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Dark energy with a shift-symmetric scalar field: obstacles, loophole hunting and dead ends

by T. Borislavov Vasilev, M. Bouhmadi-López, and P. Martín-Moruno

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Plaza de las Ciencias, 1 28040 Madrid, Spain

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Abstract

We discuss the possibility of a scalar field being the fundamental description of dark energy without the need of self-tuning any parameter. Thereby, we focus on shift-symmetric scalar-tensor theories satisfying also that the propagation speed of gravitational waves is equal to the speed of light. Analysing the stability of scalar linear perturbations, we discuss the conditions that seems to be necessary to describe (super) accelerated cosmic expansion without introducing instabilities. It has been established, however, that this stability can be ruined when taking into account the interaction with tensor perturbations (essentially gravitational waves). Indeed, although we shall point out that the standard proof of absence of dark energy stable braiding models due to this interaction has a possible way-out, we find general arguments suggesting that there are no dark energy stable solutions that can exploit this loophole. Thus, we discuss future research directions for finding viable fundamental descriptions of dark energy. We also provide a dictionary between the covariant version of the scalar field theory and that of the Effective Field Theory approach, explicitly computing the parameters in the latter formalism in terms of the functions appearing in the covariant version, and its derivatives. To the best of our knowledge, this is the first time these expressions are explicitly obtained up-to arbitrary order in perturbation theory.

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