Metallicity Gradients in Simulated Tidal Streams

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Glossary

Simulation: Astronomers simulate the formation of galaxies from the beginning of the universe to the present-day in order to make predictions about the past and make comparisons to observations in the present. These simulations include all known physics, like star formation and gravity.
Dwarf galaxy: Dwarf galaxies are basically smaller versions of galaxies.
Stream: A stream is a present-day coherent structure in the sky that is an over density of stars that tend to move 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.
Metallicity ([Fe/H]): The ratio of the amount of iron to the amount of hydrogen in a star. Iron is produced by supernovae explosions, so the amount of iron in newly formed stars tends to increase over time as the galaxy forms stars. So, metallicity tracks stellar age. It also tracks galaxy stellar mass, because more massive galaxies form stars more efficiently.
Gradient: The metallicity gradient is how the ratio of iron to hydrogen changes as a function of position for the different stars in the stream. We want to understand metallicity gradients in streams, so we can learn about the properties of the cannibalized galaxies that formed the streams.
Infall: The time when the merging process starts between the dwarf galaxy and the host galaxy.

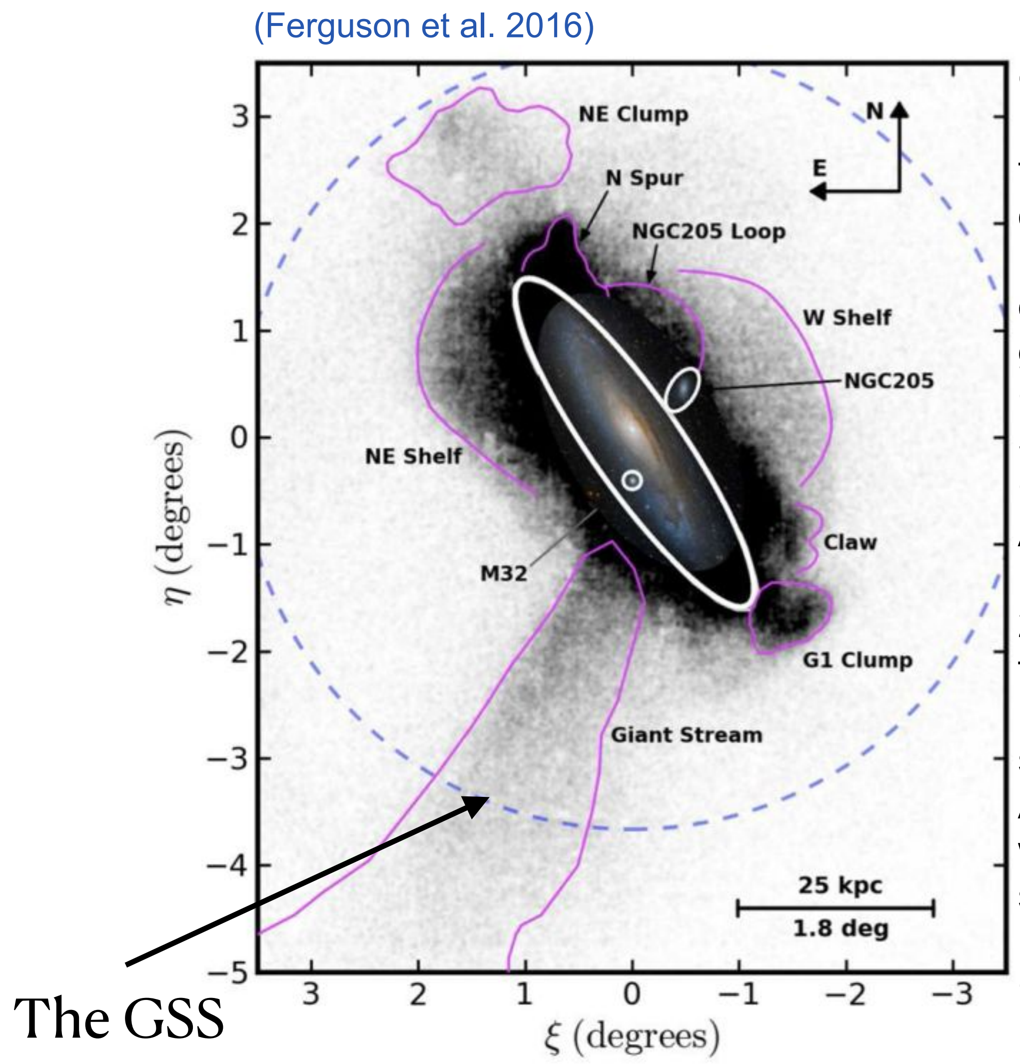

Figure 1: Our study is motivated by the recent observational measurement of a metallicity gradient in the Giant Stellar Stream, or GSS, of Andromeda. (Escala et al. 2021). The figure shows a map of giant stars in Andromeda, where stellar structures including the GSS are highlighted.

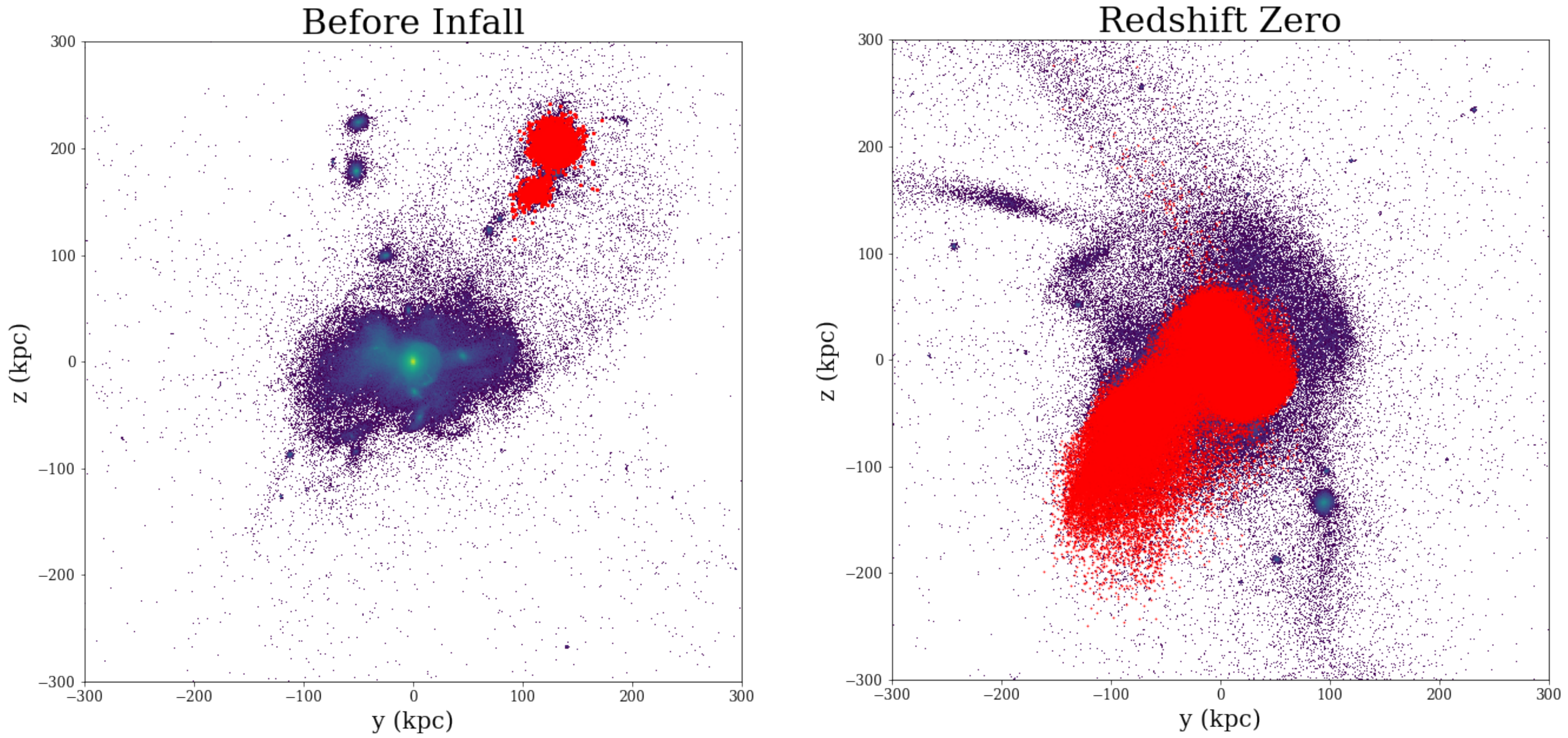

Figure 2: Above is an analog to the GSS (the GSS analog stars are in red) in the simulations both before infall on the left, where we can see that there was at one point two dwarf galaxies, and after infall on the right. The color-coding here represents the projected stellar density in a box 300 kiloparsecs on a side.

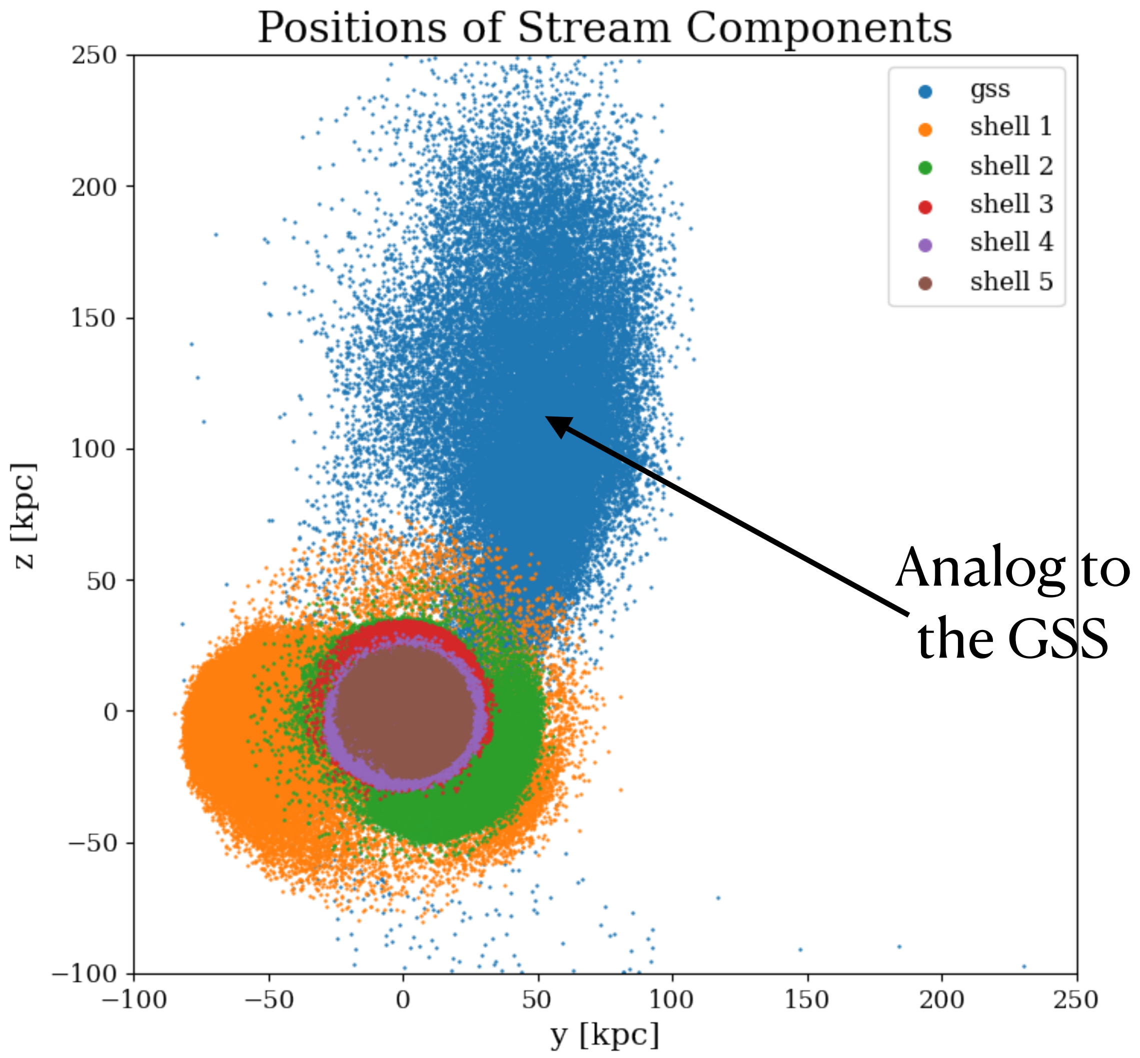

Figure 3: In order to do a detailed study of this particular stream in the simulations, we started by dividing the stream into its different shells and components. The component of the stream that we refer to as the "Giant Stellar Stream" is shown here in blue.

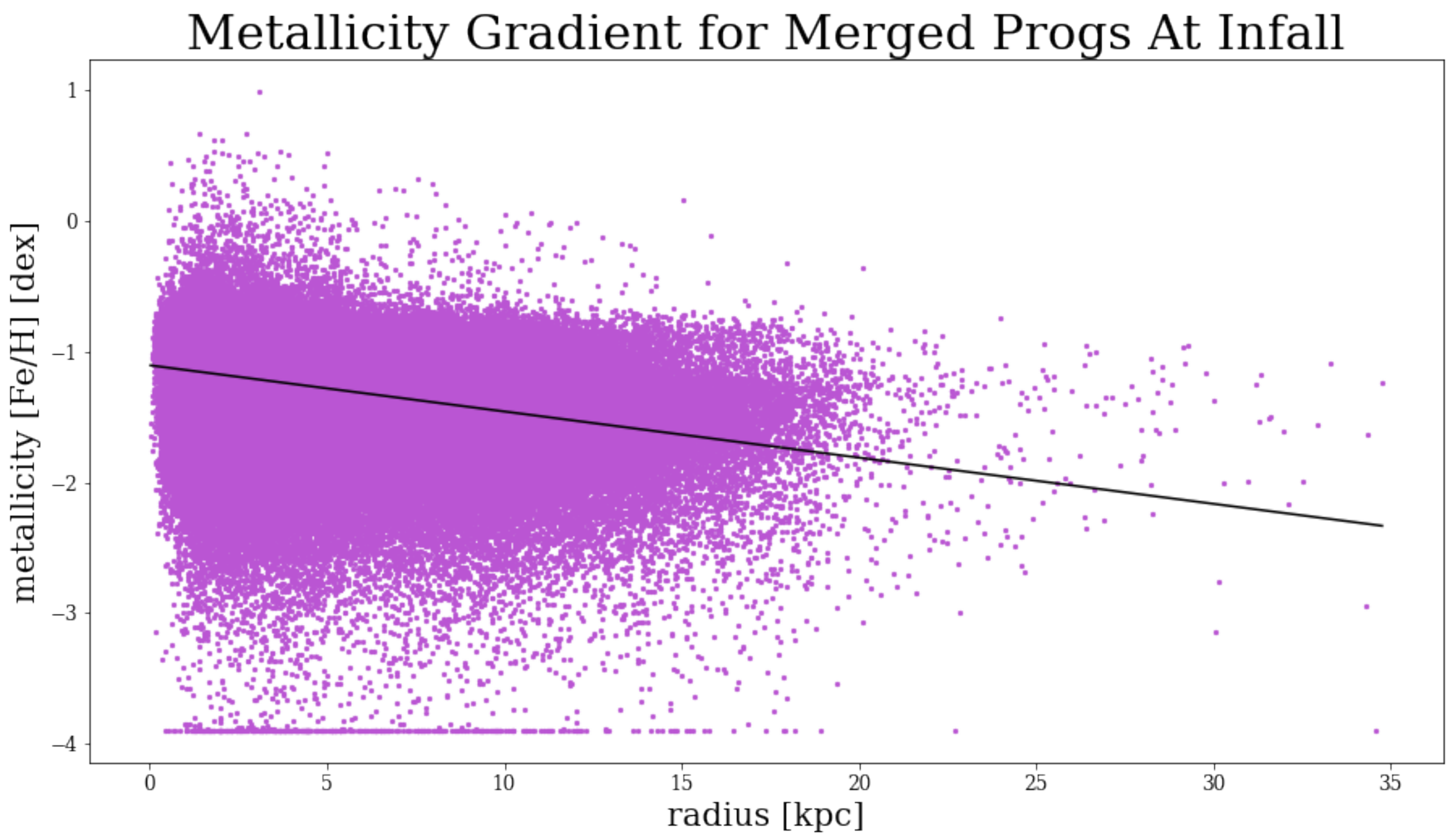

Figure 4: While there is a metallicity gradient in the dwarf galaxies for this system as shown here at infall (the declining metallicity gradient is the black line), we didn't find a significant metallicity gradient when looking at only the GSS component.

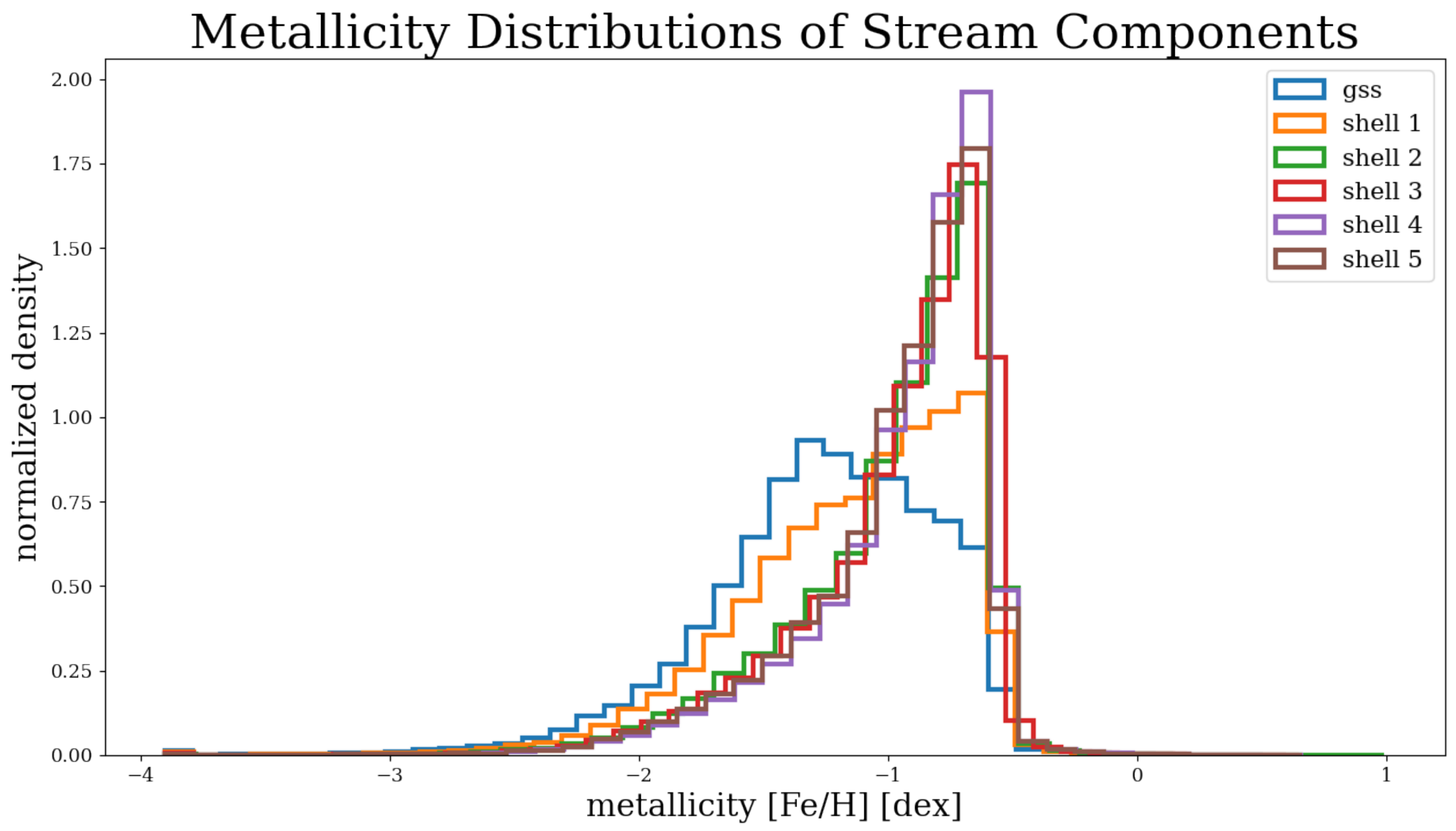

Figure 5: When we look at the metallicity distributions of the stream components, the GSS has on average a much lower metallicity than the subsequent shells. Overall the farther portions of the stream have the lowest metallicities. While we observe a very weak metallicity gradient in the GSS portion of the stream alone, our findings of an evolving mean metallicity over the different portions of the stream are very promising.

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