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The LANCELOT project: Cosmological simulations for Large Scale Structure in the modified theories of gravitation with massive neutrinos

We present LANCELOT: LibrAry for N-body large sCale structurE simuLations in mOdified Theories of gravitation. This library not only incorporates various modified cosmologies but additionally includes massive neutrinos. For modified theories of gravitation, in the current work, we consider three cases: modified teleparallel gravitation $f(T) = T + \alpha(1 - e^{-p\frac{T}{T_0}})$, it's non-minimal matter-torsion coupled extension with $f_1(T) = T$ and $f_2(T) = 1 + \lambda(T/T_0)^b$, Palatini-$f(R)$ gravitation with $f(R) = R - 2\Lambda\left(1 - e^{-R/b\Lambda}\right)$ respectively. For each modified theory of gravity, we obtain the cosmological constraints using various observables. Besides, in order to probe the validity of the aforementioned theories of our consideration, we derive various cosmological parameters, such as deceleration parameter $q(z)$, effective Equation of State (EoS) $\omega_{\rm eff}$, effective gravitational constant $G_{\rm eff}$, age of the universe and linear growth function $f\sigma_8$. As well, we analyze the tension between various free parameters. Furthermore, we modify the N-body simulations suite SWIFT to include non-standard $H(z)$ and $G_{\rm eff}$, run the simulations with $N^{1/3} = 1024$ resolution respectively for each of the 6 models that we consider with both $L_{\rm box} = 100h^{-1}$Mpc and $L_{\rm box} = 1h^{-1}$Gpc. Smaller $L_{\rm box}$ is used to probe the evolution of separate Dark Matter (DM) halos, to construct the Halo Mass Function (HMF) and void abundance profiles, void size function. The latter simulations with huge box size are designed in order to construct the full-sky maps of ISW linear effect and simulate the neutral hydrogen distribution within DM halos.

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