Unraveling the Dynamics of Stellar Streams in Merging Galaxies

Leah English[1,2], Tjitske Starkenburg[1], Sachi Weerasooriya[3]

1. *Center for Interdisciplinary Exploration and Research in Astrophysics (CIERA), Northwestern University*
2. *Illinois Institute of Technology*
3. *Carnegie Science*

Merging Low-Mass Stellar Streams in an LMC-like Halo

Stellar streams are elongated threads of stars with similar orbits in the outskirts of a galaxy. These stars can give us insight to the formation history of galaxies. Streams formed via accretion confirm that galaxies are formed hierarchically with smaller systems being accreted onto larger ones. The debris from these accretion events contains signatures from the destroyed objects and can tell us more about early universe galaxies by studying their abundances and kinematics (e.g. Helmi 2020). This is why it's important to be able to identify such streams and how merging events affect them, in addition to it telling us more about the future of our own galaxy. These streams can also give constraints on the mass distribution in a dark matter halo (e.g. Johnston 2016, Helmi 2020). *As a dwarf galaxy, called the Large Magellanic Cloud (LMC), is currently merging with our own Milky Way (MW), it is interesting to look at the effect of such a merger on pre-existing stellar streams in the infalling dwarf galaxy.*

The simulation analyzed in this poster is of an LMC-like satellite halo that is merging with a MW-like halo with parameters based on Garavito-Camargo et al. 2019: the host halo has a total mass of M = 1.6*10^12 solar masses, and a scale radius of a = 40kpc, and the satellite halo has a mass of M = 3*10^11 solar masses , and a scale radius of a = 20kpc. There are 512 lower mass (10^4 solar masses) streams and 512 higher mass (10^6 solar masses) streams with a range of initial velocities, positions, orbital eccentricities, stream lengths, and apocenter radii). Each stream contains 1,000 individual star particles. The stream star particles were created in a separate simulation in a static halo potential using the package Gala (Fardal 2015, Price-Whelan 2017) before being put in the simulation with a merging host and satellite halos. This simulation was then run for about 6 Gyr using the N-body code Gadget4 (Springel 2021).

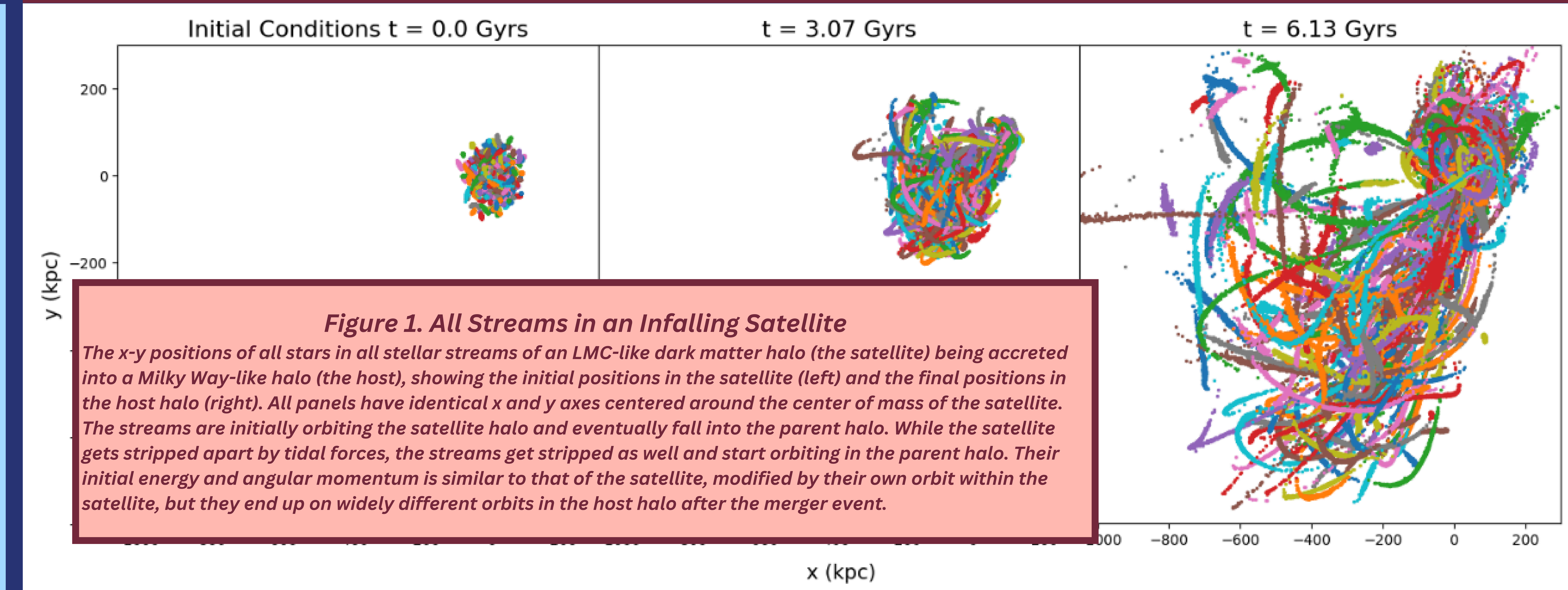


Figure 1. All Streams in an Infalling Satellite

The x-y positions of all stars in all stellar streams of an LMC-like dark matter halo (the satellite) being accreted into a Milky Way-like halo (the host), showing the initial positions in the satellite (left) and the final positions in the host halo (right). All panels have identical x and y axes centered around the center of mass of the satellite. The streams are initially orbiting the satellite halo and eventually fall into the parent halo. While the satellite gets stripped apart by tidal forces, the streams get stripped as well and start orbiting in the parent halo. Their initial energy and angular momentum is similar to that of the satellite, modified by their own orbit within the satellite, but they end up on widely different orbits in the host halo after the merger event.

Single Stream Example

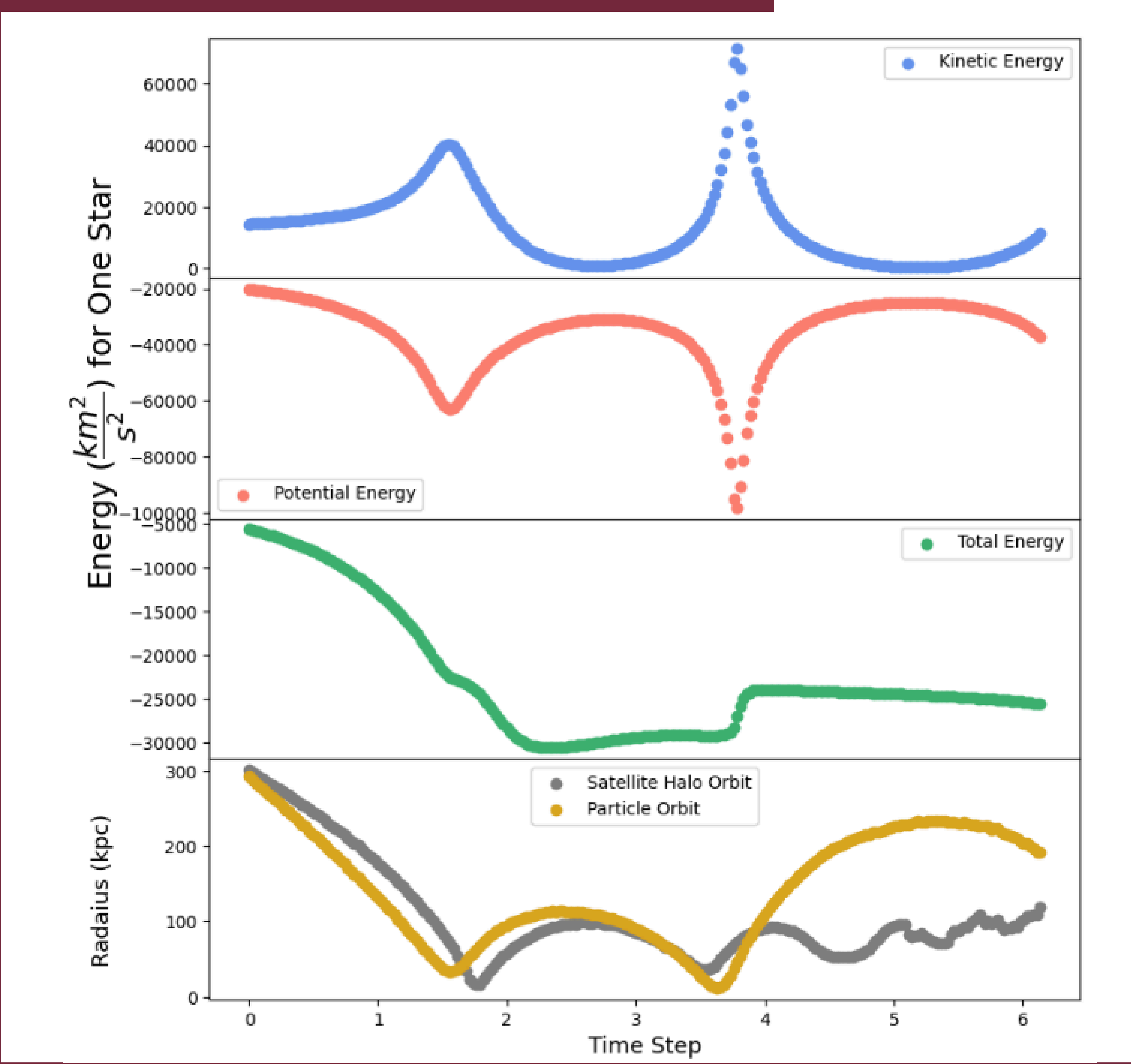


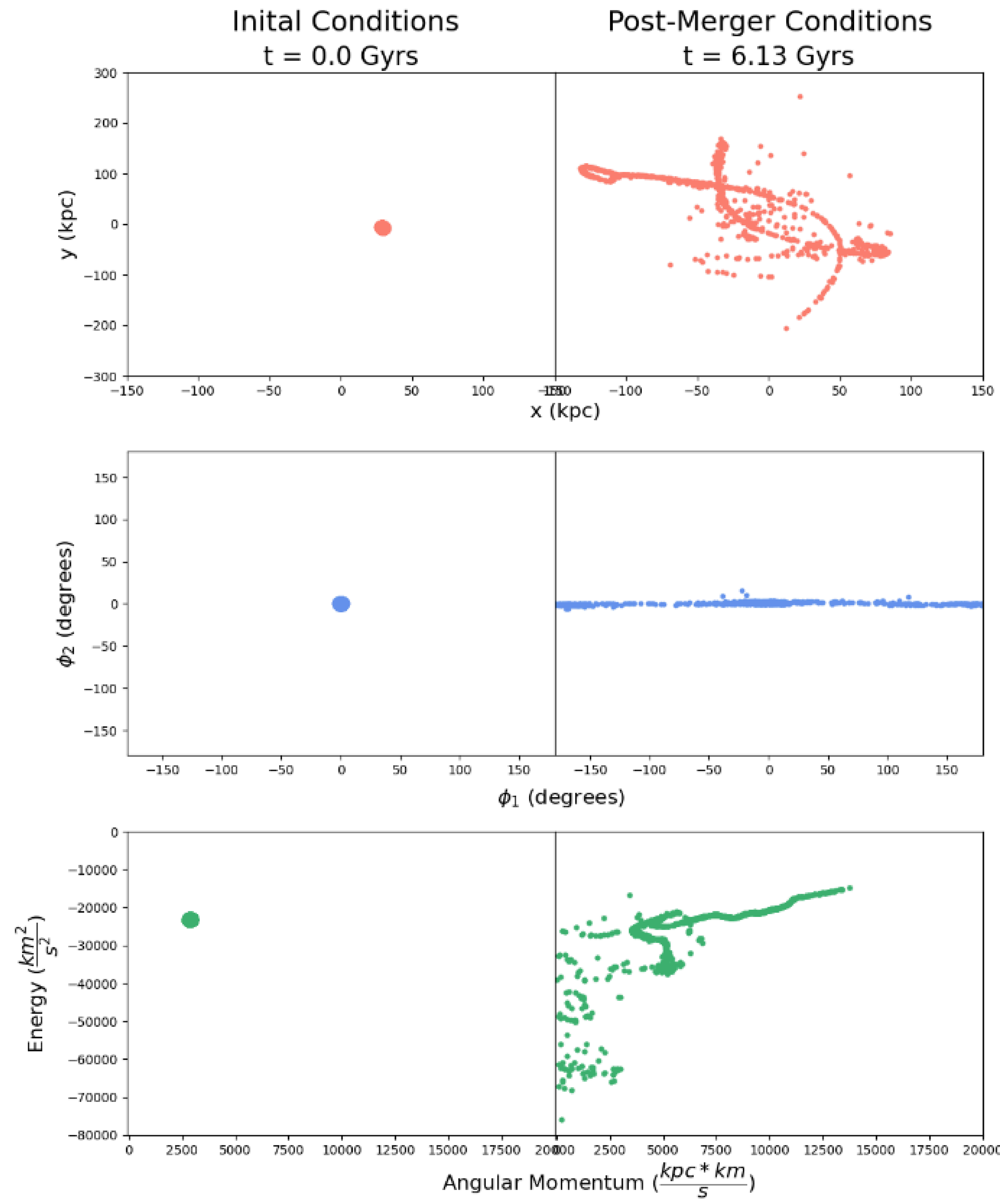
Figure 2 (left) Energy of a Single Star Particle

The figure to the left shows the energy for one star from the stream that's shown in figure 3: kinetic energy (top), potential energy (top-middle), total energy (bottom-middle). The peaks and dips in the kinetic and potential energy show where the satellite gets close to the host halo, so we can see that the satellite orbits and reaches its pericenter before orbiting out again and then finally merging. The star's orbit compared to the satellite's orbit on the bottom panel shows how the star is initially in orbit with the satellite, but the merging event pulls it into it's own orbit. The center of mass of the satellite is poorly constrained after ~4.5 Gyr as the satellite is complete merged in to the host halo.

Figure 3 (right) Evolution of a Single Stream

To the right shows the xy-plane (top), orbital coordinates (middle), and energy and angular momentum (bottom) of one stream in the satellite halo. The initial conditions (left) show how the 1,000 stars within the stream all start with very similar positions, energy, and angular momentum. After the merging event (right), we see that this is no longer the case. The stars are no longer in a recognizable stream-like structure and are now in their own individual orbits around the host halo. It is also interesting to point out that the stream looks like it has split into two in the xy-plane, but all stars are still pretty much on the same orbital plane and is very narrow in the orbital coordinates in the middle panel. This stream splits into two separate streams, and if we zoom in on the orbital coordinates it shows the slight difference in their orbital planes. Since the more defined stream has a larger radius, it corresponds to the line with the higher angular momentum.

I have a movie of these plots over time to better visualize how the streams change! Please ask me about it.



Future Work

- Do a deep analysis of more streams
- Look into more properties of the streams (morphology, orbit, thickness, phases of the orbit)
- Look closer at what's happening during the dips and peaks (large changes in the potential and kinetic energy)
- Look for trends of the evolution of streams with their initial properties.
- Comparing simulations with different mass satellites and satellites with different orbits around the host
- Compare to the evolution of the same streams in isolation in the host halo, and compare the same set of streams when evolving in the host halo when a similar satellite falls in

Key Points

- Streams are lost from the satellite halo and end up with a very wide range of different orbits, energies, and angular momenta in the host halo
- This specific stream is pulled out of the satellite halo's orbit and is split into two separate streams with slightly different orbital planes.
- Some stars are pulled out from their original streams
- The halo is pulled in close and swings out again before completely merging. Some streams are stripped during the first pericenter and some are stripped later

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