Searching for Intragroup Light in Multiple Galaxy Groups

John J. Feldmeier (YSU), Shane Downing (YSU), Chris Mihos(CWRU), Paul Harding(CWRU), Heather Morrison (CWRU)

We present an update on our deep imaging survey intended to search for intragroup stars in both conventional and compact galaxy groups. We find evidence for extensive intragroup light and tidal debris in our compact group sub-sample, as expected, but only small amounts of intragroup light thus far in conventional groups. We confirm the detection of star-forming clumps within the Leo I ring, and show signs of galaxy interaction in that group.

Introduction

Intracluster light (ICL), coming from stars between the galaxies, has been found to be common in galaxy clusters (Feldmeier et al. 2004; Mihos et al. 2005; see Arnaboldi et al. 2009 for a recent review). However, the amount of **intragroup light** (**IGL**) is much less well known. Theoretical studies (Fig.1; Purcell et al. 2007) indicate a systematic rise in IGL fraction as systems increase in mass from individual galaxies, through galaxy groups up to galaxy clusters. Unfortunately, thus far observations of IGL in normal galaxy groups have been unsuccessful. The amount of IGL found in compact groups of galaxies, where the extreme galaxy density promotes many tidal interactions, is much larger, but there is considerable scatter in the observations thus far, from observational uncertainties, but possibly from differing group assembly histories (Fig 2).

We are quantifying the amount of IGL in both normal and compact galaxy groups. Using the techniques of ultra-low surface brightness imaging that we have developed for galaxy clusters, we are able to measure the amount and spatial distribution of the IGL, and search for any tidal debris present in these systems.

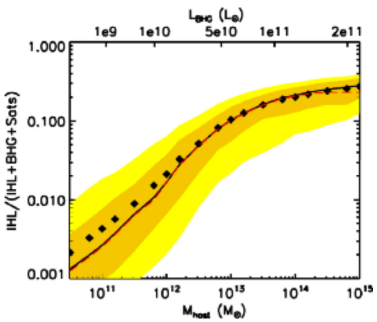

Fig. 1 – Results from Purcell et al. (2007) showing the amount of diffuse light expected from objects varying in mass from individual galaxies to rich galaxy clusters. There is a systematic increase in IGL fraction as a function of host mass.

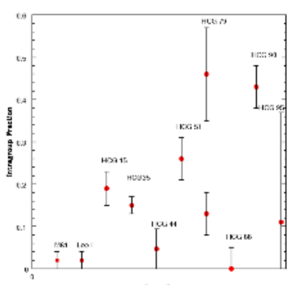

Fig. 2 – A summary of observed IGL fractions to date. Squares denote normal galaxy groups, and circles denote compact groups. Data is taken from Nishiura et al. (2000), Feldmeier et al. (2003), Castro-Rodriguez et al. (2003), Durrell et al. (2003), White et al. (2003), Aguerri et al. (2006), and Da Rocha et al. (2005, 2008)

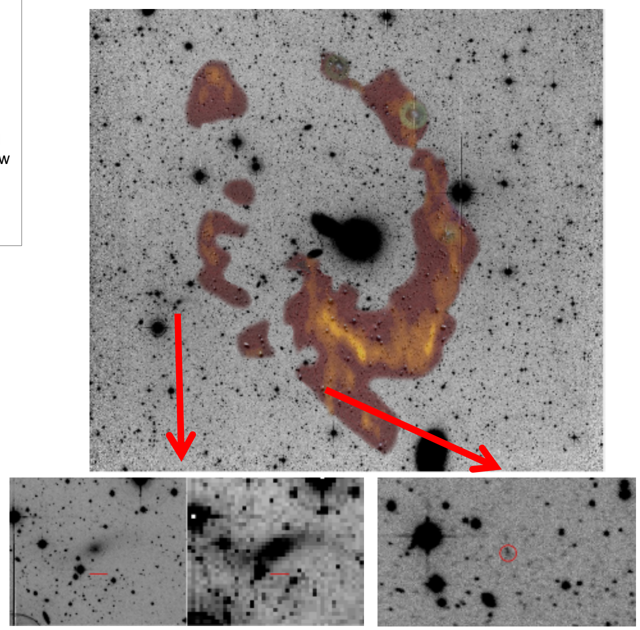

Fig. 3 – **Top** Preliminary images of the central region of the Leo I galaxy group. The well-known HI ring (Schneider 1989; Michel-Dansac et al. 2010) is overlaid for reference. **Bottom Left –** raw and median-smoothed images of the dwarf spheroid KK98-96 in Leo I. The red line denotes a scale bar of 1' .The galaxy is tidally distorted. **Bottom Right –** The area around HI clump 2E, which was found by Thilker et. al. (2009) to be actively star-forming. In our survey, this source can be easily detected, despite its low surface brightness (μ ~ 25.6). The radius of the circle is 10"

Sample and Analysis

Our goal is to construct a representative sample of both types of galaxy groups, so that relative and absolute comparisons of IGL properties can be made.

We have used the KPNO 2.1m telescope for our imaging of compact groups, and the CWRU 0.6m Burrell Schmidt telescope for observing conventional galaxy groups. We have a total of six compact groups, and four conventional galaxy groups observed thus far, including the Leo I group that is known to have an extensive HI ring

The techniques of low-surface brightness imaging are now well understood for these telescopes (Morrison, Boroson & Harding 1994; Feldmeier et al. 2002, 2004; Mihos et al. 2005), and include: 1) baffling the telescope and detector, 2) constructing high-quality dark sky flats, and 3) constructing careful error models, including all sources of noise, both random and systematic. The limiting surface brightness of our observations depends on the large-scale flat-fielding error, which typically reaches 0.1% or better.

A key restriction is to avoid galaxy groups that are near bright foreground stars. As has been known for decades (King 1971), the scattered light profile of luminous stars extends for degrees and can create a significant systematic error in sky subtraction. Likewise, we avoid groups that have large amounts of Galactic cirrus in the field, as these cause reflection nebulae at the low surface brightness limits we are probing.

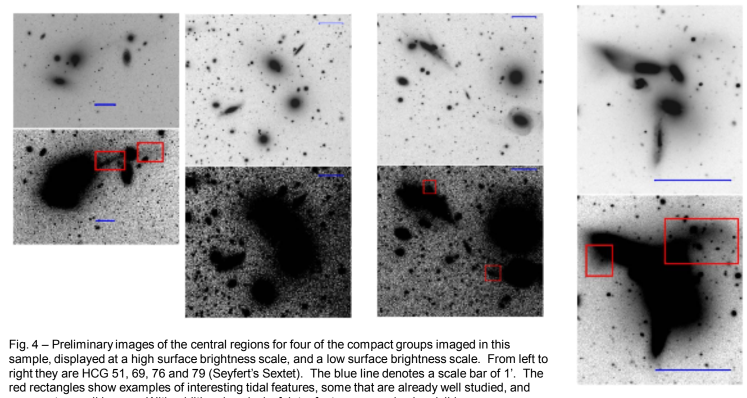

Fig. 4 – Preliminary images of the central regions for four of the compact groups imaged in this sample, displayed at a high surface brightness scale, and a low surface brightness scale. From left to right they are HCG 51, 69, 76 and 79 (Seyfert's Sextet). The blue line denotes a scale bar of 1'. The red rectangles show examples of interesting tidal features, some that are already well studied, and some not as well known. With additional analysis, fainter features may also be visible.

Preliminary Results

As would be expected, we see a large number of tidal features in our compact group sample (see Figure 4 for numerous examples). Given the extreme density of these systems, this should be expected. We also see signs of fainter tidal features that are less well known, and in some groups, see evidence for a fainter envelope surrounding the galaxies (most notably in Seyfert's Sextet; Palma et al. 2004; Durbala et al. 2008).

The amount of tidal debris in conventional galaxy groups is harder to detect, but there are signs of tidal disturbance in many galaxies (Figure 3), that should release stars to the intragroup medium. We also see the recently discovered star formation regions embedded within the HI clumps seen in the Leo I group (Figure 3; Thilker et al. 2009; Michel-Dansac et al. 2010)

Determining the exact amount of IGL in both normal and compact groups is substantially more difficult:. In the case of compact groups, accurately defining the IGL will be major challenge. From our previous work, we have found that using observational definitions can be misleading if not corrected for properly. We plan to compare our results to numerical simulations (Rudick, Mihos & McBride 2006) to correct for projection effects. For conventional galaxy groups the limiting factors will be: 1) the amount of large-scale flat-fielding error, since the groups cover a large portion of sky, and 2) proper subtraction for foreground stars. Fortunately, the scattered light profile of the Burrell Schmidt is very well understood (Slater, Harding & Mihos 2009), and this subtraction will be straightforward.

Acknowledgements

We would like to thank the staff of KPNO and CWRU for observing support. This work was funded by a Cottrell College Science Award from Research Corporation (Grant 7732) and NSF grant 0807873.

Future Work

Once the data analysis is completed, we should be able to place a stringent limit on the amount of IGL in each group. The wide (1.5 degree field) of the Burrell Schmidt ensures that sky subtraction will not be an issue.

In addition to the IGL studies, we will also perform surface photometry on all of the galaxies in each group and we will search for dwarf galaxy candidates in our data. The number of dwarf galaxies in galaxy groups is still an unresolved problem for the models of hierarchical structure formation, and our data will not be as prone to selection effects due to low surface brightness.

References

Aguerri et al. 2006, A.& A., 457, 771

Arnaboldi et al. 2009, *Diffuse Light in Galaxy Clusters,* Joint Discussion 2, IAU General Assembly

Castro-Rodriguez et al. 2003, A.& A., 405, 803

Da Rocha et al. 2005, M.N.R.A.S, 364, 1069

Da Rocha et al. 2008, M.N.R.A.S, 388, 1433

Durbala et al. 2008, A.J., 135, 130

Durrell et al. 2003, B.A.A.S 35, 1287

Feldmeier et al. 2002, Ap. J., 575, 779

Feldmeier et al. 2003, IAUS, 209, 605

Feldmeier et al. 2004, Ap. J., 609, 617

King 1971, P.A.S.P., 83, 199

Michel-Dansac et al. 2010, Ap. J. L., 717, L143

Mihos et al. 2005, Ap. J. L., 631, 41

Morrison et al. 1994, A.J., 108, 1191

Nishiura et al. 2000, A.J., 120, 2355

Palma et al. 2002, AJ, 124, 2425

Purcell et al. 2007, Ap. J., 666, 20

Schneider, S. 1989, A. J., 97, 666

Slater, Harding, Mihos 2009, P.A.S.P 121, 1267

Thilker et al. 2009, Nature, 457, 990

White et al. 2003, Ap. J., 585, 739