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New viable theories of modified gravity: Minimal Theories and Quasidilaton

Yukawa Institute for Theoretical Physics OLIOSI Michele

Abstract In light of recent developments in the study of cosmology, it is interesting to revisit large-scale modifications of gravity. I will present two new types of models, based on the idea of minimalism in terms of number of degrees of freedom. These have an interesting phenomenology and respect current constraints.

In the last few decades, several alternative models of gravity have been developed in the hope to produce large-scale deviations from general relativity (GR). The principal aim of this program is to uncover what physics could be at works behind the present-day acceleration of the Universe, other than a fine-tuned cosmological constant. However, satisfying the constraints from current observations while guaranteeing full theoretical consistency is still a challenging task for several such constructions. Two notable examples are the instabilities that plague some of the cosmological realizations of massive gravity theories and its extensions, or the recent restrictive bound on the speed of tensor modes from the multi-messenger observation of a neutron star binary merger. Finally, in light of the large number of future observational efforts to constrain the cosmological dynamics as well as the behavior of gravity on these scales, model-building efforts come by as crucial tools to be able to interpret the future data most efficiently.

We show that there exist new classes of alternative theories of gravity that are observationally and theoretically viable, and produce interesting phenomenology. In particular, we focus first on minimally modified gravity (MMG) theories, which propagate only the two tensor modes by means of violations of the Lorentz symmetry in the gravitational sector. In this context, we present a class of theories [1] constructed on the basis of the existence of a frame in which the gravitational Lagrangian is equivalent to GR. As observational constraints, we consider the bound on the speed of tensor modes, as well as on the variation of the gravitational constant. We find that there subsists a wide class of interesting possibilities to modify GR.

As a second example of a new alternative theory of gravity, we construct and study the minimal theory of quasidilaton massive gravity (MQD) [2]. This theory is motivated by some difficulties to find viable homogeneous and isotropic cosmologies in the context of quasidilaton massive gravity theories, but can also be effectively understood as an extension of a specific MMG theory, the minimal theory of massive gravity, by rendering dynamical part of the fiducial metric structure. We show that MQD is viable for a wide region of its parameter space, that it will be efficiently constrained by future cosmological surveys, and can sustain interesting phenomenology, in particular produce weak gravity while propagating the same number of degrees of freedom as usual scalar-tensor theories.

References

[1] K. Aoki, A. De Felice, C. Lin, S. Mukohyama and M. Oliosi, *"Phenomenology in type-I minimally modified gravity"*, JCAP 01 (2019) 017.

[2] A. De Felice, S. Mukohyama and M. Oliosi, *"Phenomenology of minimal theory of quasidilaton massive gravity"*, Phys. Rev. D 99, 044055 (2019).