Stream Metallicity Gradients in FIRE

By Jennifer Locke

Abstract:

We propose to quantify the relationship between observed metallicity gradients in streams at present day and the metallicity gradients of the progenitors in the FIRE-2 simulations. We want to understand the relationship between accretion time, progenitor mass, progenitor gradient, and stream gradient.

Background:

In the hierarchical paradigm of galaxy evolution, the dark matter halos of massive galaxies (like the Milky Way and Andromeda/M31) are built up over time through the accretion of smaller dark matter halos, some of which contain dwarf galaxies. The stellar remnants of these accretion events make up the component of the galaxy known as the stellar halo. Debris from a common progenitor dwarf galaxy can be found in stellar streams. By studying the remnants of these accreted galaxies, we can learn both about the mass assembly of the main host galaxy, as well as the properties of the lower mass galaxies that did not survive to the present day.

A stream is a present-day coherent structure in the sky that has an over density of stars in the sky that tend to have coherent motion. These abundance of stars in the stream are moving together. Most streams come from dwarf galaxies getting cannibalized by the Milky Way or Andromeda. The stream is created by the remnants of the cannibalization process.
Galaxies form hierarchically. They start small and then merge over time to get bigger. They grow by cannibalizing smaller dark matter halos over time. As a dwarf galaxy falls in, it stops forming stars because they don't hold on to their gas. Quenching means stop forming stars. Once a galaxy has been tidally disrupted it loses dark matter.

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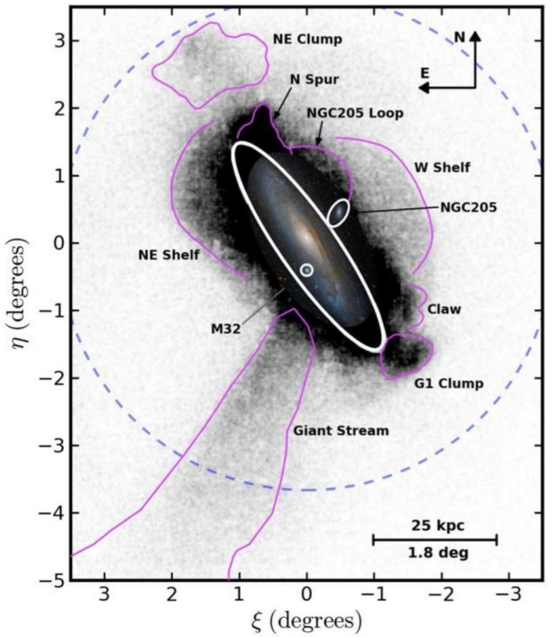
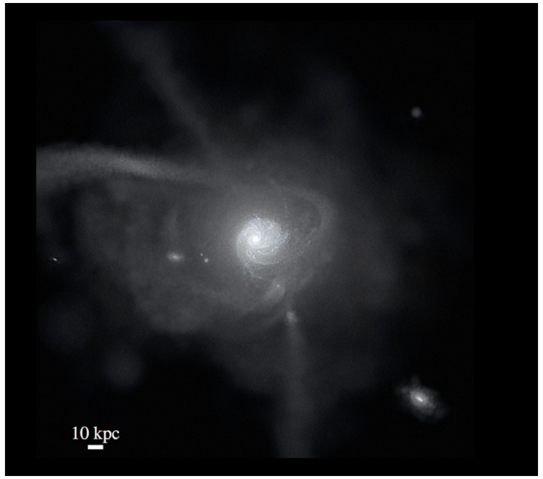
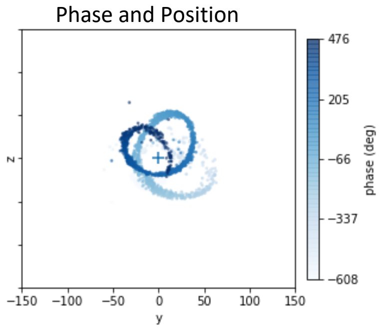
By studying the metallicity (Fe/H abundance) of the star particles, we can try to find if this depends on mass, accretion time, and quenching time. Metallicity is the amount of certain types of metals, like iron or magnesium, in stars, and for our sake, star particles. The biggest occurrence of chemical reactions that create these metals happen during supernovae. Metallicity defines how we look at stellar streams. Metallicity contains clues about the galaxies that these stars formed in. Iron and magnesium track different time scales of star formation, so it tells you something about how efficiently stars are being formed and other elements of its formation history.

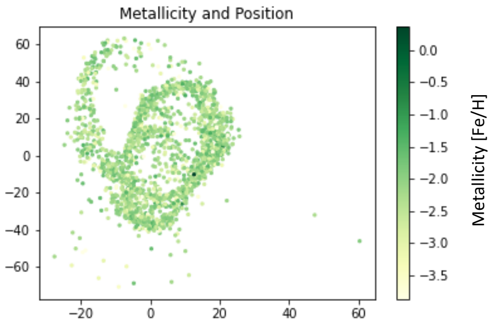




FIRE Simulations:

In a simulation, we create a big box, put everything we know about physics and the universe and everything we think we know about galaxies, see how realistic a galaxy we get out, and then we refine. We like FIRE simulations because they're cosmological zoom-in simulations. We can pick a part of the box that is a milky-way like galaxy. We will just simulate this part of the universe and take in these hyper-dynamical effects on top of dark matter. We combine galaxy formation in a cosmological context and interactions with other galaxies that are forming nearby that are also being simulated. This includes the intergalactic medium that might exist outside of the galaxy. FIRE is also hydro-dynamical: we consider in detail the physics of the gas within the galaxy and the stars that form out of that gas.





Analysis Plan:

- I will study which streams have [Fe/H] (or [Mg/Fe]) gradients, which do not, and how these these depend on mass, accretion time, and quenching time.
- I will try to find a relationship between stream gradients and progenitor gradients before infall.
- I will study how intrinsic gradients in the progenitor map onto observed gradients on the sky.
- I will research if the debris in large stream features preferentially originate from a particular region within the progenitor galaxy.
- I will study the importance, if any, of the morphology of the progenitor.

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