**Modeling the Structure of Andromeda’s Dark Matter Halo in the Presence of its Massive Satellite M33**

The Andromeda Galaxy (M31) and its satellites are emerging as one of the most exciting new testbeds of galaxy dynamics and cold dark matter (CDM) theory. Due to its proximity, M31 is the only galaxy system other than the Milky Way for which we can reconstruct the orbits of its satellites and infer its assembly history. Ongoing *HST* observations are revealing the 3-D velocities of M31 and its satellites for the first time, laying the groundwork for determining the dynamical history of the system. However, orbit reconstruction also requires an accurate model of M31’s DM distribution, and current models are too simplistic. State-of-the-art models assume a static, adiabatically contracted NFW profile and neglect the influence of M31’s most massive satellite, M33. We propose to create a suite of high-resolution *N*-body simulations of the interaction between M31 and M33 that will map the time-dependent structure of M31’s DM halo in the presence of M33 for the first time. *HST* and *JWST* are the only facilities with the required resolution to measure proper motions in the M31 system, and our cutting-edge model of M31’s gravitational potential will be crucial for accurately inferring M31’s assembly history from these measurements. Our simulations will provide the foundation for the first detailed dynamical picture of a galactic ecosystem other than the Milky Way, opening a new frontier for testing galaxy formation theories in the CDM paradigm and studying the nature of DM itself.