Dense, Low-Mass Galaxy Groups: A Phase-Space Conundrum

MSE White Paper

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Over cosmic time galaxies evolve from young, blue disks to old, red spheroids. The density of their environment plays a major role (Dressler et al., 1980, ApJ, 236, 351), hence studies have so far focussed on galaxy clusters. However, the large membership of clusters results in the simultaneous action of various physical processes, therefore hindering the identification of those mechanisms that dominate galaxy evolution. Furthermore, populous clusters represent just 2% of the stellar mass in the present-day universe (Eke et al., 2005, MNRAS, 362, 1233), with looser groupings dominating in local redshift surveys (e.g., Small et al., 1999, 1999, ApJ, 524, 31).

Enter compact galaxy groups (CGs). With similar densities as clusters but few members they enable an intimate understanding of every galaxy and the physical processes at play. Three traits set CGs aside as a class: first, their low velocity dispersions compared to more populous groupings (Tully et al., 1987, ApJ, 321, 280); second is their deficiency in neutral hydrogen gas when compared to control samples of isolated galaxies (Verdes-Montenegro et al., 2001, A&A, 377, 812); and third, their bimodal distribution of infrared colours (Walker et al., 2012, AJ, 143, 69) neatly separates star-forming and quiescent systems (Tzanavaris et al., 2010, ApJ, 716, 556), contrary to the continuum observed elsewhere.

With short gas depletion timescales, many CGs are expected to give rise to dry, i.e., gas-poor galaxy mergers, and hence the evolutionary endpoints that are slow rotators—galaxies whose disorderly stellar orbits (low specific angular momentum) indicate a multiple-merger history. The greater hierarchy around CGs suggests they are well placed to be the progenitors of such galaxies: through theoretical considerations and statistical studies, McConnachie et al. (2008, MNRAS, 387, 1281) and Mendel et al. (2011, MNRAS, 418, 1409) established that roughly half of all CGs are isolated and other half embedded in larger groupings, often clusters. This places them in pole position to deliver evolved galaxies to their parent groups, having processed them within their intra-group medium, or through interactions. This is supported by our recent discovery of slow-rotators forming in cluster over-densities, that is, CGs embedded in clusters (Fogarty et al. 2014, MNRAS 443, 485).

The reach of MSE to faint objects, along with its vast multiplexing factor, makes it ideal for characterising the dynamics of galaxy groups. We do not yet understand precisely what it is that makes CGs special (mostly studied through the sample defined by Hickson, 1982; 1992); but group dynamics are our prime suspect. The main obstacle is that we do not understand the dwarf galaxy contingent of these systems, which is revealing of the dynamical state (Virial vs unbound; see Konstantopoulos et al., 2013, ApJ, 770, 114), since it is difficult to reach with current multi-fibre facilities.

This project would have MSE probe hundreds of CGs, preselected from GAMA (Driver et al, 2011, MNRAS, 413, 971), SDSS (York et al., 2000, AJ, 120, 1579), and other surveys, all the way to the turn-off of the dwarf luminosity function: at $M_V = -15$mag the LF is expected to either plateau (Hunsberger et al., 1998, ApJ, 505, 536), or possibly increase for Sd/Irr dwarfs (Driver et al., 2003, 2003, AJ, 126, 2662).