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The cosmic equation of state & primordial black holes

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Gravitational wave detection has revived primordial black holes (PBHs) as a compelling dark matter candidate. PBH formation from overdensity collapse during the radiation-dominated era depends sensitively on the cosmic equation of state, particularly across the QCD transition. Following Bödeker et al. 2021, I investigate how lepton flavor asymmetries—poorly constrained prior to neutrino decoupling—impact the cosmic trajectory through the 5+1 dimensional space of chemical potentials (μ_B, μ_Q, μ_Le, μ_Lμ, μ_Lτ) and temperature. High lepton asymmetries could remain hidden in the undetectable cosmic neutrino background, enabling exploration of a large parameter space with significant effects on both the cosmic phase diagram trajectory and the resulting PBH mass distribution. I compute the equation of state for various lepton flavor asymmetry scenarios, extending beyond previous work by incorporating charm quark contributions using the latest lattice QCD and functional QCD data.

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