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The Impact of Stellar-mass Primordial Black Holes on Early Cosmic History

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Using cosmological hydrodynamic zoom-in simulations and semi-analytical models, we explore the role of stellar-mass primordial black holes (PBHs) on first star formation, and their imprint on the cosmic radiation background during the epoch of reionization ($z \geq 6$), combining two competing effects: initial (isocurvature) perturbations induced by PBHs and BH accretion feedback. When PBHs constitute $f_{\rm PBH} \sim 10^{-4} - 0.1$ of dark matter, we find that for PBH masses around $\sim 30~\mathrm{M}_{\odot}$, the standard picture of first star formation in primordial gas clouds by molecular-cooling remains largely unaffected. On larger scales, PBHs accelerate structure formation with enhanced initial perturbations and shift star formation towards more massive halos by heating the gas. However, for $f_{\rm PBH} \sim 10^{-4} - 0.01$, the two effects almost cancel each other out, and the impact of PBHs on the cosmic star formation history at $z \geq 10$ is minimal. For the radiation produced by PBH accretion, PBHs in the intergalactic medium (IGM) and within halos play a crucial role. By $z \geq 30$, PBHs in the IGM are major contributors to the radiation background energy density, but at lower redshifts, accretion feedback in halos prevails. In the UV spectrum, for $f_{\rm PBH} \leq 10^{-3}$, H-ionizing and Lyman-α fluxes from PBHs are consistent with reionization constraints, while in the X-ray domain, they substantially contribute to the cosmic X-ray background. Furthermore, Lyman-Werner photons from PBH accretion might pave the way for direct-collapse BH formation.

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