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Can blue-tilted primordial power spectrum save the small scale crisis in MW? –From the perspective of Zoom-In simulation for MW host size dark matter halo

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Recent observations from the James Webb Space Telescope revealed a surprisingly large number of galaxies at high redshift, challenging the standard Lambda Cold Dark Matter cosmology with a power-law primordial power spectrum. Previous studies alleviated this tension with a blue tilted primordial power spectrum ($P(k) \propto k^{m_s}$ with $m_s > 1$ at small scales $> 1\ \mathrm{Mpc}^{-1}$). In this study, we examine whether the blue tilted model can boost dark matter substructures especially at low redshift, thereby addressing other potential challenges to the standard cosmology. First, substructures in the standard cosmological model may not be sufficient to explain the anomalous flux ratio problem observed in strong gravitational lensing. Second, the number of observed nearby satellite galaxies could be higher than the theoretical predictions of the standard cosmology, after completeness correction and tidal stripping by baryonic disks. To study the impact of a blue tilted primordial power spectrum on substructures, we perform high-resolution cosmological zoom-in dark matter-only simulations of Milky Way host size halos, evolving to redshift $z = 0$. At $z = 0$, we find that the blue-tilted subhalo mass functions can be enhanced by more than a factor of two for subhalo masses M_{sub}
$lesssim10^{10}$
$msun$, whereas the subhalo V_{max} functions can be enhanced by a factor of four for maximum circular velocities V_{max}
$lesssim30\ \mathrm{km/s}$. The blue-tilted scaled cumulative substructure fraction can be an order of magnitude higher at ∼10\% of the virial radius. The blue-tilted subhalos also have higher central densities, since the blue-tilted subhalos reach the same V_{max} at a smaller distance R_{max} from the center. We have also verified these findings with higher-resolution simulations. This work is based on the preprint https://arxiv.org/abs/2412.16072.

Presenter: WU, Jianhao (CUHK)

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