Searching for Faint Stellar Streams in the Distant Halo

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1. Introduction and Motivation

The Halo Outskirts With Variable Stars (HOWVAST) survey contains very deep catalogues (~5 to 270 kpc), using a region of the sky mostly unobserved at that depth. It also includes a catalogue of more than 500 RR Lyrae stars: variable stars which are very good tracers of old, metal poor stars, such as those comprising stellar streams [3]. The presence of many RR Lyrae and the depth of the survey indicates there is a high chance of detecting stellar streams within the data.

The stream search code from Shipp et al. 2018 [1] uses Dark Energy Survey data to locate 11 new streams, as well as many more since.

Goal:

- Learn stream search code, calibrate stacked HOWVAST data, then run data through stream search pipeline to detect very faint / distant stellar streams

2. Stream search code

- Uses **matched filter algorithm** to search for stellar streams
- Takes **synthetic isochrone** of old, metal poor stellar population and selects stars in range of colours around isochrone
- Specifically working with updating section of code that uses Dark Energy Camera Legacy Survey (**DECaLS**) data
- DECaLS and HOWVAST both use **DECam data**
- Uses 5th degree **polynomial background fitting** and **masking** functions

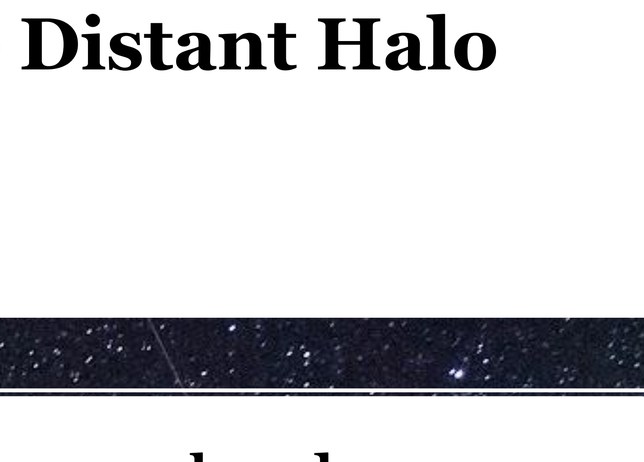


Figure 1: Plot of DECaLS data with selection of known streams overlaid over data, plotted using galstreams

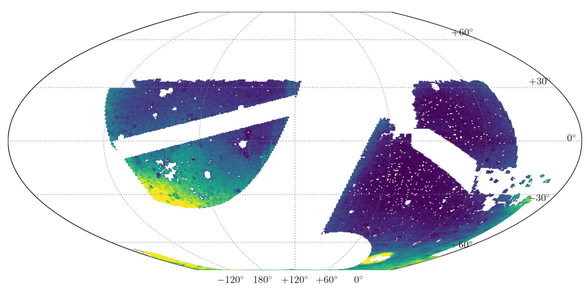


Figure 2: Testing masking DECaLS density plot for background fitting

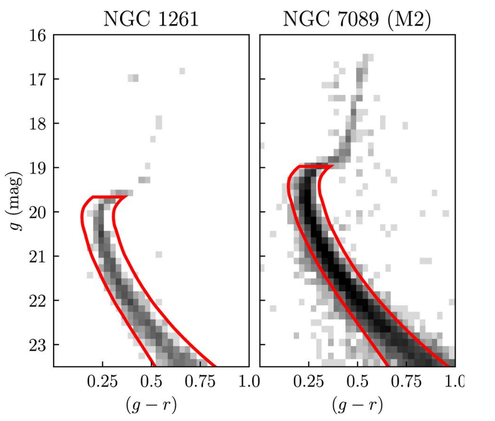


Figure 3: Matched filter plot of two clusters from Figure 2 of Shipp et al. 2018

3. HOWVAST data calibration

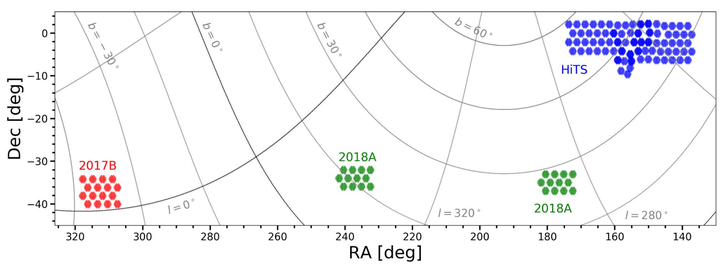


Figure 4: HOWVAST and High cadence Transient Survey (HiTS) footprints (Medina et al. 2020 [2]). Each dot is one field.

- **Photometrically calibrating** 2017 and 2018 HOWVAST stacked data by field
- Calibrating stacked data by **limiting** and **crossmatching** with National Optical-Infrared Astronomy Research Labratory (NOIRLab) data
- Calculate instrumental magnitudes then correct with crossmatched information to find final magnitudes

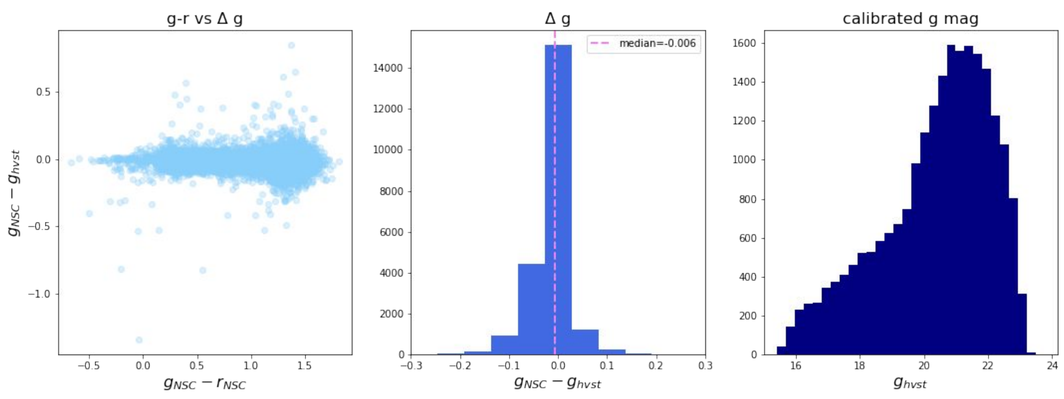
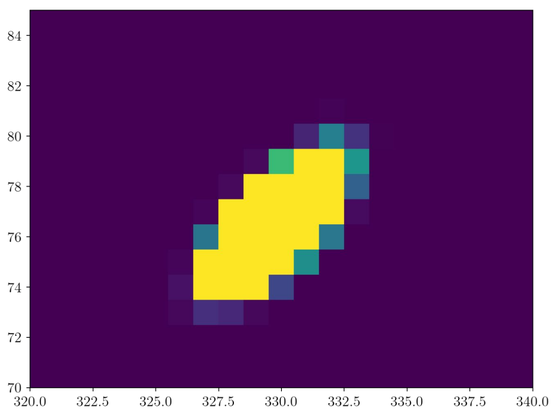


Figure 5: Plots of 2017 HOWVAST 4th field data, showing respectively NSC g-r colour versus g magnitude difference, a histogram showing magnitude difference between NSC g magnitude and calculated HOWVAST g magnitude, and calculated HOWVAST g magnitude values. The small differences between the nsc and calculated magnitudes are a good sign for the success of the calibration.

4. Preliminary results:

Figure 6: A **VERY** preliminary density plot of HOWVAST data from the streamsearch pipeline! Plot is very pixelated because the HOWVAST footprint is so small, when the pixel sizes are adjusted to compensate it should look similar to Figure 7 in greyscale, and hopefully features will be seen.



5. Next Steps

- Testing by running single calibrated field through streamsearch pipeline then run all stacked HOWVAST fields
- Once residual density plots for fields found (Figure 7), use RR Lyrae positions + distance moduli from catalogue to zoom in on possible streams
- Expand to running other surveys that use DECam (HiTS, DELVE) through the stream search pipeline

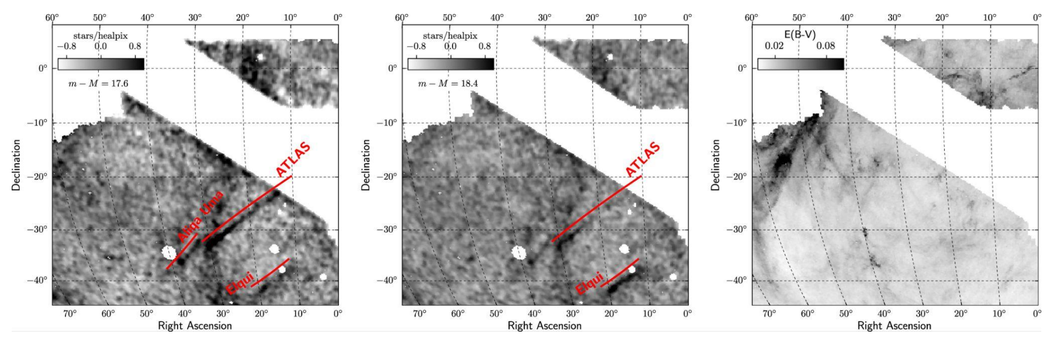


Figure 7: Residual density plots that cycle through distance moduli in order to get preliminary identification of streams from Shipp et al. 2018. The goal!

References

- [1] Shipp et al., 2018 *ApJ* 862 114, https://doi.org/10.3847/1538-4357/aacdab
- [2] Medina G. E. et al., 2020, https://doi.org/10.48550/arXiv.2012.06619
- [3] Baker, M. and Willman, B., 2015 *AJ* 150 160, http://dx.doi.org/10.1088/0004-6256/150/5/160