Isolated Ellipticals and ΛCDM

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Introduction: Isolated elliptical galaxies (IEs) should have little, if any, local material, and, therefore, evolution should have stopped. Yet many IEs have extant tidally disrupting dwarf companions (Lane et al. 2013). And even if no merger remnants are visible, IEs are often dynamically young (Lane et al. 2014). Furthermore, not all IEs require dark matter to explain their dynamics. NGC 7507, for example, does not require any dark matter to explain it's dynamics out to $\sim 1 R_e$ (Salinas et al. 2012). However, all elliptical galaxies should be dark matter dominated, even if isolated, according to ΛCDM simulations, and IEs are much rarer in nature than predicted by ΛCDM (e.g. Niemi et al. 2010). Moreover, merging at the $\sim 10^7$ $M_\odot$ level was recently discovered in the M31 system (Amorisco et al. 2014), showing that hierarchical merging may indeed be scale-free, as predicted by ΛCDM.

So what craziness is going on here?? Keep reading to find out more!

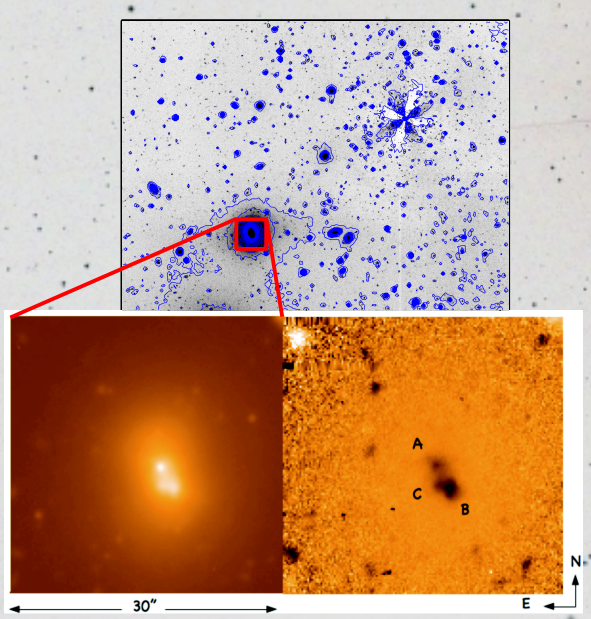

FIG 2: NGC 7796 – *B* and *V* band imaging, with NGC 7796 subtracted, showing the dwarf companion's extended tidal tails *(top panel)* and three cores *(lower panels)*. The lower right panel shows a *(B-V)* colour map of the three cores with black indicating bluer colours and white indicating redder colours. The three cores are all much bluer than the dwarf companion itself, and are probably merging/interacting star clusters. This means we are seeing hierarchical merging at two different mass scales in the same IE system.

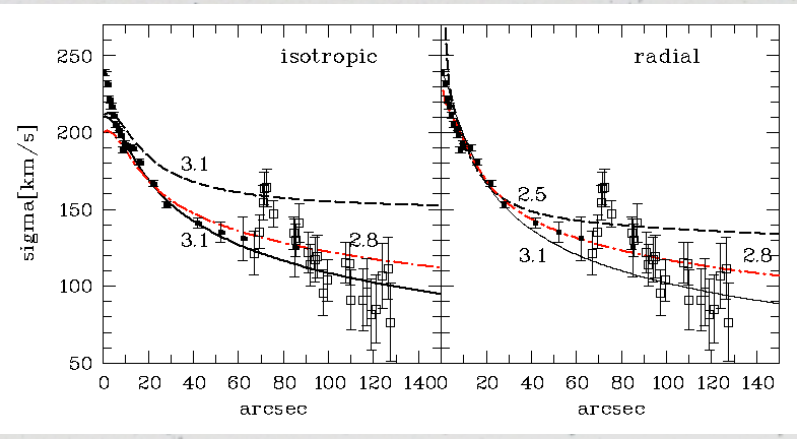

FIG 1: NGC 7507 – Velocity dispersion versus galactocentric radius. Filled squares are from GMOS longslit spectra (Salinas et al. 2012), open squares are from GMOS slitmask spectra (Lane et al., 2014). The assumed M/L ratios are shown next to the models. Black dashed = model with MONDian circular velocities at all radii, red dot-dashed = NFW halo, solid black = dark matter free. *Left panel:* Isotropic models. *Right panel:* anisotropic models. Note that the only model that fits the data at all radii is the dark matter free anisotropic model.

Results: Using GMOS longslit and slitmask spectra we have measured the velocity dispersion profile of NGC 7507 using the pPXF code by Capellari (2004). We fit MONDian (Milgrom 1983), NFW (Navarro et al. 1997) and dark matter free models, both isotropic and anisotropic (Fig.1). The only model that fits the velocity dispersion at all radii is our anisotropic, dark matter free, model. Furthermore, the peak at ~70" ($\sim 1.5 R_e$) is likely an extant dynamical merger remnant, possibly caused by a major spiral-spiral merger (Schauer et al. 2014).

Deep *B* and *V* band imaging of NGC 7796 (Fig.2) reveals a tidally disrupting companion with three cores (Richtler et al. 2014). Since it is possible to produce dwarf galaxy-like objects with merging star clusters (Assmann et al. 2013a,b), it appears that we have captured, for the first time, hierarchical merging at two different mass scales in the same system! Could hierarchical merging truly be scale-free as ΛCDM predicts?

Conclusions: IEs are weird. They are not as common as ΛCDM simulations predict and some may be dark matter free, putting them at odds with current ΛCDM theories. However, it also appears that we have uncovered the first evidence for hierarchical merging at two mass scales in the same system, indicating that ΛCDM predictions of scale-free merging may indeed be realistic. IEs can also be dynamically young, and often have interacting dwarf companions, despite living in isolation. Could all IEs simply be fossil groups? X-rays may help.

Refs: Amorisco et al., 2014, Natur, 507, 335; Assmann et al., 2013, MNRAS, 432, .274(a) – MNRAS, 435, 2391(b); Cappellari & Emsellem, 2004, PASP, 116, 138; Lane et al., 2013, A&A, 549, 148; Lane et al., 2014 *(submitted)*; Milgrom, 1983, ApJ, 270, 365; Navarro et al., 1997, ApJ, 490, 493; Niemi et al., 2010, MNRAS, 405, 477; Richtler et al., 2014 *(submitted)*; Salinas et al., 2012, A&A., 538, 87; Schauer et al., 2014, ApJ, 783L, 32