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Exploring Ultralight Scalar Assistance in Sterile Neutrino Dark Matter: Cold Spectrum and Unusual X/Gamma-ray Signatures

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We present a scalar-driven sterile neutrino production model where the interaction with the ultralight scalar field modifies the oscillation production of sterile neutrinos in the early universe. The model effectively suppresses the production of sterile neutrinos at low temperatures due to the heavy scalar mass, resulting in a colder matter power spectrum that avoids constraints from small-scale structure observations. In this model, the dominant dark matter relic is from sterile neutrinos, with only a small fraction originating from the ultralight scalar. Furthermore, the model predicts a detectable X/Gamma-ray flux proportional to the cubic density of local sterile neutrinos for a light scalar mass due to the light scalar coupling tosterile neutrinos. This distinguishes our model from normal decaying dark matter, which has a linear dependence on the density. In addition, the model predicts a potential low-energy monochromatic neutrino signal that can be detectable by future neutrino telescopes.

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