Highlights of Astronomy, Volume 15
XXVIIth IAU General Assembly, August 2009
Ian F. Corbett, ed.

doi:10.1017/S1743921310008203

Dark Matter and Elliptical Galaxy Dynamics

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The halos of elliptical galaxies, through their orbit and angular momentum distribution, contain important information about the formation and evolution of these systems.

There have been several recent advances in obtaining stellar kinematics at faint surface brightness levels. Planetary nebulae have been shown to trace stellar kinematics, and the velocity fields obtained with them point to more frequent kinematic misalignments and more complicated angular momentum properties in the outer halos than indicated by kinematics within the effective radius R_e (Coccato *et al.* 2009). In M87, the outer edge of the stellar halo and the transition to the unbound intracluster light has been reached at 150 kpc, where the halo velocity dispersion is below 100 km/s (Doherty *et al.* 2009). New techniques based on slitlets (Proctor *et al.* 2009) and on combining IFU data (Weijmans *et al.* 2009) have pushed the limits of absorption line spectroscopy to 3–4 R_e.

Made-to-measure adaptive particle modeling techniques have become competitive with the familiar Schwarzschild method (De Lorenzi *et al.* 2007), and first modeling results have been obtained for two intermediate luminosity ellipticals, NGC 3379 and NGC 4697 (De Lorenzi *et al.* 2008, 2009). The results show a strong mass-anisotropy-shape degeneracy in these systems with falling velocity dispersion profiles. As a consequence, these galaxies need not be devoid of dark matter, as has sometimes been suggested, but may simply be part of the lower concentration population of halos within the scatter predicted by dark matter simulations. If so, their orbit structure must be strongly radially anisotropic, which is not unexpected (Dekel *et al.* 2005).

The circular velocity curves of especially high-mass ellipticals are approximately flat within $2R_e$, but the recent study by Thomas *et al.* (2007) has shown some variety. Within R_e ∼10–40% of the matter is dark, within $5R_e$ dark matter contributes ∼50–80% of the mass. Thomas *et al.* (2009) have dynamically measured dark matter mean densities (DMMD) within the central $2R_e$ for a sample of Coma cluster ellipticals, and have related these to the assembly redshifts of ellipticals relative to those of spirals (updating Gerhard *et al.* 2001). They find the highest DMMDs in lower-luminosity ellipticals, that at the same luminosity (baryonic mass), the DMMD's of ellipticals are ~ 7 (~ 13) times higher than those of spirals, pointing to an assembly redshift $z = 2$–3.

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