

TITLE: Large-scale structure formation with massive neutrinos and dynamical dark energy

ABSTRACT: Over the next decade, cosmological measurements of the large-scale structure of the Universe will be sensitive to the combined effects of dynamical dark energy and massive neutrinos. The matter power spectrum is a key repository of this information. I use higher-order perturbative methods for computing the power spectrum to investigate these effects on quasi-linear scales. Through comparison with N-body simulations I establish the validity of a Time-Renormalization Group (Time-RG) perturbative treatment that includes dynamical dark energy and massive neutrinos. I also quantify the accuracy of Standard (SPT), Renormalized (RPT), and Lagrangian (LPT) Perturbation Theories without massive neutrinos. I show that an approximation which neglects neutrino clustering as a source for matter clustering predicts the Baryon Acoustic Oscillation (BAO) peak position to 0.25% accuracy for red shifts $1 < z < 3$, justifying the use of Lagrangian perturbation theory for BAO reconstruction in upcoming surveys. Finally, I discuss possible applications and future prospects for perturbative calculations in cosmology.