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Learning from interactions between the Milky Way and satellite galaxies

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Abstract. The Milky Way (MW) is interacting with its satellite galaxies and the tidal remnants of satellite galaxies have been observed especially in the MW halo. Understanding the spatial and velocity distributions of stars stripped from satellite galaxies will be of particular importance when interpreting the data from upcoming observations, such as Gaia, Subaru-HSC and PFS. We study tidal stripping events of satellite galaxies with various internal structures using high resolution N-body simulations. The dynamics of satellite galaxies is dominated by dark matter halos, but their density structure is still uncertain. The simulations reveal satellite galaxies with more tightly bound dark matter halos are more robust against the tidal force of the MW and have longer lifetimes than loosely bound ones (Ogiya *et al.*, in prep.). Density scratches on the MW caused by the gravitational force of satellite galaxies and the observability are also discussed (Ogiya & Burkert 2016).

Keywords. methods: n-body simulations, Galaxy: evolution, Galaxy: kinematics and dynamics

1. Robustness of satellite galaxies to the tidal force of the MW

Satellite systems orbiting inside more massive and larger hosts may be disruped by the tidal force of the hosts. The density structure of their dark matter halos is still under debate (e.g. Walker *et al.* 2009; Strigari, Frenk, & White 2017) and the survivability of dwarf satellite galaxies may depend on it (e.g. Taffoni *et al.* 2003; Peñarrubia *et al.* 2010). We study the fate of satellites using N-body simulations, varying their internal structure. The initial density profile of the satellites is given as $\rho(r) = \rho_{\rm s}(r/r_{\rm s})^{-\alpha}(1+r/r_{\rm s})^{-3+\alpha}$, where r is the distance from the center of the satellite and $\rho_{\rm s}$ and $r_{\rm s}$ express the scale density and length of the satellite, respectively. The inner density slope is controlled by the parameter, α. Another parameter is the concentration defined as $c = r_{\rm vir}/r_{\rm s}$, where $r_{\rm vir}$ is the virial radius of the satellite. Figure 1 shows satellites with steeper cusps (larger α) and higher c (when $c \geqslant 10$) are more robust against the tidal force of the host because they are more tightly bound. If satellites are loosely bound, the mass function may be altered (Ogiya *et al.*, in prep.).

2. Dynamical friction and scratches of orbiting satellites on the MW

Dynamical friction is a fundamental process to govern the orbital evolution of satellite galaxies in larger hosts. As discovered by Chandrasekhar (1943), the origin of dynamical friction is the density scratches created by the satellites on the hosts (Chandrasekhar 1943). So far, only a few numerical simulations have observed the density scratches (e.g. Weinberg & Katz 2007; Antonini & Merritt 2012). We propose an analytical model to predict the response in the density distribution of the hosts and validate it using N-body simulations with high resolutions (Figure 2). We then apply the model to the interaction between the MW and the Large Magellanic Cloud and find that the column density of

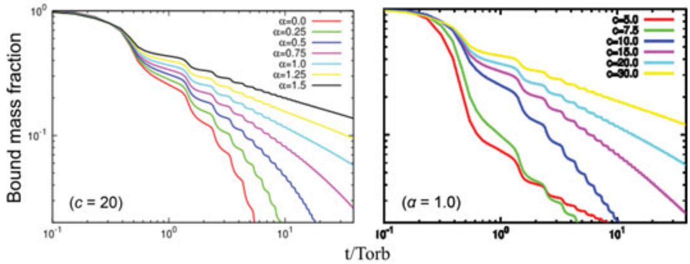

Figure 1. Bound mass fraction of the satellites. Time is scaled by the orbital period. Left and right panels study the dependence on α and c, respectively. In all simulations, the host system is represented by a fixed NFW potential (Navarro, Frenk, & White 1997) with $c = 10$ and a mass 1000 times greater than that of the satellites, and the satellite orbit is assumed to be the typical one observed in cosmological simulations.

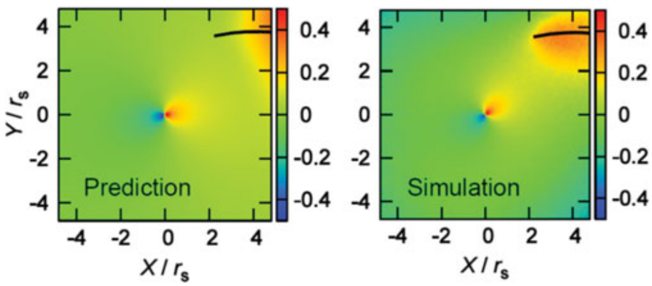

Figure 2. Distribution of enhancement and reduction in the column density of the host system derived by the analytical model (left) and from the simulation (right). The colour bar represents enhancement and reduction in the column density, $\Sigma - \Sigma_0)/\Sigma_0$, where Σ_0 is the initial column density at given position in the host frame. Spatial coordinates are scaled by the scalelength of the host system, r_s. The black line shows the satellite orbit.

the MW in the direction of the Galactic Rotation of the Solar system is expected to systematically exceed that in the opposite direction when one sees the south-side sky (for more details, see Ogiya & Burkert 2016).

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