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Resolving the neutrino mass and DESI BAO tensions with neutrino chemical potential

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The standard Planck ΛCDM model is well known to encounter several tensions when confronted with various cosmological data, including the neutrino mass and the DESI BAO tensions. The former tension refers to the neutrino mass constraint from CMB fitting being substantially below the lower bound from neutrino oscillation experiments. In the latter, the BAO scales measured by DESI disagree significantly with the Planck ΛCDM prediction at redshifts below 1. To resolve these tensions, we examine a simple and natural extension of the standard ΛCDM model, which allows relic neutrinos to have finite chemical potentials. We confront this ΛCDMξ model, ΛCDM with neutrino mass Mν and degeneracy ξ3 as additional parameters, with various cosmological datasets. Fitting the ΛCDMξ model to the CMB temperature data, we find 3σ evidence for nonzero neutrino mass (Mν = 0.57 + 0.17 − 0.13 eV) and degeneracy (ξ3 = 1.13 + 0.41 − 0.19), and the O(1) neutrino degeneracy parameter is compatible with galaxy pairwise velocity and Big Bang Nucleosynthesis (BBN) data. Furthermore, the recent DESI BAO data strongly prefer the ΛCDMξ model to the Planck ΛCDM model.

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