Iron and Alpha Element Abundances in the Outer Disk, Giant Southern Stream, and Inner Halo of M31

Ivanna Escala, Evan N. Kirby, Karoline M. Gilbert, Jennifer Wojno, Emily C. Cunningham

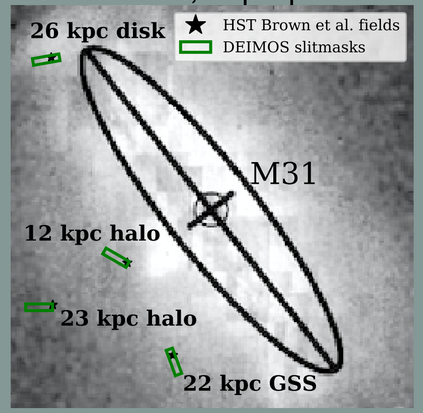
Caltech

ie@astro.caltech.edu

Why M31?

Stellar halos and disks preserve signatures of a galaxy's accretion history, as well as in-situ star formation, in the form of chemical abundances ([Fe/H] and [α/Fe]). M31 provides a complement to the MW and has been studied in detail using photometry and shallow spectroscopy, but its distance (785 kpc; [1]) has historically precluded measurements of spectroscopic [Fe/H] and [α/Fe].

Escala et al., in preparation.



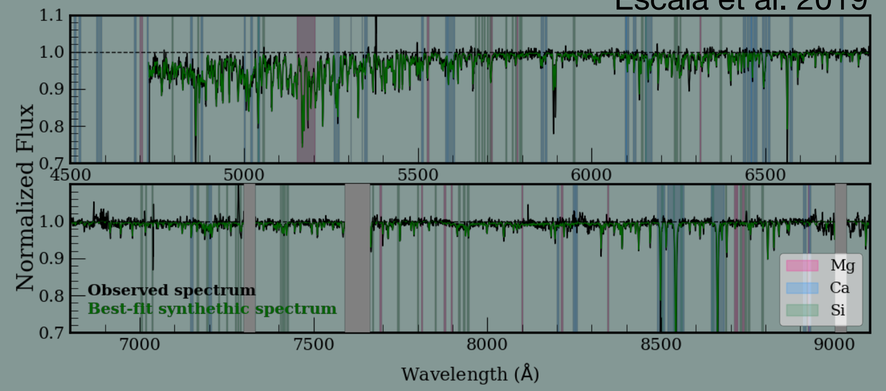
Star count map from [2].

Measuring abundances from low-resolution spectroscopy of individual stars in M31

We developed a technique to apply spectral synthesis to low-resolution stellar spectra [3] to measure [Fe/H] and [α/Fe] in individual stars. We measured abundances for 170 giant stars in 5 Milky Way globular clusters based on Keck II/DEIMOS spectroscopy to validate our method.

Using DEIMOS, we obtained deep (~5+ hour) spectra of 260 individual red giant branch stars in 4 fields across the outer disk, Giant Southern Stream (GSS; [4]) and inner halo of M31, comprising the largest deep spectroscopic sample in M31 to date. The DEIMOS fields overlap with HST fields with measured star formation histories [5].

Escala et al. 2019



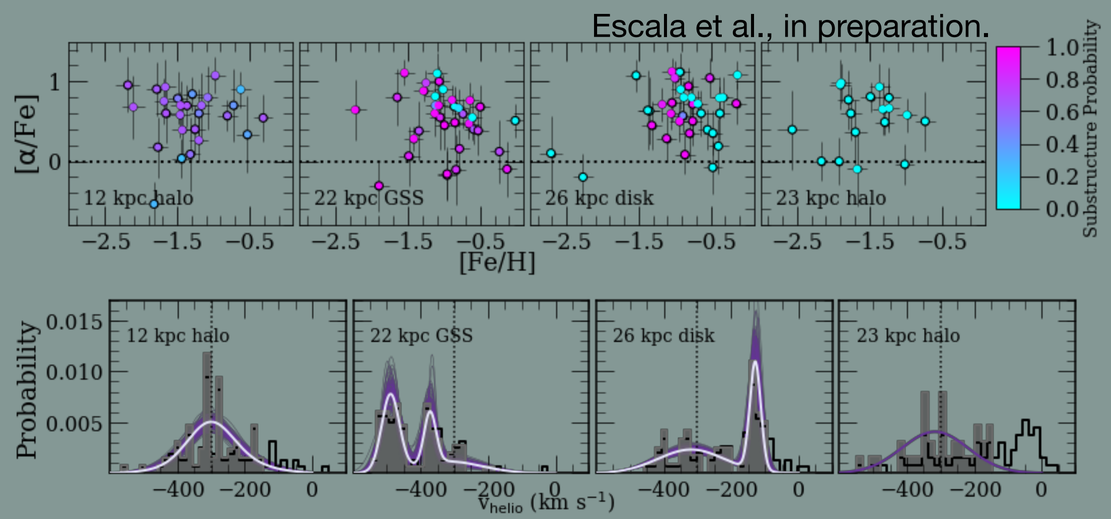
Low-resolution DEIMOS spectrum of a star in MW globular cluster NGC 2419.

Separating stellar populations in M31 into kinematic components

The heliocentric velocity distributions (where M31's systemic velocity is -300 km/s) of M31 RGB stars (grey histograms) show that our spectroscopic sample probes the Southeast shelf [6] in the 12 kpc field, the GSS core and substructure of unknown origin [7] in the 22 kpc field, and the outer disk in the 26 kpc field, whereas the 23 kpc field does not contain substructure.

Based on the velocity distribution in each field, we assigned each of the 70 stars in our abundance sample a probability of belonging to the stellar halo, GSS, disk, or other substructure.

Escala et al., in preparation.



What have we learned about M31?

- The inner halo, GSS, and outer disk of M31 are α-enhanced (> 0.35 dex).
- The GSS core does not show abundance gradients between 17-22 kpc.
- The chemical properties of the GSS are consistent with a massive progenitor that experienced a high star formation efficiency (see also [8]).
- We find evidence for a negative [α/Fe] gradient between the inner halo (this work) and outer halo [9].
- The metal-rich (> -1.5 dex), inner halo (< 26 kpc) is inconsistent with having formed from progenitors similar to present day M31 satellite galaxies ([10]).
- The outer disk is highly α-enhanced (0.60 dex), supporting a global episode of star formation in the disk induced by a major merger (e.g., [11]).

References. [1] McConnachie+2005, [2] McConnchie+2018, [3] Escala+2019, [4] Ibata+2001 [5] Brown+2009, [6] Gilbert+2007, [7] Gilbert+2009b, [8] Gilbert+, submitted, [9] Vargas+2014b, [10] Kirby+, in prep, [11] D'Souza & Bell 2018b