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General Relativity and Cosmic Structure Formation

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The Newtonian approximation which is usually invoked in N-body simulations of cosmic large scale structure relies on the assumptions that gravitational fields are weak and that they are only sourced by nonrelativistic matter. The latter constitutes an implicit assumption about the nature of the “dark” components of the Universe (dark matter and dark energy), thereby precluding a serious assessment of some potentially interesting models. Here we present the first N-body simulations of cosmic structure formation based on a weak field approximation to General Relativity, taking into account all six degrees of freedom of the metric. The geodesic equations are solved consistently also for relativistic particles, such as massive neutrinos. Our approach is very general and can be applied to various settings where the Newtonian approximation would be unreliable or inconsistent, for instance some models of dynamical dark energy or modified gravity.

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