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Very large scale structures in growing neutrino quintessence

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A quintessence scalar field or cosmon interacting with neutrinos can have important effects on cosmological structure formation. Within growing neutrino models the coupling becomes effective only in recent times, when neutrinos become non-relativistic, stopping the evolution of the cosmon. This can explain why dark energy dominates the universe only in a rather recent epoch by relating the present dark energy density to the small mass of neutrinos. Such models predict the presence of stable neutrino lumps at supercluster scales ($\sim$ 200 Mpc and bigger), caused by an attractive force between neutrinos which is stronger than gravity and mediated by the cosmon. We present a method to follow the initial non-linear formation of neutrino lumps in physical space, by integrating numerically on a 3D grid non-linear evolution equations, until virialization naturally occurs. As a first application, we show results for cosmologies with final large neutrino average mass $\sim$ 2 eV: in this case, neutrino lumps indeed form and mimic very large cold dark matter structures, with a typical gravitational potential 10^{-5} for a lump size $\sim$ 10 Mpc, and reaching larger values for lumps of about 200 Mpc. A rough estimate of the cosmological gravitational potential at small k in the non-linear regime, $\Phi_\nu = 10^{-6}(k/k_0)^{-2}$, $1.2 \cdot 10^{-2}$ h/Mpc $< k_0 < 7.8 \cdot 10^{-2}$ h/Mpc, turns out to be many orders of magnitude smaller than an extrapolation of the linear evolution of density fluctuations. The size of the neutrino-induced gravitational potential could modify the spectrum of CMB anisotropies for small angular momenta.