Uncovering Ultra-Faint Galaxies in the Local Group

M | ASTRONOMY

The Missing Satellite Problem

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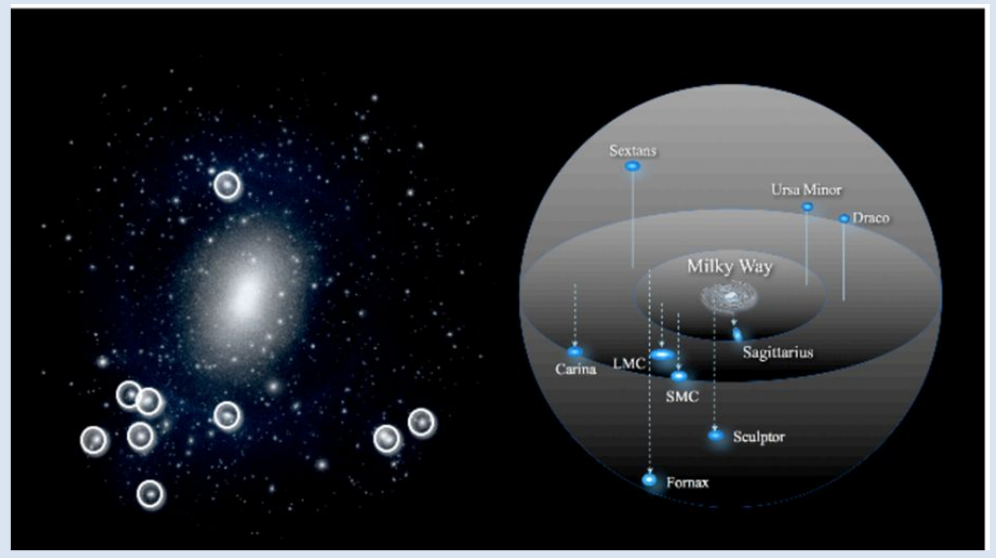
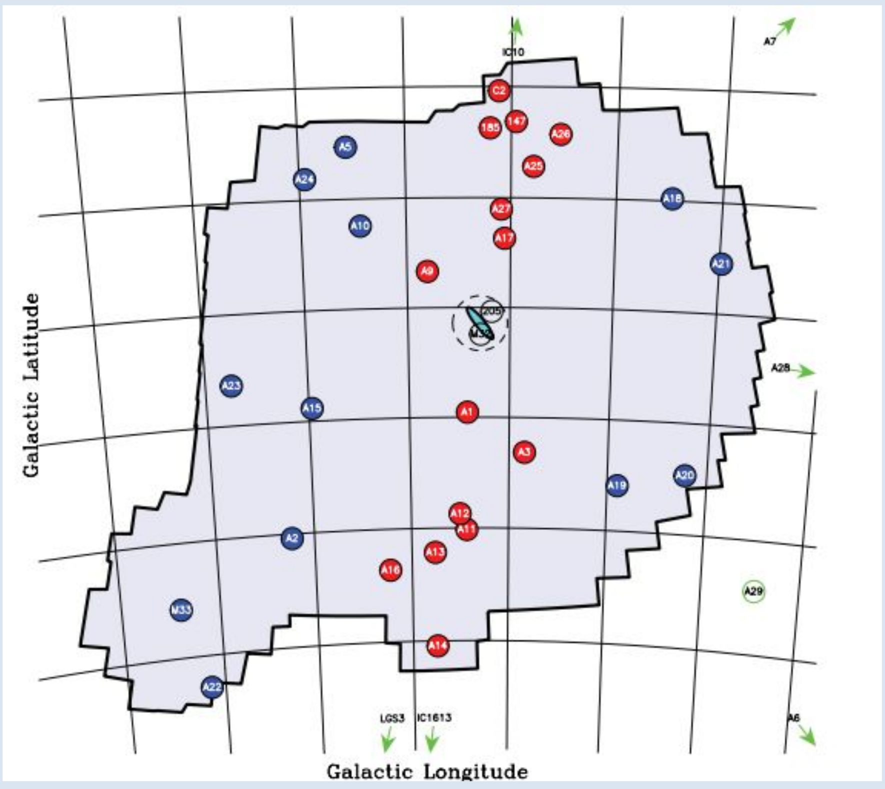
Abstract: By analyzing the stellar spatial distribution, we try to search for potential dwarf satellite galaxies by examining stellar overdensities within the DELVE survey. We attempt to search for overdensities for horizontal branch stars and red giant branch stars using the Density-Based Spatial Clustering of Applications with Noise (DBSCAN). We have focused on the Pegasus IV dwarf galaxy and its stellar population properties as a guide for our overdensity search. With the detected overdensities on the color-magnitude diagram, we also explore the stellar overdensities regarding their spatial distribution.

"The Missing Satellite Problem"

- The ultra-faint dwarfs are the oldest, most dark-matter dominated, most metal-poor, and least chemically evolved stellar system known (Simon, 2019).
- To place robust constraints on cosmological and galaxy formation physics, and to further refine the use of dwarf galaxies as cosmological probes, it will be crucial to replicate the present analysis on dwarf galaxy systems.
- The "Missing Satellites Problem" is the inconsistency between the number of simulated satellite galaxies and observed satellite galaxies around a Milky-Way type galaxy.
- Theoretical simulations predict M31 hosts (66, 111) dwarf galaxies (Doliva-Dolinsky et al., 2023).



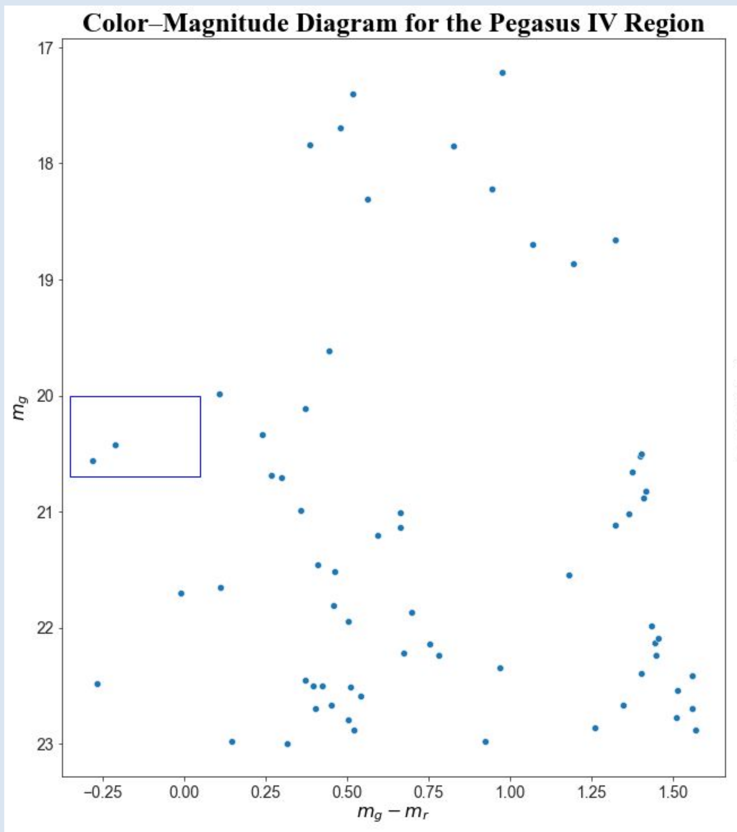
Dwarf/Satellite galaxies seen in (*left*) a simulation with a Milky Way sized halo, and (*right*) observations of the Milky Way from sky surveys.

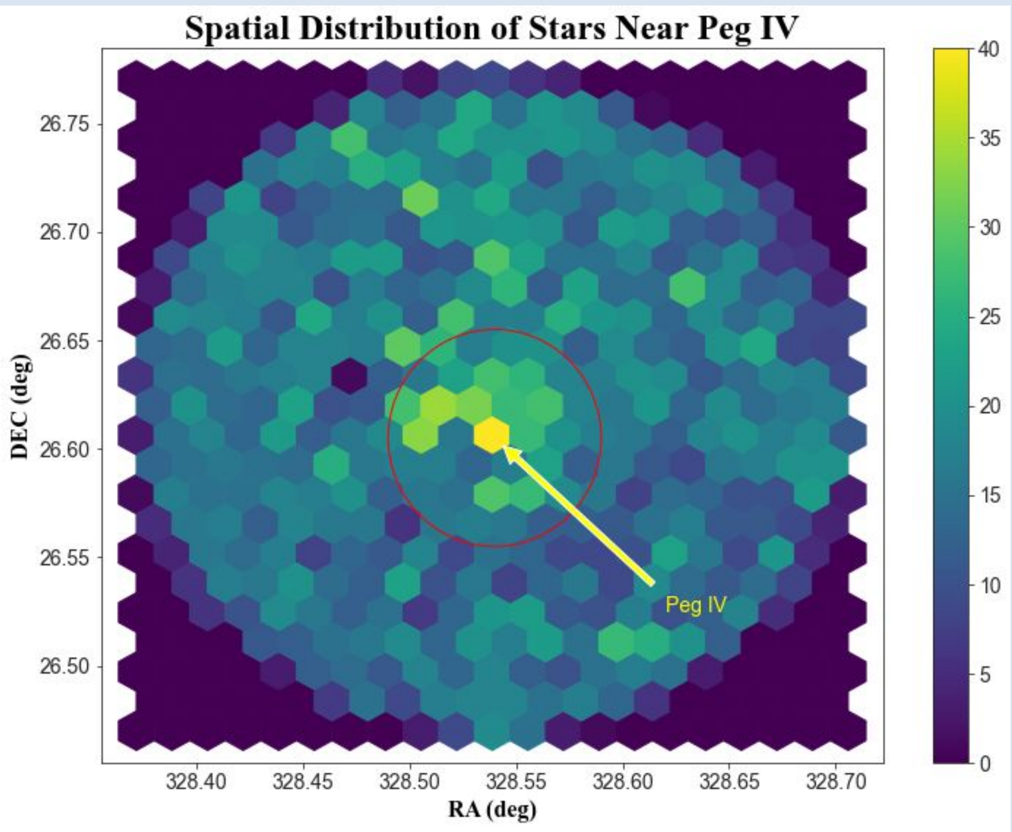


The distribution of dwarf galaxies around Andromeda

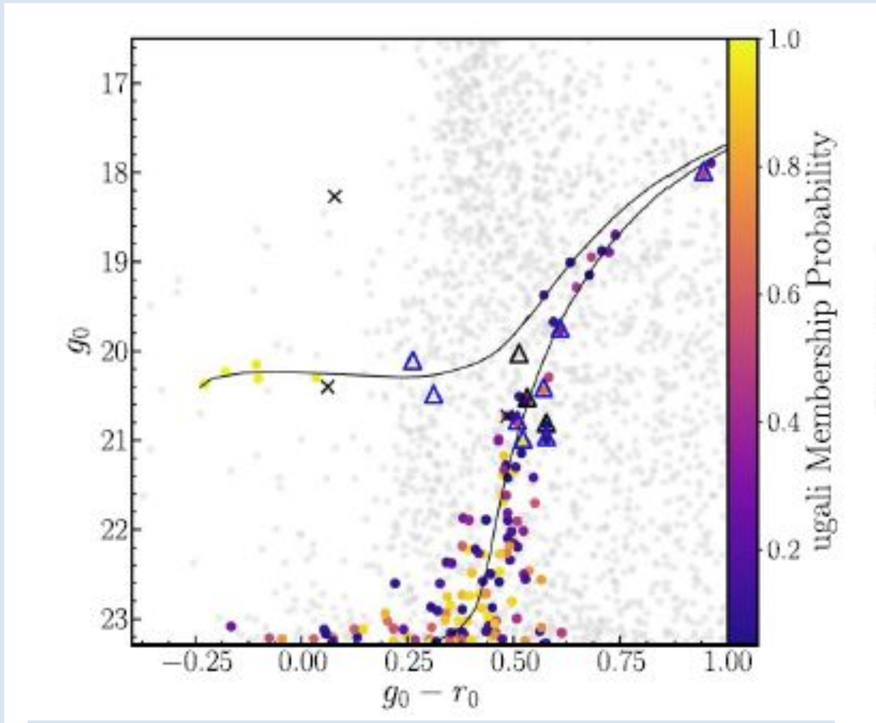
Searching for Ultra-faint Galaxies

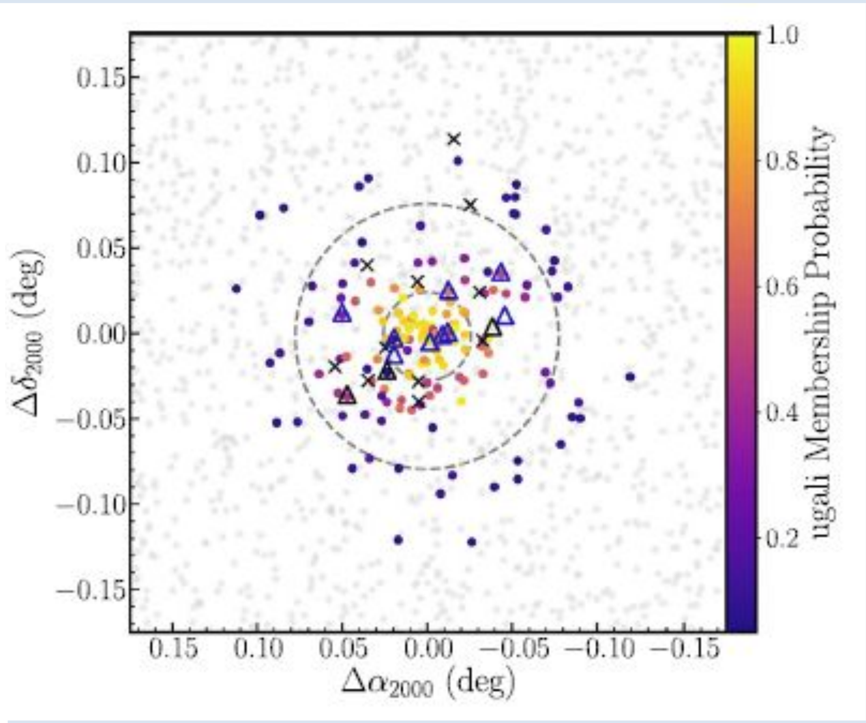
- The Pegasus IV detection result is recovered using HB Stars clustering search.





Pegasus IV Discovery (Cerny et al., 2023)





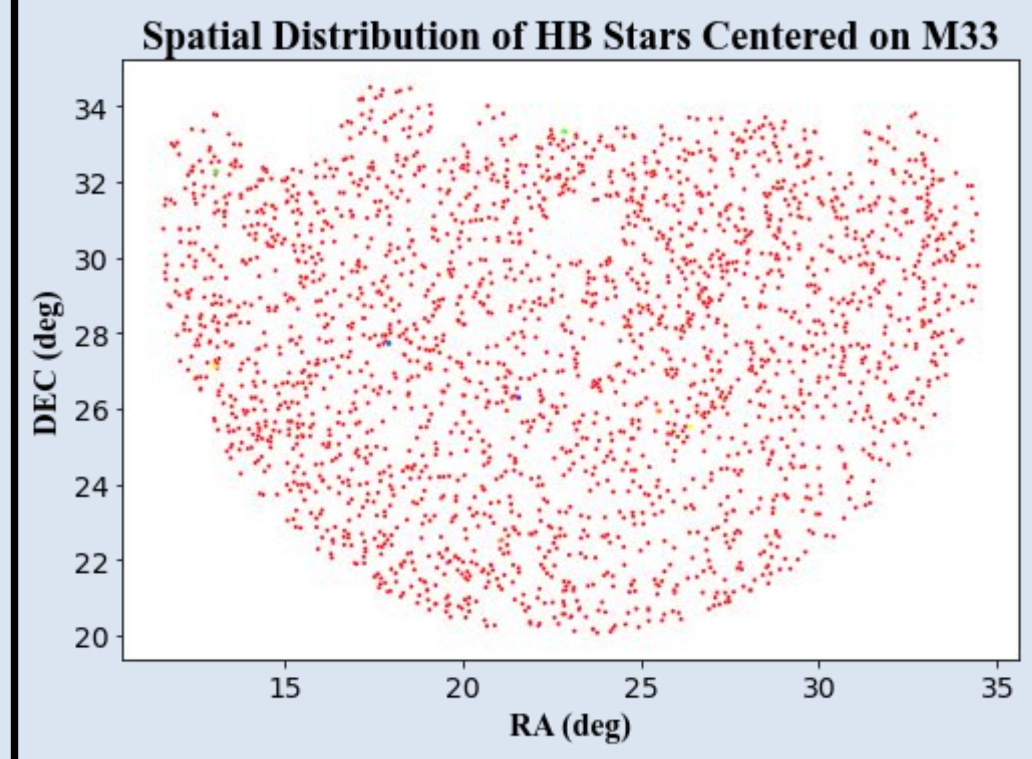
Color–Magnitude Diagram for the same region shown in the left panel

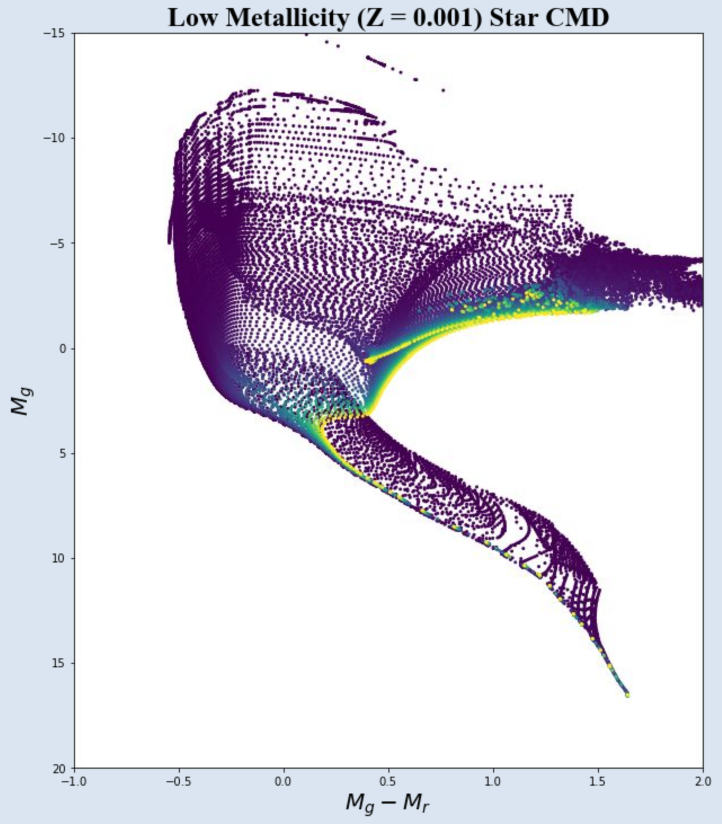
Spatial Distribution of Stars Centered on Pegasus IV

Methods to Detect Satellite Galaxies

- A 10 x 10 degrees sky near the M33 (Triangulum) galaxy is obtained through the Astro Data Lab (delve_dr2.objects)
- All stars are filtered through either the red giant branch or the horizontal branch stars criteria (i.e., $20.0 < m_g < 20.5$ & $-0.35 < g\text{-}r < 0.05$) (Cerny et al., 2023).
- DBSCAN cluster search is conducted to find stellar overdensities.
- Locate the clustering region to generate corresponding color-magnitude diagrams and spatial distribution diagrams.

Potential Satellites of M33





Implications of the Missing Satellites

- Ultra-faint galaxies (high redshift; before reionization) can act as well-preserved "fossils" to trace chemical enrichment histories of the galaxies they associate with.
- Testing cosmological constraints of the Lambda Cold Dark Matter (ΛCDM) model through studying the dark matter distribution within our target.
- Provide insights into the process of tidal stripping between the host galaxies and their satellite galaxies.

Next Step

- Generating theoretical isochrones (EZPADOVA) for metal poor stars on the color magnitude diagram to better fit isochrones and set up searching criteria.
- Develop statistical framework specific for DBSCAN search for different stellar distribution for dwarf galaxies.
- Use detected stellar isochrones to understand star formation histories of dwarf galaxies.

Reference:

Cerny, W. et al. (2023). Pegasus IV: Discovery and spectroscopic confirmation of an Ultra-faint dwarf galaxy.

Doliva-Dolinsky, A. et al. (2023). The PAndAS view of the Andromeda Satellite System.

Drlica-Wagner, A. et al. (2022). The DECAM Local Volume Exploration Survey Data release 2

Fouesneau, M. (2022). EZPADOVA. Retrieved 2023, from https://github.com/mfouesneau/ezpadova

Simon, J. D. (2019). The faintest dwarf galaxies