Science Justification

The large scale structure of our local universe is dominated by voids and filamentary structures of groups and clusters of galaxies (e.g., Courtois et al. 2013). Half of the Local Volume galaxies reside in loose groups and associations, such as the Sculptor filament and the Canes Venatici Cloud (Karachentsev 2005). The nearest such structure is the NGC 3109 association (see Figure 1), an association of 5 dwarf galaxies in Leo, Sextans, and Antlia (van den Bergh 1999; Tully et al. 2006). This galaxy association, with a linear extent of 1.2 Mpc across the sky (Bellazzini et al. 2013), lies just at the edge of the Local Group at a distance of 1.3–1.7 Mpc. Pawlowski & McGaugh (2014) identified several possibilities for the origin of the NGC 3109 association: an infalling dark matter filament, a pre-existing group tidally stretched by an encounter with the MW, or galaxies formed as tidal dwarfs from a past Milky Way/M31 encounter. Constraining the number and properties of additional group members can help to discriminate between these possibilities. The search for additional group members also has implications for predictions from Local Volume simulations that at least a dozen more dwarf galaxies outside the virial radii of M31 and the Milky Way remain to be discovered (Garrison-Kimmel et al. 2014).

Recent discoveries of the newest member of the NGC 3109 association, Leo P (Giovanelli et al. 2013), and tidal substructure near the Antlia dwarf suggestive of an interaction with NGC 3109 (Penny et al. 2012) mean that the time is right for a search for additional members of the association. While the region is covered by existing and planned survey data, none are deep enough to detect faint galaxies and structures at this distance. The most well-known recent examples of nearby dwarf galaxy discovery are from the SDSS (e.g., Koposov et al. 2008). Despite lying within the SDSS footprint, Leo P was discovered as part of a blind H I survey; it is too faint to be well-detected at the SDSS depth ($g = 22.2$, $i = 21.3$), and using LBT imaging, McQuinn et al. (2013) measured the tip of its red giant branch to be at $i = 22.1$. A wide-field optical survey has the potential to detect additional faint members of the group as well as tidal debris from interactions between members.

The outcome of a search for additional members of the NGC 3109 association has implications for understanding galaxy evolution. A lack of additional tidal debris would constrain the timescales and progenitor galaxy masses involved in a tidal dwarf origin. A lack of additional bound-galaxy members of the group would constrain the mass of a possible dark-matter filament or progenitor halo. On the other hand, finding additional members of the group and subsequent follow-up would allow a better characterization of the group's spatial and kinematical extent; current studies suffer from small-number statistics. If additional group members lie close to the same plane as the existing members, this would tend to confirm Pawlowski & McGaugh's (2014) claim that the non-satellite galaxies to the north of the Milky Way are confined to a single plane. Identification of new members as potential 'backsplash galaxies' (Teyssier et al. 2012) or not could also test Pawlowski & McGaugh's claim that there is an 'overabundant backsplash galaxy' problem with ΛCDM. Additional group members would also allow better constraints on the group's luminosity function and subsequent comparison to CDM simulations of galaxy formation in low-density environments (as in Garrison-Kimmel et al. 2014). Using a Local Group formation simulation, Benítez-Llambay et al. (2013) suggested that gas removal through stripping by the 'cosmic web' of filaments and pancakes could explain the diversity of properties of local dwarf galaxies; identification of additional galaxies possibly associated with a filament could provide additional tests of this idea. Finally, the tidal-dwarf characterization of the group can be tested with follow-up spectroscopy in order to determine whether additional group members are dark-matter dominated.

We propose here to map the northern portion of the NGC 3109 filament with CFHT/MegaCam. Deeper imaging than the available SDSS data ($g = 22.2$, $i = 21.3$) is required in order to detect

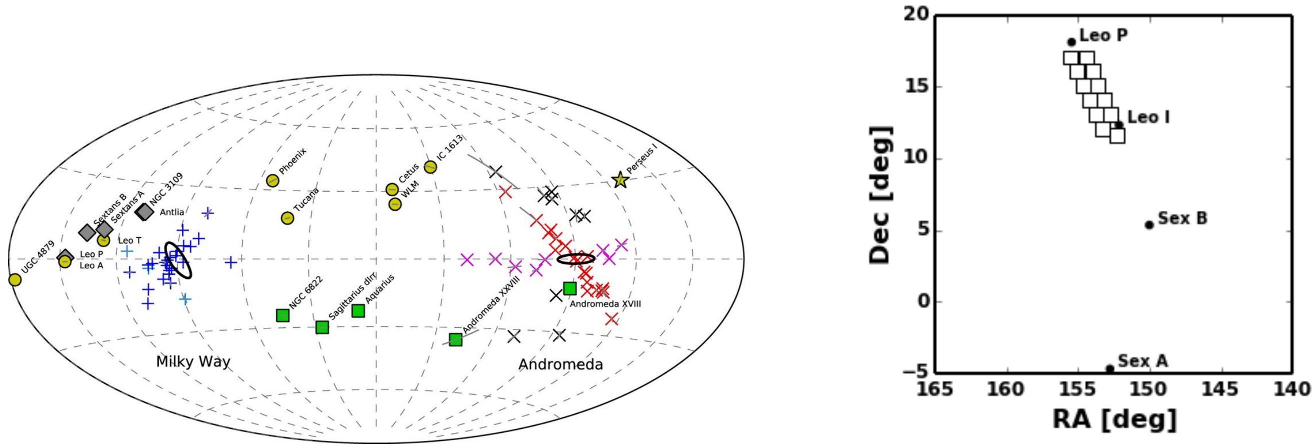

Figure 1: (Left) From Pawlowski & McGaugh (2014): Local Group galaxies on the sky as seen from a position half-way between M31 and the Milky Way. The NGC 3109 association members are shown as grey diamonds. (Right) Sky projection of the proposed observations. The boxes are 1-degree MegaCam fields; the black circles at the galaxy locations have 15-arcminute radii.

dwarf galaxies at distances beyond 1 Mpc. CFHT/MegaCam's ability to go both wide and deep is essential for such observations: the nearby nature of the filament means that it covers a large area of sky, yet the expected faint dwarf galaxies are resolved into individual stars. The area to be mapped, defined by the direction from Leo P to Sextans A/B, happens to pass quite close to the more nearby (240 kpc) Local Group dSph Leo I. Peñarrubia et al. (2009) predicted the location of a tidal break in this galaxy's surface brightness profile which is beyond the radius currently mapped (Sohn et al. 2007); the MegaCam imaging can be used to probe the outer reaches of Leo I and test this prediction, as well as searching for additional nearby low-surface-brightness features.

The goal of this proposal is to complete the substructure census and probe the faint end of the luminosity function in a portion of the nearest filamentary structure in the universe. Detected structures will be characterized in terms of structural properties and their association to the subgroup will be pursued via tip-of-the-red-giant-branch (TRGB; Lee et al. 1993) measurements and, where possible, spectroscopic measurements (e.g. with Gemini/GMOS). Multi-wavelength follow-up can be pursued with the ALFALFA Hi survey and other wide-area surveys. The key first step is identifying additional NGC 3109 group galaxies, for which MegaCam is ideally suited.

References

Bellazzini, M. et al. 2013, A&A 559, L11
Bellazzini, M. et al. 2014, A&A 566, 44
Benítez-Llambay, A. et al. 2013, ApJ, 763, L31
Chiboucas, K. et al. 2009, AJ, 137, 3009
Courtois, H.R. et al. 2013, AJ, 146, 69
Garrison-Kimmel, S. et al. 2014, MNRAS, 444, 222
Giovanelli, R. et al. 2013, AJ, 146, 15
Karachentsev, I. 2005, AJ, 129, 178
Koposov, S. et al. 2008, ApJ, 686, 279
Lee, M.G. et al. 1993, ApJ, 417, 993
McQuinn, K.B.W. et al. 2013, AJ, 146, 145
Pawlowski, M.S. et al. 2014, MNRAS, 440, 908
Peñarrubia, J. et al. 2009, ApJ, 298, 222
Penny, S.J. et al. 2012, ApJ, 758, L32
Sohn, S.T. et al. 2007, ApJ, 663, 960
Teyssier, M. et al. 2012, MNRAS, 426, 1808
Tully, R.B. et al. 2006, AJ, 132, 729
van den Bergh, S. 1999, ApJ, 517, L97