Too-Big-To-Fail is in the eye of the beholder – Insights from the MoRIA simulations

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The Too-Big-To-Fail (TBTF) problem states that dwarf galaxy kinematics imply that the dwarfs inhabit lower mass halos than is expected in ΛCDM. It is often cited as a crucial problem for the standard model of cosmology. The problem is present for satellites around the Milky Way and M31, as well as for isolated dwarf galaxies.

Using the MoRIA (Models of Realistic dwarfs In Action) suite of dwarf galaxy simulations, we investigate TBTF. They are run with an extended version of Gadget-2, including radiative cooling, heating by the cosmic UV background, star formation, stellar feedback, chemical enrichment, and Population III star formation. To account for growth over cosmic time, we use the extended Press-Schechter formalism to obtain the progenitors and merger history of a galaxy with a certain final halo mass. These progenitors are initially simulated in isolation and allowed to merge according to the merger tree. The resulting dwarf galaxies were shown to be very realistic, as they reproduce a broad range of dwarf galaxy properties. Together with their high resolution (~$10^{3\text{-}4}$ $M_\odot$ baryonic mass resolution and ~10 pc force resolution), this makes them very well suited to investigate the TBTF problem.

We use astronomical software like GIPSY to obtain the "observed" rotation curve from the datacubes of the simulations. We correct for pressure support, which is non-negligible for these low-mass systems, to obtain the circular velocity profile. However, we find that even this underestimates the dynamical rotation curve, which is what we would theoretically expect from the matter distribution. The reason for this is the fact that these low-mass galaxies do not have a thin disk, making the tilted-ring model and corrections for pressure support inaccurate. This can in turn be attributed to stellar feedback.

When analyzing the MoRIA galaxies like real dwarfs, we find that they suffer from the same apparent TBTF problem as the observed ones. TBTF is thus not a crucial problem for ΛCDM, but rather a result of the different ways rotation curves are obtained for observations and simulations.