Weaving Dreams in the Dark

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Overview

Aim: To investigate the robustness of Merger Timescale(MTS) predictions for satellite galaxies in Semi Analytical Models (SAMs).

In large cosmological simulations, finite mass and force resolution means that satellite galaxies are prone to artificial disruption, and so their orbits cannot always be tracked until the point at which they physically merge. To get realistic lifetimes for these unresolved objects, SAMs use an analytical formula known as the MTS. Because it uses orbital properties to predict when the merger would happen if the halo were resolved, we develop an orbital extraction tool known as **OrbWeaver**. We then test the predictions from the MTS and analyse their shortcomings by comparing to the lifetimes found from a simulation.

Input Orbital Data

The simulation data is from the ASTRO 3D GENESIS high cadence N-Body simulation 105 Mpc 2048[3], with; halos extracted by VELOCIraptor, precisely built merger trees and resolved halo masses down to 10^9 $M_\odot$. We extract the orbital histories of all halos using **OrbWeaver**† (Poulton et al, in prep). An example orbit traced by **OrbWeaver** is given in Fig. 1. It shows the trajectory of a halo that is 1/100 of M_{host} orbiting around its host that does not merge i.e. not lost within $0.1R_{vir,host}$. The ▲ and ● markers represent points at which **OrbWeaver** outputs the interpolated orbital properties of the orbiting halo. This enables an in-depth study of not only how the type of orbit can affect galaxy mergers, but also the types of orbits that are present for a host.

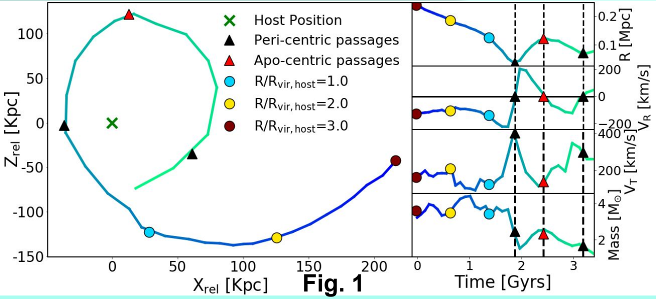

Fig. 1

†This code is publicly available on GitHub: https://github.com/rhyspoulton/OrbWeaver

Merger Timescales

The MTS prescription is from Jiang et al. 2008, which is a widely used formulation implemented by SAMs. The timescale is calculated when the halo crosses $R_{vir,host}$ and gives the expected lifetime (y-axis, Fig. 2). This is compared to the actual lifetime (after crossing $R_{vir,host}$) found in the simulation (x-axis). The MTS calculation is only performed for resolved haloes with at least >1000 particles. The solid red line shows the median of all the satellites in the simulation and the shaded region is the standard deviation. From the figure, it is evident that both are in good agreement for most T_{sim} but disagree for long T_{sim}.

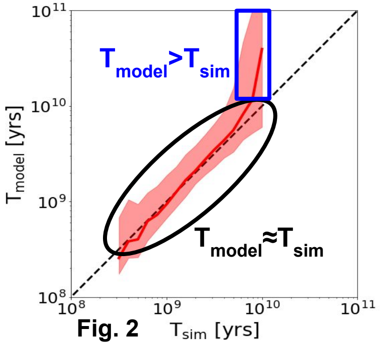

Fig. 2

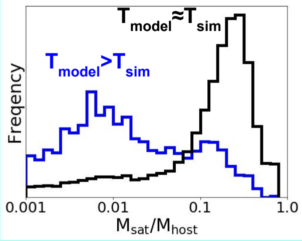

Fig. 3

The agreement between model prediction and simulation depends on the ratio of M_{sat}/M_{host}. Fig. 3 shows that the region with a good agreement is dominated by $M_{sat}/M_{host}>0.05$, whereas small M_{sat}/M_{host} dominates the region with a bad agreement. An example of halo that falls in the latter region is shown in Fig. 1; here, the orbiting halo undergoes a rapid mass loss at the first pericentre rather than the smooth evolution predicted by the MTS. This indicates that there is another mechanism causing this mass loss that is not captured by the MTS. We are currently exploring this for an upcoming paper.

References

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