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Evolution of tidally stripped dark matter subhalos

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The mass of cosmic structures, such as galaxies and galaxy clusters as well as their surrounding dark matter (DM) halos, is a key quantity to characterize themselves. In the scenario of the hierarchical structure formation in the Universe, mergers between them are one of the main drivers for their mass evolution. Various physical mechanisms non-linearly couple with each other and work all together in the merging process. Cosmological N-body simulations have been utilized as the primal tool to investigate the complicated processes of the formation and evolution of DM halos and had tremendous success in reproducing the observations of the cosmic large scale structures. However, van den Bosch (2017) suggested that DM subhalos are artificially disrupted in current state-of-the-art cosmological simulations. This has been actually discussed as the over-merging problem in the past. We call up the classical problem. First, we analytically study various physical mechanisms which may disrupt subhalos and find that they cannot explain the subhalo disruptions in cosmological simulations. Secondly, using a large set of controlled N-body simulations varying numerical parameters, we identify two mechanisms for the artificial disruptions, relating to the spatial and mass resolutions of the simulations, and find two criteria to assess the reliability of the mass evolution of subhalos in the simulations. Thirdly, we make the empirical models for the mass and structural evolution of tidally stripped subhalos using simulations, satisfying the criteria. We will also present galaxy merger simulations, reproducing the observation of the ultra diffuse galaxy of the significant DM mass deficit.

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