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Resolving a Cosmological Tension with Galaxy Cluster Formation Histories

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Our concordance cosmological model describes the history and large-scale structure of the universe using a few key parameters, one of which is the clustering of matter due to density fluctuations in the early universe. Modern constraints on this parameter using different observational methods are in statistical tension. Our ability to resolve this tension is limited by the parameter's degeneracy with the overall matter density when inferred from observations of galaxy clusters. An improved understanding of galaxy cluster formation history can break the degeneracy, providing new insights into this tension in our cosmological model. Using the IllustrisTNG suite of cosmological simulations, we explore structural indicators of the dynamical state of galaxy clusters and their correlations with mass accretion history and formation time. We find that large centre-of-mass offsets, luminosity gaps, and asymmetries in galaxy clusters consistently identify dynamically disturbed systems that have undergone recent major mergers. These structural properties of galaxy clusters observable through x-ray emission, weak gravitational lensing, and intra-cluster light may greatly improve the constraining power of galaxy cluster samples in large forthcoming surveys. By identifying indicators of the dynamical states of galaxy clusters and their relationships to growth history, this work will provide insight into galaxy evolution in different environments, cluster mergers, and the ongoing tension in cosmological parameter constraints.

Keyword-1

Galaxy Clusters

Keyword-2

Cosmology

Keyword-3

Simulation

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