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Detecting Dwarf Galaxies Around NGC 55

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Introduction

Lambda-CDM predicts the existence of faint dwarf galaxies orbiting both large host galaxies, like the Milky Way, and smaller hosts like the Magellanic Clouds. However, the satellite populations around these smaller host galaxies are poorly understood from both a theoretical and observational perspective.

In order to improve our understanding of the satellite populations of low-mass galaxies, we are performing a search for satellites around the nearby, low-mass galaxy, NGC 55. As part of this search, we aim to characterize our detection sensitivity by injecting artificial dwarf galaxies into our data set and attempting to recover them.

Upon determining this sensitivity, our goal will be to search for dwarf galaxy satellites of NGC 55 and produce the first complete satellite luminosity function for a distant LMC-mass galaxy down to an unprecedented limit of $M_V \sim -7$.

Data

Our data comes from the DECam Local Volume Exploration (DELVE) Survey[1]. The DEEP component of this survey performs 135 deg^2 of deep imaging in the g and i bands around 4 isolated, Magellanic-sized galaxies in the Local Volume. For this project, we are focusing on one of these targets, NGC 55 (see Figure 1). DELVE-DEEP expects to be sensitive to satellite galaxies up to $M_V \sim -7$, and simulations predict a total of 5-17 of such satellites around these hosts[2].

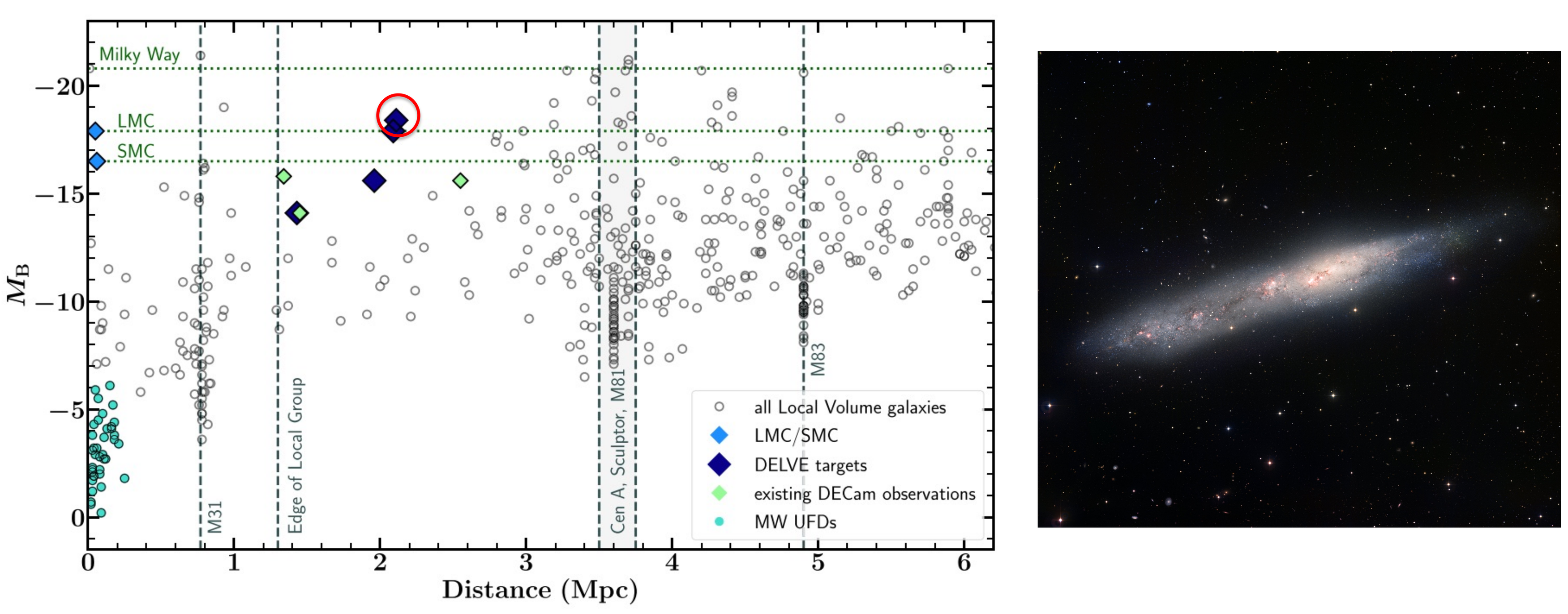

Figure 1: Left: B-band absolute magnitude vs. distance for nearby galaxies. LMC and SMC represented by light blue diamonds, DELVE-DEEP targets represented by dark blue diamonds, NGC 55 circled in red.[1] Right: Color image of NGC 55.[3]

Methods

Injection and Recovery:

We wish to determine our dwarf detection sensitivity as a function of size, measured as the log of the half-light radius in parsecs, and luminosity, measured in V-band absolute magnitude. A total of 650 dwarfs of varying size and luminosity were injected across 26 DELVE-DEEP NGC 55 coadded images of varying exposure time and limiting magnitude.

Each artificial dwarf galaxy's stellar population was generated from an isochrone modeling the age and metallicity of an expected NGC 55 satellite and distributed according to an exponential profile. Additionally, the resolved and unresolved stars within each dwarf were created separately. The resolved stars were created as point sources convolved by the observed PSF, while the unresolved stars were modeled with a Sérsic galaxy profile.

Upon injection, each coadd was run through Source Extractor[4] for recovery.

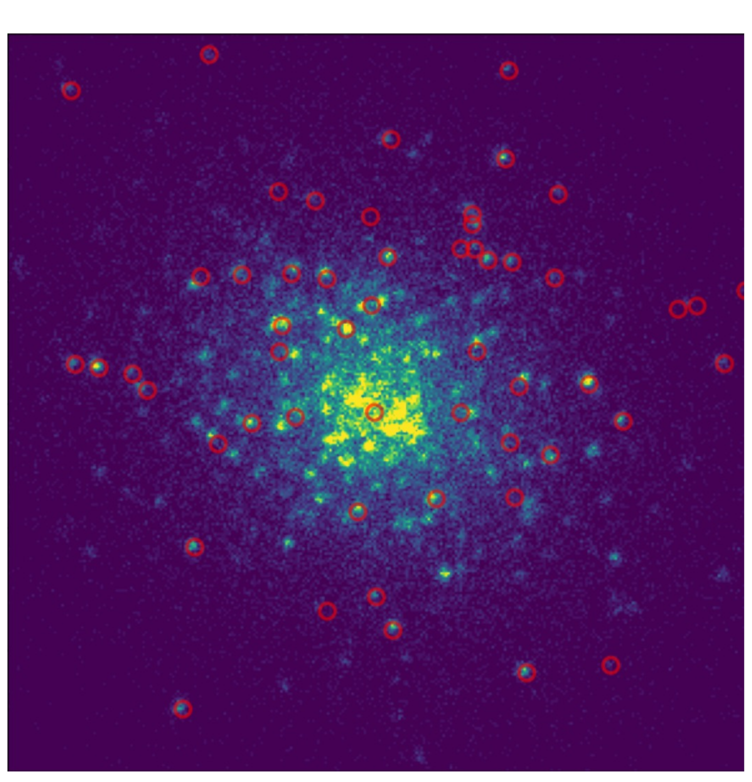

Figure 2: Image of an artificial dwarf galaxy injected into one of DELVE-DEEP's NGC 55 coadds. Sources recovered by Source Extractor circled in red.

Methods (cont.)

Blending:

An issue that often arises with the recovery of dwarf galaxies is the overlapping of light, or blending, between resolved stars near the central region of the dwarf. In order to explore this issue, dwarf galaxies of varying central density were generated, and upon recovery, the absolute magnitude of each dwarf was re-calculated using only the recovered stars. On average, dwarfs with higher central densities saw more significant decreases in their absolute magnitude assembled from recovered stars (see Figure 3).

Dwarf Search:

Each catalog outputted by Source Extractor was run through our dwarf-search algorithm in order to determine whether or not each injected dwarf could be detected. This algorithm first selects the red-giant-branch stars within each catalog using an RGB selection box and applying star-galaxy separation. Over-densities of these RGB stars are then detected using the `photutils`[5] function, `find_peaks`, and for each size-luminosity bin, we determine how many of our injected dwarfs are identified by this function.

Results

A preliminary summary of the detection sensitivity for each size-luminosity bin, and an example of how blending affects dwarfs' recovered magnitudes, are given by Figure 3. In general, dwarf sensitivity is highest for larger, brighter dwarfs and lowest for dimmer, smaller dwarfs.

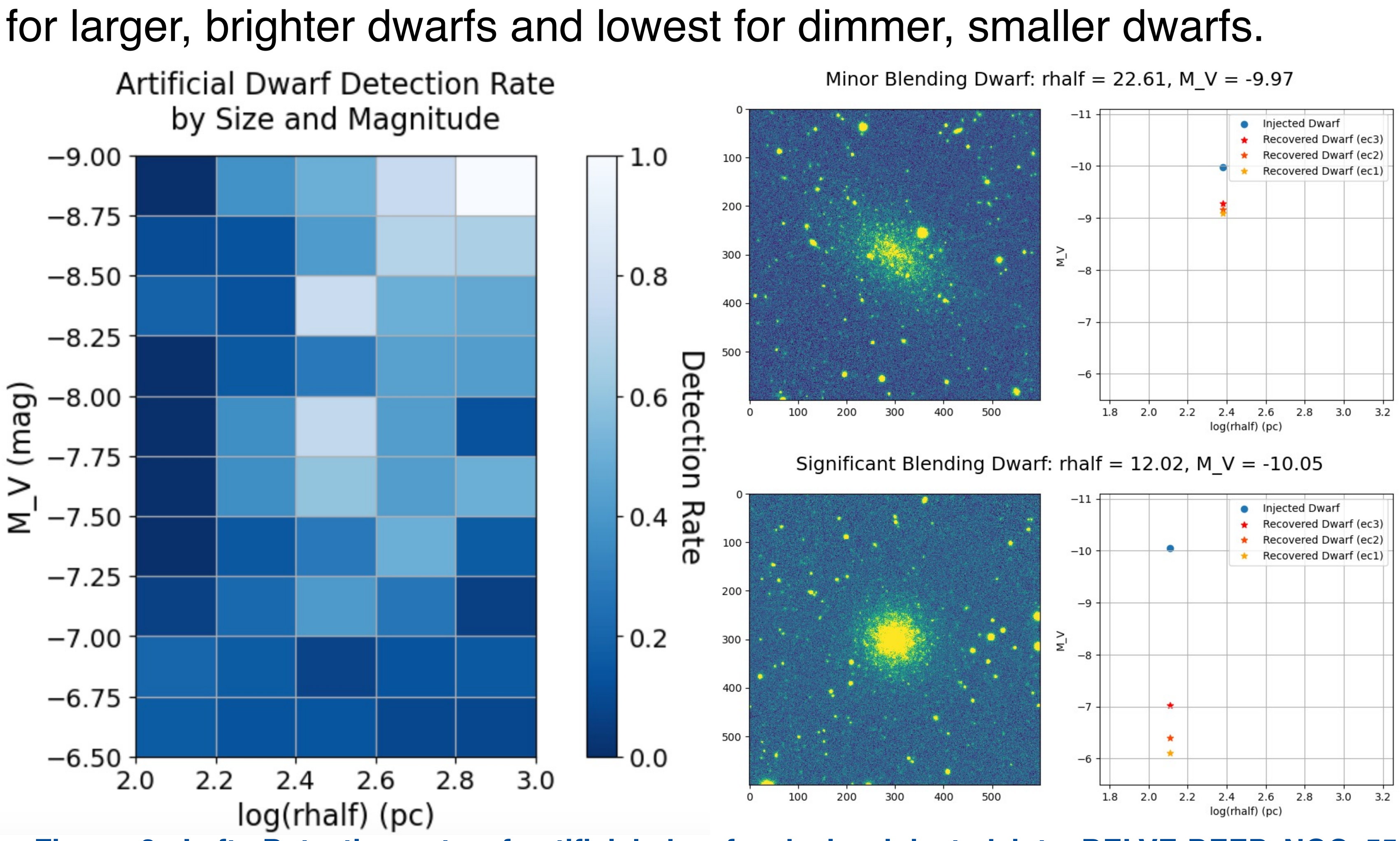

Figure 3: Left: Detection rate of artificial dwarf galaxies injected into DELVE-DEEP NGC 55 coadds, binned by half-light radius (in parsecs) and V-band absolute magnitude. The detection rate is given by the fraction of dwarfs in each bin that were recovered by our dwarf search algorithm. Right: Two images of artificial dwarf galaxies with their corresponding injected and recovered absolute magnitudes. Three recovered magnitudes are plotted for each one, corresponding to three different degrees of star-galaxy separation that were applied.

Conclusion

Eventually, this dwarf search algorithm will be run on the entirety of DELVE-DEEP's real NGC 55 data, and this dwarf detection sensitivity tells us exactly the types of dwarf galaxies we should be able to detect. Identifying any dwarf galaxy satellites that may exist around NGC 55 will allow us to place a constraint on the abundance of dwarfs we expect to find around low-mass hosts and produce the first complete satellite luminosity function for a distant low-mass galaxy down to $M_V \sim -7$.

Acknowledgements & References

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