Convergence of Galaxy Properties with Merger Tree Temporal Resolution

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Dark matter halo merger trees are now routinely extracted from cosmological simulations of structure formation. These trees are frequently used as inputs to semi-analytic models of galaxy formation to provide the backbone within which galaxy formation takes place. By necessity, these merger trees are constructed from a finite set of discrete "snapshots" of the N-body simulation and so have a limited temporal resolution. To date, there has been little consideration of how this temporal resolution affects the properties of galaxies formed within these trees. In particular, the question of how many snapshots are needed to achieve convergence in galaxy properties has not be answered. Therefore, we study the convergence in the stellar and total baryonic masses of galaxies, distribution of merger times, stellar mass functions and star formation rates in the Galacticus model of galaxy formation as a function of the number of "snapshot" times used to represent dark matter halo merger trees. When utilizing snapshots between z=20 and z=0, we find that at least 128 snapshots are required to achieve convergence to within 5% for galaxy masses. This convergence is obtained for mean quantities averaged over large samples of galaxies - significant variance for individual galaxies remains even when using very large numbers of snapshots. We find only weak dependence of the rate of convergence on the distribution of snapshots in time - snapshots spaced uniformly in the expansion factor, uniformly in the logarithm of expansion factor or uniformly in the logarithm of critical overdensity for collapse work equally well in almost all cases. We provide input parameters to Galacticus which allow this type of convergence study to be tuned to other simulations and to be carried out for other galaxy properties.

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