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Self-Interacting Neutrinos in Light of Large-Scale Structure Data

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We explore a self-interacting neutrino cosmology in which neutrinos experience a delayed onset of free-streaming. We use the effective field theory of large-scale structure (LSS) to model matter distribution on mildly non-linear scales within the self-interacting neutrino cosmology for the first time. We perform the first combined likelihood analysis of BOSS full-shape galaxy clustering, weak lensing, and Lyman-α forest measurements, together with the cosmic microwave background (CMB) data from Planck. We find that the full data set strongly favors presence of a flavor-universal neutrino self-interaction, with a characteristic energy scale of order 10 MeV. The preference is at the $> 5\sigma$ level and is primarily driven by the Lyman-α forest measurements and, to a lesser extent, the weak lensing data from DES. The self-interacting neutrino model reduces both the Hubble tension and the S_8 tension between different cosmological data sets, but it does not fully resolve either. Finally, we note a preference for a non-zero sum of neutrino masses at the level of $\sim$0.3 eV under this model, consistent with previous bounds. These results call for further investigation in several directions, and may have significant implications for neutrino physics and for future new-physics searches with galaxy surveys.

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