Kinematics of diffuse elliptical galaxies

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Abstract. New observations show that most of the flattened diffuse elliptical (dE) galaxies are essentially isotropic rotators. This supports the idea that dEs have evolved from fast rotating dIrr systems or late-type spirals after their gas was expelled by SN-driven winds and stripped by ram pressure against the intergalactic medium.

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1. Observational material

We have published kinematical observations of 20 dEs in Simien & Prugniel (2002). They were obtained at the CARELEC long-slit spectrograph attached to the 2-m telescope of the Observatoire de Haute-Provence. Figure 1 presents two typical velocity profiles: those of NGC 205 (extending out to 5 arcmin), and IC 3328, a Virgo-Cluster dE.

The kinematical profiles, extending beyond one effective radius, reveal significant rotation in all our candidate objects. A similar result is presented in Pedraz et al. (2002).

From these and other sources, we have selected 14 galaxies with reliable kinematical measurements. We did not include four of the faint Virgo dwarfs observed by Geha et al. (2002), where no rotation was detected, because the profiles extend to only a fraction of the effective radius; experience from past observations reveals that extrapolations of central profiles is hazardous.

2. Discussion of the kinematical data

For more than 10 years, dE galaxies were though to be flattened by anisotropy (Bender & Nieto, 1990). Because new observations extend farther out, more rotation can be detected.

Since dEs feature roughly exponential photometric profiles, we cannot apply directly the $V/\sigma$ anisotropy test (Binney, 1978), which is adapted to the case of $r^{1/4}$ profiles. We thus developed a simple isotropic dynamical model as in Loyer et al. (1998), but for a $r^{1/n}$ profile (Sérsic, 1968). Letting $a$ be the semi-major axis of an isophote (with $a_0$ corresponding to the effective isophote), Figure 2 presents typical normalized...
rotation curves for $n = 1$ and $n = 4$. The model shows that the maximum rotation is expected at $a \sim 2a_e$ for a dE ($n = 1$ or 2), compared to $a \sim 0.5a_e$ for an elliptical ($n = 4$). And for a dE, the expected $V(a_e)/\sigma_0$ ratio (where $\sigma_0$ is the peak central velocity dispersion) is $10\sim20\%$ larger than for a normal E.

Figure 3 shows the kinematic test for our data supplemented by other sources. Most galaxies are compatible with being rotationally supported. The two flattest objects, IC 3393 and IC 3773, bear large error bars but do not seem incompatible with isotropy. Other interesting cases are NGC 205 and IC 794. Despite the significant rotation we have found, the former is unlikely to be isotropic; and the latter is certainly anisotropic.

3. The origin of dE galaxies

Several similarities do exist between E and dE galaxies: a) there is a continuum in the surface brightness versus luminosity diagram (Prugniel, 1994), b) there is a transition in the shape of the photometric profile and, c) on taking into account the difference in stellar populations (Prugniel & Simien, 1996), the dE galaxies lie on the Fundamental
Plane of ellipticals. These characteristics, however, reflect equilibrium relations and do not necessarily imply a common origin. Conversely, the difference in clustering properties of the two classes is a clue for different origins.

The new kinematical observations imply that the dE progenitors are probably rotating dIrr systems and low-mass, late-type spirals. As in the Dekel et al. (1986) scenario, the intrinsic low-mass of the progenitors may result in an important mass loss due to the SN-driven winds, and this may explains their low metallicity. In addition, the ram pressure against the hot intergalactic medium strips off the residual neutral gas. Dynamical harassment from encounters with massive galaxies, which predicts anisotropic objects (Moore et al., 1998), does not appear to represent a key factor for these dEs, but ram pressure stripping of the gas may have helped to stop the star formation.

A few interesting objects deserve additional comments. NGC 205 may own its anisotropy to its interaction with M 31 (Mayer et al., 2001). But we note that the relevance of the diagnostic may be questioned, since the observed kinematics fail to fit the isotropic model with a constant $M/L$ ratio. IC 794 is particularly interesting. As noted by Pedraz et al. (2002), it is strongly anisotropic, young, and metal rich. These characteristics make it a good candidate for being a tidal dwarf issued from enriched material after a major collision involving a spiral. We have no information on the stellar content of IC 3344, the other anisotropic object of Geha et al., which may be similar to IC 794 (both lie in center of the Virgo cluster).

The other galaxies where Geha et al. did not detect rotation are fainter; they may have been more sensitive to environment and predisposed to anisotropy. But observations extending to larger radii are needed to conclude.
Figure 3. The $V/\sigma$ kinematic test for a sample of dE galaxies.

References

Bender, R., Nieto, J.-L.: 1990, A&A, 239, 97-112
Binney, J.: 1978, MNRAS, 183, 501-514
Dekel, A., Silk, J.: 1986, ApJ, 303, 39-55
de Rijcke, S., Dejonghe, H., Zeilinger, W. W., Hau, G. K. T.: 2001, ApJ, 559, L21-L24
Geha, M., Guhathakurta, P., van der Marel, R.: 2002, preprint, astro/ph 0206153
Loyer, E., Simien, F., Michael, R., Prugniel, Ph.: 1998, A&A, 334, 805-813
Mayer, L., Governato, F., Colpi, M., Moore, B., Quinn, T., Wadsley, J., Stadel, J.,
Lake, G.: 2001, ApJ, 559, 754-784
Moore, B., Lake, G., Katz, N.: 1998, ApJ, 495, 139-151
Pedraz, S., Gorgas, J., Cardiel, N., Sánchez-Blázquez, P., Guzmán, R.: 2002,
MNRAS, 332, L59-L63
Prugniel, Ph.: 1994, in G. Meylan and Ph. Prugniel, editors, Proceedings of an
ESO/OHP Workshop on Dwarf galaxies. ESO, Garching, p. 171
Prugniel, Ph., Simien, F.: 1996, A&A, 309, 749-759
Sérsic, J. L.: 1968, Atlas de Galaxias Australes, Observatorio de Córdoba
Simien, F., Prugniel, P.: 2002, A&A, 384, 371-382