Probing substructures of the Jet stream with deep u-band photometry

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Introduction

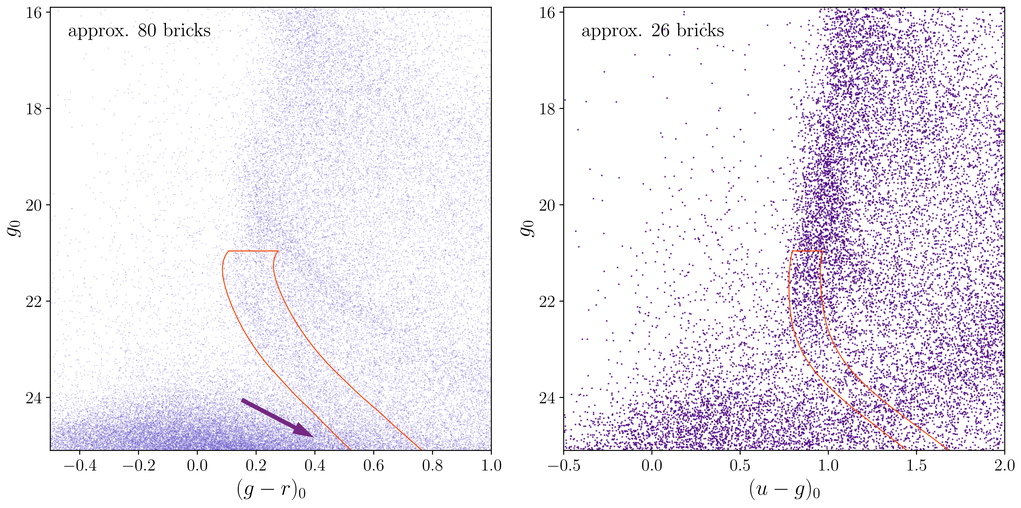
- Thin, dynamically cold stellar streams are powerful probes of the presence of small-scale dark matter subhalos in the Milky Way gravitational potential.
- Studies before have been focusing on streams closer to the Milky Way disk, which can cause noise coming from the disk stars in the dark matter signal.
- The Jet stream[1] lies clear from the Milky Way disk, suggesting a higher likelihood of detecting past encounters of dark matter subhalos.
- Previous study using the DELVE survey[2] finds a ~4° under-density and indicators of a possible spur off its main track analogous to that of GD-1 in Jet.

Observations & Methods

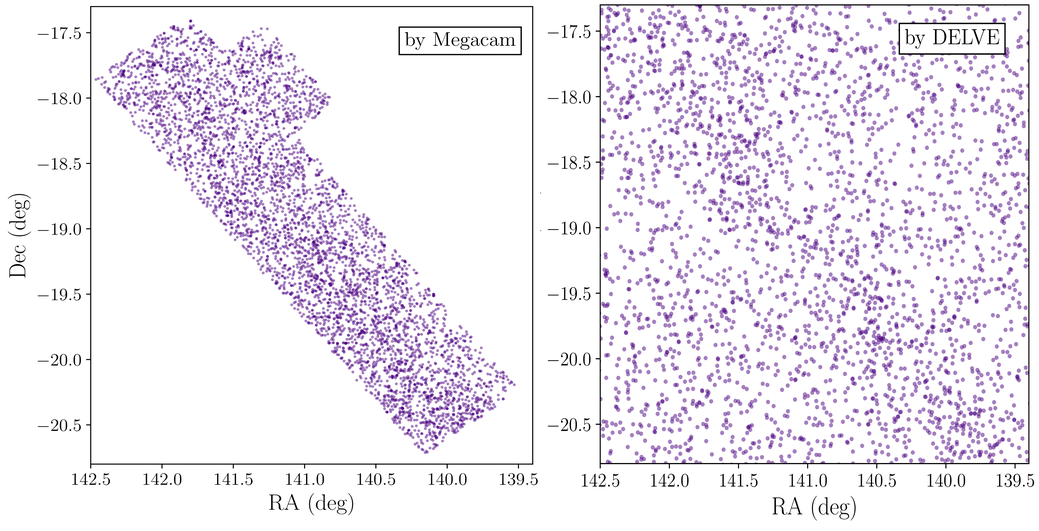
- Observed 114 fields of size 24 arcminutes squared with Magellan/Megacam[3] over 2022-2023; images obtained are in u, g, r bands with respectively 3x90s, 3x30s, and 3x60s dithered exposures, and a median seeing of 0.68.
- Images are then processed with the Harvard CfA pipeline (dark and flat frames subtraction, cosmic ray detection, etc.), also producing data quality and weight maps for each exposure.
- We adapt the Legacy Imaging Surveys reduction pipeline, *legacypipe* (based on *the Tractor* framework[4]), for the Megacam images. Using Gaia DR3 as reference, we first find astrometric and photometric zeropoints for each CCD chip, and then extract and fit sources across all images covering a 0.25°x0.25° sky area (a "brick").
- Only sources labeled as PSF (star-like) with detection significance above 5 sigma are used in our subsequent analysis. We use a widened Dotter isochrone[5],[6] with synthetic magnitudes (Age 12.1 Gyrs, [Fe/H] = -1.75) to filter out likely members of the Jet stream.

Preliminary Results

- Photometry ~2 magnitudes deeper than the previous surveys used, combined with u-band images, can significantly improve our resolution in mapping Jet and other cold, thin streams.
- Our preliminary dataset with a small portion of the total fields covered provides color-magnitude diagrams (CMDs) that show the improved depth and a prominent main sequence of the stream in the g against g-r CMD.

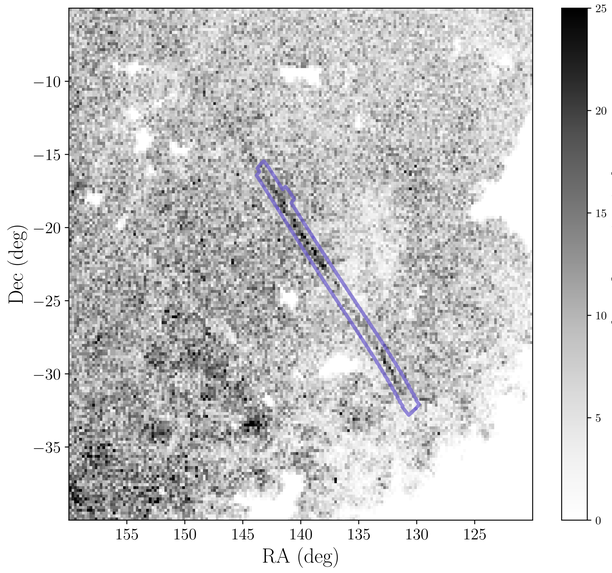


- A map produced with around 20 Megacam fields, or ~80 *legacypipe* bricks in the g and r bands, are shown below in comparison with the previous map of the same region in DELVE: this indicates how much density substructures could be revealed with deeper photometry.



Next Steps

- The entire 114 fields (800+ bricks) of images should match the coverage in the figure shown below. The resulting CMD will show a clearer picture of Jet's main sequence, hence revealing more substructure.



- With the u-band data providing the possibility of a color-color (u-g against g-r) diagram, we can select a stellar locus to eliminate contamination from unresolved distant galaxies. This would improve our selection of Jet members on the faint end.
- Adding proper motion or spectroscopic follow-up data would help us refine the distance gradient and further improve our matched-color filter as well as stream morphology models.

References

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