Dwarf Galaxies: From the Deep Universe to the Present
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Isolated dwarf galaxies in the Local Group

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Abstract. The *Solo* (*So*litary *lo*cal) Dwarf Galaxy Survey is a volume limited sample of all nearby (<3 Mpc) and isolated (>300 kpc from the Milky Way or M31) dwarfs, with wide-field g and i imaging. This survey uses resolved stellar populations to parameterize these low mass systems. Comparison to the well studied satellite dwarfs characterizes the evolutionary impact of a large galaxy in close proximity. The deep, wide field nature of this survey also lends itself to searching for nearby substructures, both globular clusters and possible faint satellites.

Current work is focused on the 16 closest *Solo* dwarfs, all within the virial radius (approximately 1 Mpc) of the Local Group. This subset has been characterized using consistent methods, despite their diversity in stellar mass and apparent size. The analysis highlights the extended stellar structure and morphology. We will examine trends with star formation history, and separation from a large host. This first subset emphasizes the survey's unique challenges and advantages.

The *Solo* Survey provides detailed look at the extended structure of dwarfs and characterizes the evolution of galaxies in the faint limit.

Keywords. galaxies: dwarf, galaxies: fundamental parameters, Local Group, galaxies: structure, galaxies: stellar content

1. Introduction

Due to their shallow potential wells, dwarf galaxies are very sensitive to both internal process and their external environment. For instance, star formation feedback, super nova, tidal effects and ram pressure stripping are a few of the processes which may alter a dwarf. Environmental impacts are clearly demonstrated by Spekkens *et al.* (2014) in which a distinct transition, from gas poor dwarf spheroidals to gas rich dwarf irregulars, is seen as a function of distance from a large host galaxy. By understanding low mass systems, we explore the processes that shape and reshape dwarfs during their evolution. The *Solo* (*So*litary *lo*cal) Dwarf Galaxy Survey explores some of the lowest mass systems and minimizes possible environmental impacts by studying isolated dwarfs near the Local Group (LG).

Parameters, such distances or half light radii, for nearby dwarfs have been derived using a large number of methods. In the compilation of McConnachie (2012), this heterogeneous array of metrics is apparent. For example, characteristic scale radii can be derived from integrated light or resolved stars and defined in numerous ways, resulting in significant variations, particularly for the lowest mass systems. However, robust analysis of systematic trends and comparisons to dark matter simulations (e.g. Fattahi *et al.* (2018)) or other groups (e.g. satellites of Milky Way analogues in the SAGA Survey Geha *et al.* (2017)) benefit from homogeneously defined and derived parameters.

For the *Solo* Survey, each dwarf is characterized using consistent techniques, hence derived parameters can be compared and contrasted over this diverse sample of dwarfs.

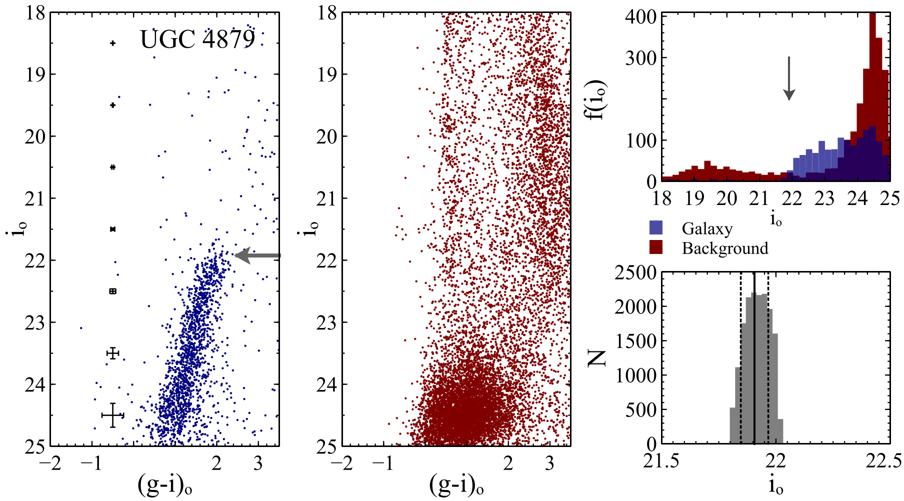

Figure 1. *Left:* A CMD for UGC 4879 showing the galaxy with the tip of the RGB indicated. *Centre:* The foreground and background contaminating sources. *Right:* The LF (*top*) of the RGB and the tip of the RGB with varied binning of the LF (*bottom*).

The *Solo* Survey is comprised of 45 dwarf galaxies, 16 galaxies of which lie within the virial radius of the LG. The LG subset consists of WLM, And XVIII, IC 1613, UGC 4879 (VV 124), Leo T, Leo A, Sag DIG, NGC 6822, Phoenix, Aquarius (DDO 210), Peg DIG (DDO 216), Cetus, And XXVIII, Tucana, Perseus, and the mostly recently discovered, Eridanus II. There is great diversity in mass, stellar populations, and structure within this sample. This subset is analyzed in Higgs *et al.*(in prep.).

2. Example Galaxy: UGC 4879

UGC 4879 is presented here as one example of the *Solo* dwarfs. The basic analysis techniques are detailed in Higgs *et al.* (2016). Fig. 1 shows the colour magnitude diagram (CMD) and luminosity function (LF) of the red giant branch (RGB). The CMD reveals some of the stellar populations present. UGC 4879 has a well populated RGB but few young blue stars or asymptotic giant branch stars. The contamination from foreground Milky Way halo and disk stars is visible at all magnitudes, predominantly at redder colours. Distant red elliptical galaxies misidentified as stars are the dominant contamination at faint magnitudes. Distances are derived using the tip of the RGB as a standard candle. As the focus of the *Solo* Survey is wide-field imaging, rather than deep CMDs, we do not derive star formation histories.

We used the fact that stellar sources are resolved in the *Solo* Survey to trace the structure of the dwarfs to extremely low surface brightness limits. Fig. 2 shows the extended spatial structure of UGC 4879 using the RGB stars to untangle the dwarf from Milky Way stars or more distant sources and trace the outskirts of this dwarf. UGC 4879 shows significant extensions along its semi-major axis. The position angle and ellipticity are derived using intensity weighted second moments. Twisting of the isophotes may indicate tidal effects. UGC 4879 shows no sign of such interactions. Using the median values, elliptical annuli are fitted to generate a radial profile. Extra tidal stars at large radii may also indicate interactions with another galaxy. There are a significant number of extra tidal stars in this dwarf, seen in the spatial distribution. These stars, coupled with the regular isophotes and its isolated location, perhaps supports the idea of a roughly edge-on disk rather than an interaction. However no rotation has been observed, as discussed in Bellazzini *et al.* (2011) among others, making this dwarf an interesting target.

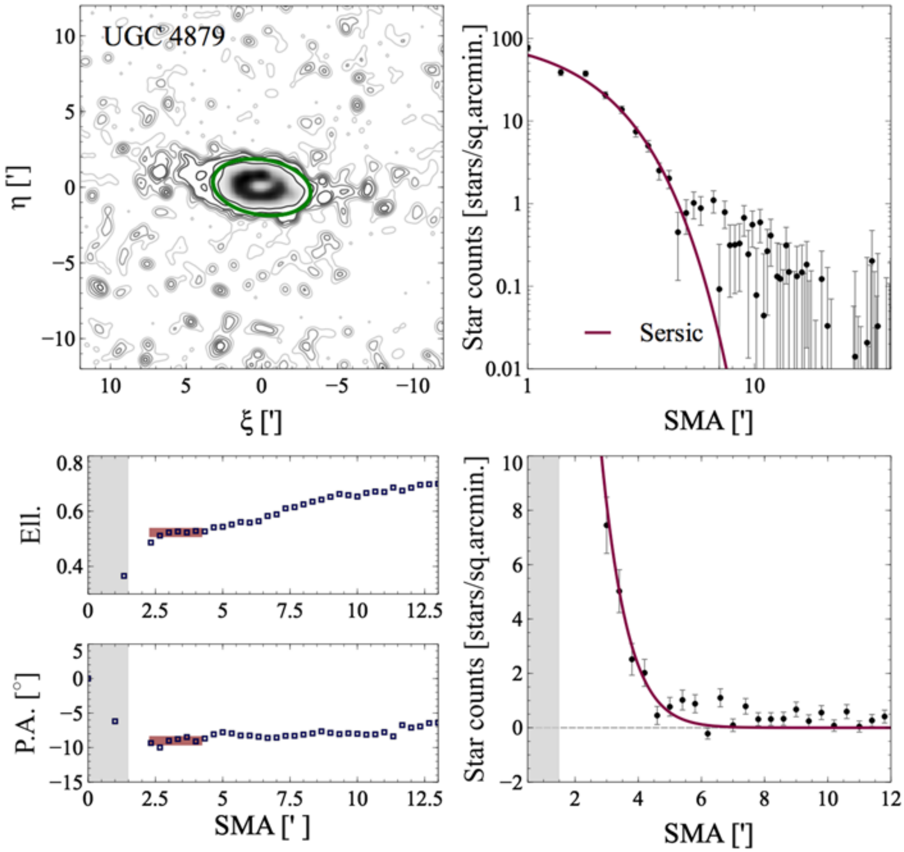

Figure 2. *Top left:* The distribution of RGB stars with the green ellipse showing the median position angle (P.A.) and ellipticity (Ell.) at twice the half light radius. *Lower left:* P.A. and Ell. as a function of radius along the semi major axis (SMA). *Right:* The radial profile of RGB stars fitted with a Sersic profile with logarithmic *(top)* and linear *(bottom)* scaling.

The derived parameters can be compared with other values, where available. Fig. 3 shows a comparison of the position angles (P.A.) derived here with those from McConnachie (2012). There is good agreement, excluding Leo T, NGC 6822, and IC 1613. These three dwarfs are largely circular so their P.A. is poorly constrained.

3. Trends within the Local Group

With the completed survey, we can study trends within and beyond the LG. In addition, by comparing to the well studied Milky Way and M31 satellites, we isolate properties which depend on the dwarfs' proximity to a large galaxy. Fig. 4 is a preliminary demonstration, showing the dependence of ellipticity on distance, with a possible intriguing trend of increasing ellipticity with increasing distance. The full *Solo* Survey extends to more than twice the distances shown with the LG subset, which will verify this trend.

The role of environmental effects and the impact of internal physics on the large scale morphology and properties of dwarf galaxies has been highlighted recently with dark matter simulations. As discussed in Smercina *et al.* (2018), the "too big too fail" and "missing satellite" problems have largely been solved by considering stellar feedback in the dwarf regime. However, they highlight the continuing importance of understanding dwarf populations for simulations.

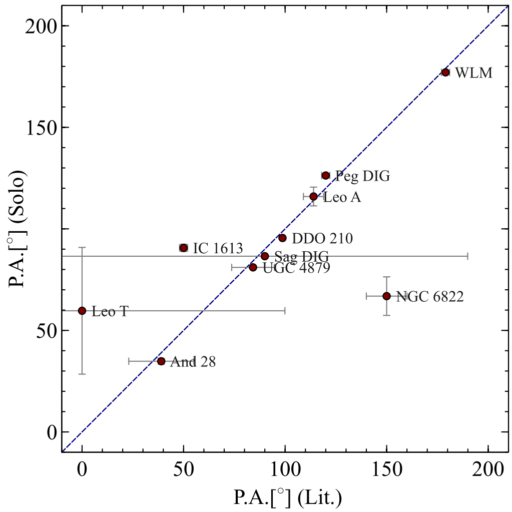

Figure 3. Comparing the *Solo* position angles to McConnachie (2012).

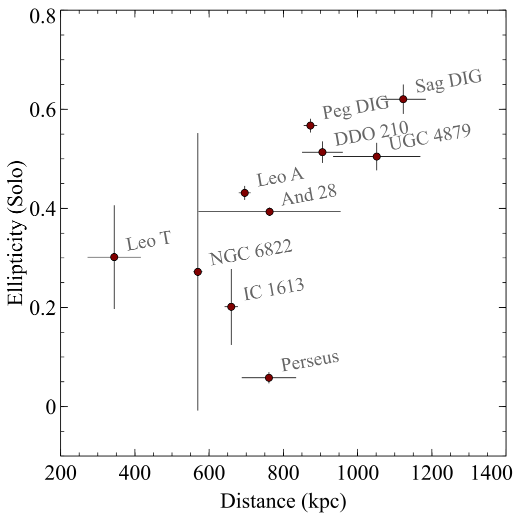

Figure 4. Ellipticity as a function of distance from the Milky Way.

The *Solo* Survey is ideally placed to gain a better understanding the constraints dwarfs place on our understanding of galaxy formation and the fundamental properties of dwarfs in isolation, utilizing the unique opportunities presented by our nearest neighbouring isolated dwarfs.

References

Bellazzini, M., Beccari, G., Oosterloo, T. A., Galleti, S., Sollima, A., Correnti, M., Testa, V., Mayer, L., Cignoni, M., Fraternali, F. & Gallozzi, S. 2011, *A&A*, 527, A58

Fattahi, A., Navarro, J. F., Frenk, C. S., Oman, K. A., Sawala, T. & Schaller, M. 2018, *MNRAS*, 476, 3816

Geha, M.,Wechsler, R. H. Mao, Y., Tollerud, E. J., Weiner, B., Bernstein, R.,Hoyle, B., Marchi, S., Marshall, P. J., Muñoz, R. & Lu, Y. 2017, *ApJ*, 847, 4

Higgs, C. R., McConnachie, A. W., Irwin, M., Bate, N. F., Lewis, G. F., Walker, M. G. & Côté 2016, *MNRAS*, 458, 1678
McConnachie, A. W. 2012, *AJ*, 144, 4
Smercina, A., Bell, E. F., Price, P. A., D'Souza, R., Slater, C. T., Bailin, J. Monachesi, A. & Nidever, D. 2018, *ApJ*, 863, 152
Spekkens, K., Urbancic, N., Mason, B. S., Willman, B. & Aguirre, J. E. 2014, *ApJ*, 795, L5

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