Science Justification

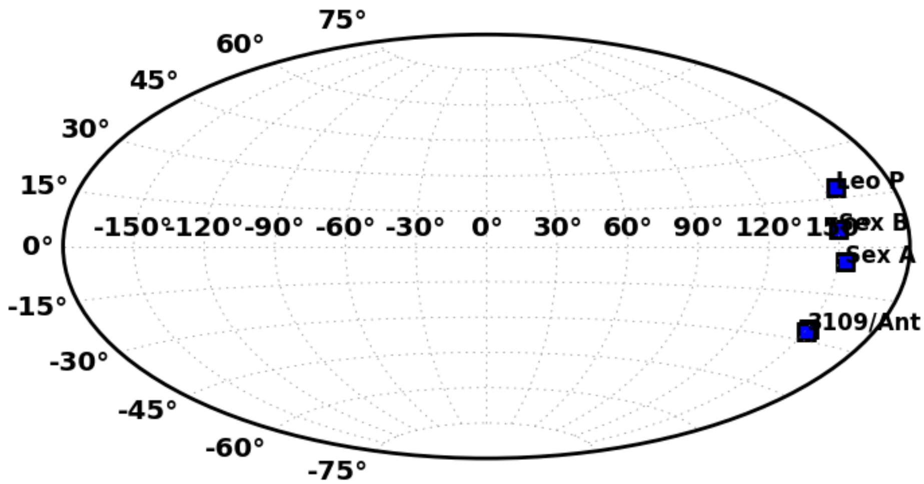
The large scale structure of our local universe is dominated by voids and filamentary structures of groups and clusters of galaxies (e.g., Courtois et al. 2013). Half of the Local Volume galaxies reside in loose groups and associations, such as the Sculptor filament and the Canes Venatici Cloud (Karachenstev 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. It is presumably on its first infall towards the Local Group, thus having still retained its filamentary structure.

The newest member of the NGC 3109 association, Leo P, was recently discovered as part of a blind H I survey; it has an H I mass of 10^6 solar masses and a stellar mass about 3×10^5 $M_\odot$, and is extremely metal-poor (Giovanelli et al. 2013). This suggests to us that additional faint members of the group may await discovery. Tidal debris from interactions between group members may also be located along the filament; indeed tidal substructure near the Antlia dwarf suggestive of an interaction with NGC 3109 was recently discovered by Penny et al. (2012). Completing the substructure census and probing the faintest end of the luminosity function in the nearest filamentary structure are the goals of this proposal. Detected low-surface brightness structures will be characterized in terms of structural properties and their association to the sub-group will be pursued via follow-up tip-of-the-red-giant-branch (TRGB; Lee et al. 1993) measurements. Filamentary structures are considered to be in an earlier stage of their evolution, thus a complete characterization of the interacting environment of the NGC 3109 structure will provide us with insights to lend interpretation to more distant structures, such as the Sculptor filament (e.g. Jerjen et al. 1998).

Using LBT imaging of Leo P, McQuinn et al. (2013) measured the TRGB magnitude in this galaxy to be $i = 22.1$. This is a useful guide to the kind of depth needed to uncover the distant and sparsely populated dwarfs which might be undiscovered in the NGC 3109 filament. While the region is covered by existing and planned survey data, none are deep enough to detect the anticipated faint structures. The northern portion of the filament, from Leo P to Sextans B, is covered in the SDSS imaging, but while the SDSS depth ($g = 22.2$, $i = 21.3$) is adequate for the discovery and characterization of nearby faint dwarfs within the virial radius of the Milky Way (e.g., Koposov et al. 2008), it is inadequate to dwarfs such as Leo P . The southern portion of the filament does not have currently useful survey data: the VST/KiDS survey just misses the region between Sextans A and B, and the VST/ATLAS survey is only of SDSS depth, thus unsuitable for our study. The SkyMapper southern sky survey (Keller et al. 2007) is planned to cover the southern sky to slightly greater than SDSS depth, but it is unclear when those data might become available or what their eventual depth will be.

A dedicated survey using a 4-m class telescope is required to detect low-luminosity galaxies at the distance of the NGC 3109 filament and we propose a survey of this nearest filamentary structure with CFHT/MegaCam. MegaCam's ability to go both wide and deep is essential for this project: the nearby nature of the filament means that it covers a large area of sky, and faint dwarf galaxies are resolved into individual stars. Mapping the NGC 3109 filament will lead to a measurement of the galaxy luminosity function and interaction history to extremely faint levels in a 'primitive' galaxy structure, with implications for cosmological models of galaxy formation and evolution.

Figure 1: Equatorial coordinates of the NGC 3109 association galaxies. The present proposal is to image a 1-degree-wide strip from Sextans A to Leo P using MegaCam.



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Technical Justification

As defined by Bellazzini et al. (2013), the NGC 3109 filament is distributed along a line extending from Leo P in the north ($\delta = +18°$) to Antlia in the south ($\delta = -27°$). The galactic latitude ranges from $b = +54°$ (Leo P) to $b = +22°$ (Antlia). We have mapped this filament onto sky positions and defined a series of 21 MegaCam pointings which will cover the region from Leo P to Sextans A ($\delta = -5°$); the southern-most part of the filament is better-observed at the beginning of Semester A and we will re-propose next semester.

We propose to image in a single filter and use spatial filtering algorithms and visual examination to detect overdensities along the filament direction, following the method used by Chiboucas et al. (2009) for their successful detection of more than a dozen dwarf galaxies in the M81 group. Candidate dwarf galaxies or tidal debris can then be followed-up with multi-band imaging over smaller areas, either with MegaCam or Gemini/GMOS.

Of the MegaCam filters, the r band is best-matched to the SED peak of red giants in an old stellar population. The depth is set by the requirement to detect enough stars for a significant measurement of overdensity. As a comparison, with data reaching 3 magnitudes below the TRGB, McQuinn et al. (2013) found Leo P to have a *central* surface brightness of $\mu_V = 24.5$ mag arcsec^2 and only a few hundred RGB stars. We aim to reach a depth of two magnitudes below the TRGB ($M_r = -3.1$, or $r = 23$ at 1.7 Mpc), meaning $r = 25$. To reach $S/N = 5$ at this depth requires 0.5-hour exposures (including overheads for 4 dithered exposures) in relatively pessimistic conditions (grey time, 1 arcsec seeing, airmass 1.5; we note that Chiboucas et al. (2009) had somewhat better conditions and reached $r = 25$ in approximately 1200 s exposures). We therefore request a total of 10.5 hours of exposure time.

The proposed observations overlap in RA with the MATLAS Large Programme, and with this in mind, we have constrained the observing conditions only loosely.