Characterizing Dwarf Satellite Galaxies with Roman

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Pl: B. Williams (U of Washington)

Partial view of simulated observation of M83 (4.5 Mpc)

Simulation of a Draco-like dwarf ($M_V = -8$) at $D = 4.5$ Mpc
H158, Y106, Z087, 1 hr exposure
With STIPS

Akseson et al. 2019
A Taste of What is Possible with Roman

At the point where we can simulate dwarfs

1. Implementing precursor surveys and observations.
2. Demonstrated techniques for doing full image simulations of dwarfs.

Akeson et al. 2019
Motivation: Dozens of new Milky Way and M31 satellites

Most recently, Drlica-Wagner & Bechtol+20
Dozens of new Milky Way and M31 satellites

Stolen from a DES talk
Realistic inclusion of baryons significantly reduces CDM’s ‘problems’ on sub-galactic scales.

Theory + Observations converging in the Local Group.

But are we over-tuning our models to reproduce two spiral galaxies in a loose group?
Where do we go from here? The Local Group is nice, but....

• Are our baryonic solutions to the ‘Missing Satellites Problem’ and ‘Too Big to Fail’ just tuned to the Local Group?

• Halo to Halo scatter is expected. Can we observationally quantify this? What physically drives the scatter?

• Does parent galaxy morphology matter?

• Environment and formation history?

• Next step is to probe new systems -- our NEXT nearest neighbors.
Where do we go from here? The Local Group is nice, but.... What we want:

Subhalo property can be dwarf luminosity function, stream richness, you name it.
McConnachie et al. 2009; Lewis et al. 2012, Martin et al. 2013 and MANY more

220 hrs of CFHT/Megacam; 400 deg²
~2-3 mags below the Tip of the RGB
A Taste of What is Possible with Roman

~10 hours with Roman at 10 Mpc

M101: 7.4 Mpc

PAndAS Survey of M31
The field of Streams of CenA

A disrupting dwarf galaxy -- detected not by low surface brightness measurements but in individual resolved stars!

There are clearly other streams emerging.

All in resolved RGB stars

Crnojevic et al. 2016
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Other RGB maps (not exhaustive)

- HSC map of RGB stars around NGC2403 (D~3.2 Mpc), showing a stripped DDO 44 satellite (Carlin+16, 19, 20)
- HSC map of RGB stars in the M81 group (D~3.5 Mpc), color coded by metallicity (Smercina+20). See also Okamoto+15.
A close pair of satellites (as an example of ground-space synergy)

Crnojevic et al. 2014

Roman Infrared Nearby Galaxies Survey

November 15, 2021
A close pair of satellites

CenA-MM-Dw1 cluster?

HST CMDs

CenA-MM-Dw1

Roman Infrared Nearby Galaxies Survey

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CenA-Dw1 has four clear globular clusters in HST imaging. Fornax-like system to constrain DM properties. Must go to space to find more such systems.
HST followup is revealing a rich variety of star clusters — a preview for Roman

At an average $M_V=-7$, we can use star clusters to probe kinematics of halo substructures and DM profile of CenA, and other nearby galaxies.

See Voggel et al. 2020
Satellite Luminosity Function of Nearby ‘MW-like’ Galaxies

Large halo-to-halo scatter.
What drives it?
Reproduced in recent simulations; e.g. Samuel et al. 2020; Engler et al. 2021

Environment
Less dense
More dense

Some indication that ‘host’ halos in denser environments have richer satellite systems. Needs confirmation.

Need to investigate accretion history, feedback, reionization, etc.

Bennet, Sand et al. 2019; see also Carlsten et al. 2020, 2021ab, Geha et al. 2017, Mau et al. 2021
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Where Can We Go From Here?
Lets think about resolved stars from the ground with HSC (& VRO)
D<5 Mpc Roughly

Red corresponds to r~27.4, g~27.8 at 50% comp — close to LSST 10-yr depth
HSC data (Carlin et al. 2016, 2019)

Mutlu-Pakdil, Sand, et al. 2021
Implanting simulated dwarfs with a range of size, luminosity, ellipticity, stellar background & galactic latitude to forecast resolved dwarf discovery over the next decade from the ground. Directly translatable to Roman simulations now.

Mutlu-Pakdil, Sand, et al. 2021
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Results at three fiducial distances

Ultra-faint dwarfs in NGC3109

Fill out the census at D=3.5 Mpc down to M_V=-7 to -8

M64, M94 and M83 are excellent targets

Mutlu-Pakdil, Sand, et al. 2021
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Dooley et al. 2017

Mutlu-Pakdil, Sand, et al. 2021
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$10^3$ Ly

$10^4$ Ly

$10^5$ Ly

$M_V=-6$ dwarf at $D\approx1.5$ Mpc

NASA Keck time with HSC awarded as precursor WINGS program

Mutlu-Pakdil, Sand, et al. 2021
Next step: Combine our machinery for dwarf simulations and detection efficiency and apply to Roman/STIPS and plausible nearby galaxy surveys.

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Mutlu-Pakdil, Sand, et al. 2021
Summary

• Roman will do critical work on dwarf galaxies and other substructures to constrain our picture of structure formation on small scales.
• WINGS team has begun simulating dwarf galaxies with STIPS.
• Infrastructure in place to do a comprehensive study of dwarf galaxy detection efficiency with Roman.
• Precursor surveys with HSC and other wide-field imagers will provide critical targets for Roman.

~10 hours with Roman at 10 Mpc
Thank you