of the images allows us to determine for the first time accurate colour gradients $(B-R)$, which might provide a key to further classify these dwarfs. In fact, dwarf ellipticals show a colour gradient throughout the whole galaxy, the outer parts being redder than the inner regions, whereas disk galaxies (dS0) show a constant colour in the inner parts and get slightly bluer outwards. Such differences in the colour gradients indicate differences in the formation and evolution of these galaxies (see Fig. 1 right panel, as an example).

As in a former study (Binggeli et al. 2000) we measure the off-sets of the nuclei from the centers of the brightness distributions, providing an observational test of theoretical work suggesting such

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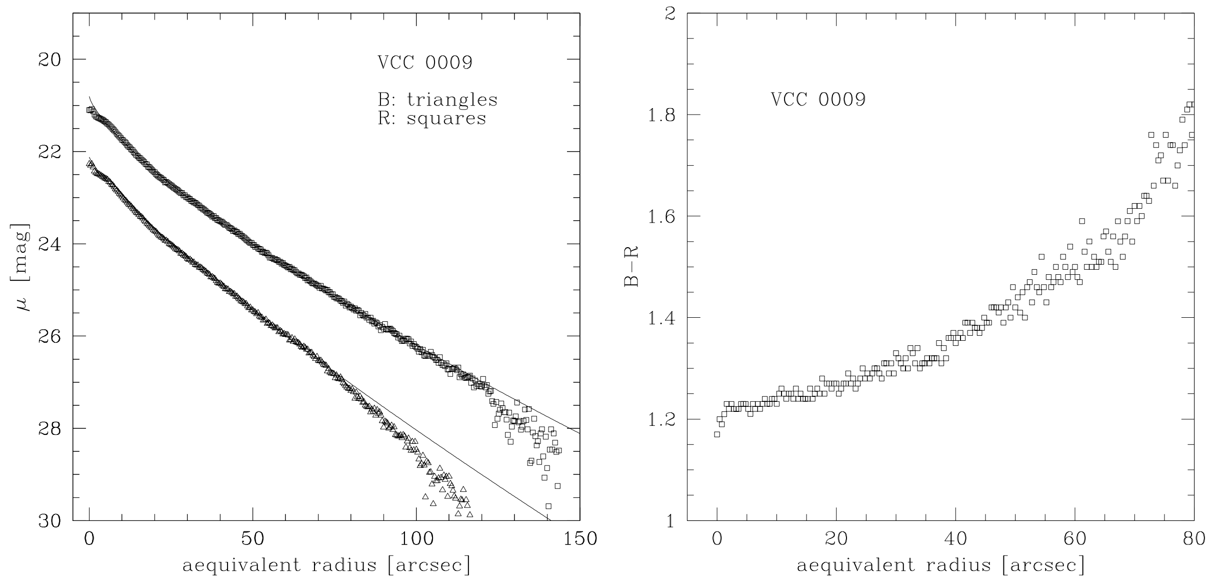

Figure 1: left: surface brightness profile of VCC0009 and best-fitting Sersic profile (B: triangles, R: squares); right: $B - R$ color gradient of VCC0009.

displacements. In these scenarios the nuclei orbit around the mass centroid. These orbital motions appear to be overstable in numerical experiments and therefore one would expect to observe the nuclei to be at a certain distance from the center of the nearby isophotes (Miller et al. 1992). In addition, gas or even dust in the central regions should show flow patterns with possible shocks. An other idea was recently proposed by Oh and Lin (2000). In their framework the nuclei are formed through the merger of several globular clusters. They suggest that the nucleus might be slightly off center 1 Gyr after the last merger event. In any case, properties like colour, luminosity and off-center position of nuclei might explain how these objects were formed.

In particular, we are also looking for hidden spiral structures. This is done by deriving a map of the galaxy in which the intensity of each pixel is a measure for the change of the surface brightness at this position. In fact, such a map can be regarded as the derivative of the intensity in the direction to the galaxy center, where a slight change in the surface brightness gradient, not cognizable on the optical frame, clearly shows up. Preliminary analyses show that our sample contains at least three galaxies showing clear evidence of a spiral structure which previously have been classified as dS0 or even dE.

3 Spiral structure in VCC490

The galaxy VCC 490 (IC 783) is classified as dS0. Its disk character is already evident on photographic plates and by analysing its averaged surface brightness profile. A map of the surface brightness gradient with respect to the galaxy center, shown in Fig. 2 (right panel), reveals its true character. Fig. 2, left panel, shows the R-band frame of the galaxy.

There is clear evidence of spiral arms and, less certain, of a bar. The green regions of the map indicate a steep colour gradient whereas in the blue regions the colour gradient is shallow. The two

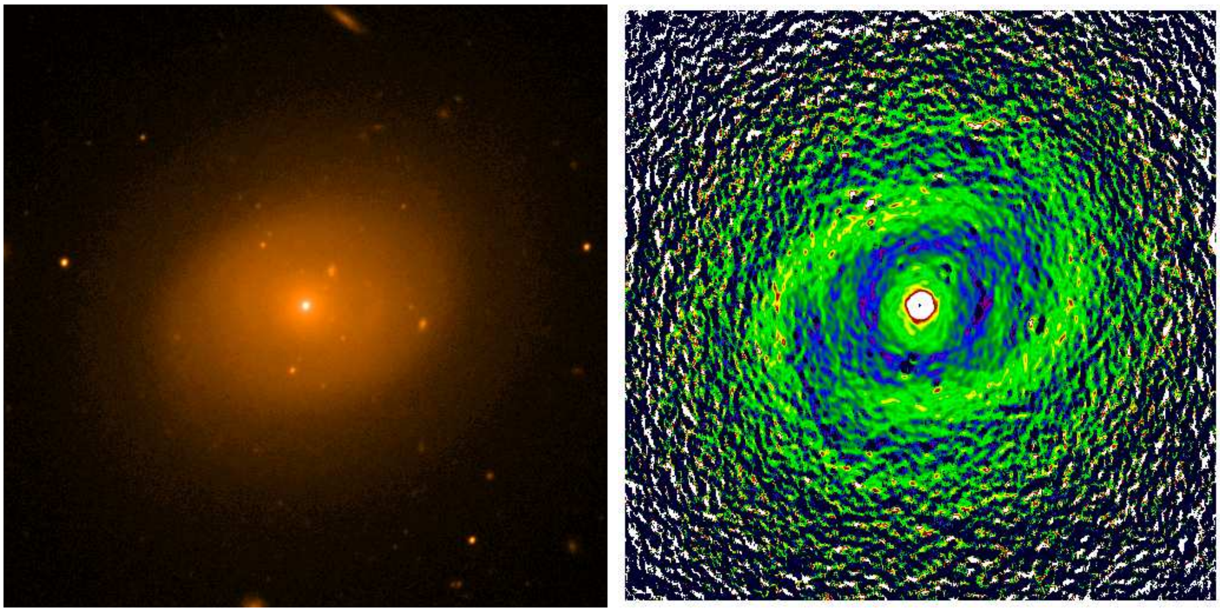

Figure 2: left: R-band image of VCC490. The disk character of the galaxy is evident, but the spiral structure can only be suspected. right: map of the surface brightness gradient with respect to the center for VCC490. The green colour indicates steep brightness gradient, the blue colour indicates shallow brightness gradient. Size of both frames: $1.7' \times 1.7'$.

spiral arms (in green) could be connected to a bar; the evidence of such a structure is very weak, though the central green region is slightly streched in the "correct" direction. After the discovery of a spiral structure in VCC 856 (IC 3328) (Jerjen et al. 2000), this is the second detection of this kind.

It is not surprising that both galaxies are not in the most dense regions of the cluster near M87. VCC 856 is located in a rather underdense part of the cluster, southeast of M87 and VCC 490 belongs to a subgroup, dominated by M100, which is belived to be infalling into the cluster. The two galaxies therefore are no exeption to the morphology-density relation but may rather constitute a new class of dwarf galaxies.

The data described seem to provide the means to examine with high accuracy the global but also some inner structure and properties of the observed dwarf galaxies. These insights could make it possible to further subdivide the classes of dwarf ellipticals and dwarf S0's and consequently constrain the evolutionary tracks of these galaxies.

References

Bender, R., Möllenhoff, C., 1987, A&A 177,71
Binggeli, B., Barazza, F.D., Jerjen, H., 2000, A&A 359,447
Ferguson, H.C., Binggeli, B., 1994, A&ARv 6,67
Jerjen, H., Kalnajs, A., Binggeli, B., 2000, A&A 358,845
Miller, R.H., Smith, B.F., 1992, ApJ 393,508
Oh, K.S., Lin, D.N.C., 2000, AJ 543,620
Sérsic, J.-L., 1968, Atlas de galaxias australes, Observatorio Astronomico, Cordoba