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A Local Perspective on Hubble Tension from Cosmological N-body Simulations

We use cosmological N-body simulations to study a local Hubble constant measurement and study the uncertainty introduced by our lack of peculiar velocities. We consider observers to be located in dark matter halos and target galaxies to be distributed amongst dark matter halos. We average over all observers. Our findings show a trend where local measurements have a significant dispersion but these progressively converge toward the global value as we extend our measurements to the local volumes at greater distances. The statistical errors attributed to the influence of the large-scale structure diminish as we move farther away, ultimately reaching a level of comparability with the errors found in Planck and SH0ES measurements at approximately 100 Mpc. Measurements at smaller scales are susceptible to errors arising from peculiar motions and this error can propagate to measurements at larger scales in the distance ladder. Notably, we observe a negative correlation between the local overdensity around an observer and the deviation of the local Hubble constant from the global value. We show that deviations larger than 5% of the global values can be encountered frequently at scales of up to 40 Mpc.

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