PROBING TRANSIENT STRUCTURES IN THE UNIVERSE

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One of the key open and nagging questions in cosmology today is our lack of understanding of the nature of dark matter. Despite the remarkable success of the LCDM paradigm and precision tests of the model, dark matter, the major constituent of all matter in the universe remains elusive. The lack of detection of dark matter particles in the various direct detection particle experiments suggests that either we are yet to understand some critical properties of dark matter aside from clustering and its spatial distribution as a function of scale in the universe that astronomical observations have yielded thus far. There are several aspects of the hierarchical build-up of structure that currently remain unexamined. In particular, the re-distribution of dark matter during mergers and the nature of transient phenomena during these processes are yet to be studied in detail. There are, for instance, several missing pieces in our understanding of the assembly history of clusters of galaxies, the dynamics of in-falling groups and transient structures that form during the merger of sub-clusters. Groups of galaxies appear to be the basic building blocks for large-scale structure and with shorter than Hubble time crossing times, they are dynamic astrophysical laboratories to explore the re-distribution of dark matter and baryons. We now know after detailed cluster studies with HST that in-falling groups are the primarily how clusters build up mass. Current high-resolution studies even with Hubble though have not yet systematically explored the formation mechanisms and kinematic properties of galaxy groups. A large UVOIR space telescope, post-JWST with sub-arc-second resolution (ACS quality or better), combined with a large field of view with a filter set that is blue-through red sensitive will be needed to systematically study groups at high and low redshift with comparable fidelity. Color-selected merging sub-clusters and the bursts of star formation that they produce in addition to lensing signatures of the higher redshift background galaxies need to be followed up systematically. To map and track the fate of dark matter in these transient systems, we need to detect down to a magnitude limit of AB = 29-32, akin to the HST Frontier Fields depths over larger areas of the sky. Transient structures offer the best future window to understanding the true nature of dark matter. As we push imaging deeper to bring into focus higher redshift objects, it is clear that we will start detecting unvirialized objects that are very much in the process of assembling. With precision UVOIR data, we will be able to actually detect and calibrate any offsets between light and mass, i.e. between baryonic matter and dark matter that might provide clues to the true nature of dark matter. This is the next frontier, deeper and wider UVOIR imaging that will reveal the earliest structures that are very much in the process of assembling and prior to virializing. Such transient objects will be found abundantly and characterizing their detailed properties might well reveal the nature of dark matter or catalyze a major rethinking of our conception of dark matter. A deep and wide, space-based UVOIR survey is the future instrument and strategy that are needed to uncover the interplay between baryons and dark matter at the earliest cosmic epochs.