On Life and Death of Satellite Haloes


We study the evolution of dark matter satellites orbiting inside more massive haloes using semi-analytical tools coupled with high-resolution N-Body simulations. We select initial satellite sizes, masses, orbital energies, and eccentricities as predicted by hierarchical models of structure formation. Both the satellite (of initial mass $M_s^0$) and the main halo (of mass $M_h$) are described by a Navarro, Frenk & White density profile with various concentrations.

We explore the interplay between dynamical friction and tidal mass loss/evaporation in determining the final fate of the satellite. We provide a user-friendly expression for the dynamical friction timescale $\tau_{df, live}$ and for the disruption time for a live (i.e. mass losing) satellite. This can be easily implemented into existing semi-analytical models of galaxy formation improving considerably the way they describe the evolution of satellites.

Massive satellites ($M_s^0 > 0.1M_h$) starting from typical cosmological orbits sink rapidly (irrespective of the initial circularity) toward the center of the main halo where they merge after a time $\tau_{df, rigid}$, as if they were rigid. Satellites of intermediate mass ($0.01M_h < M_s^0 < 0.1M_h$) suffer severe tidal mass losses as dynamical friction reduces their pericenter distance. In this case mass loss increases substantially their decay time with respect to a rigid satellite. The final fate depends on the concentration of the satellite, $c_s$, relative to that of the main halo, $c_h$. Only in the unlikely case where $c_s/c_h \lesssim 1$ satellites are disrupted. In this mass range, $\tau_{df, live}$ gives a measure of the merging time. Among the satellites whose orbits decay significantly, those that survive must have been moving preferentially on more circular orbits since the beginning as dynamical friction does not induce circularization. Lighter satellites ($M_s^0 < 0.01M_h$) do not suffer significant orbital decay and tidal mass loss stabilizes even further the orbit. Their orbits should map those at the time of entrance into the main halo.

After more than a Hubble time satellites have masses $M_s \sim 1 - 10\%M_s^0$, typically, implying $M_s < 0.001M_h$ for the remnants. In a Milky Way like halo, light satellites should be present even after several orbital times with their baryonic components experiencing morphological changes due to tidal stirring.

They coexist with the remnants of more massive satellites depleted in their dark matter content by the tidal field, which should move preferentially on tightly bound orbits.