

Safe Phantom Divide Crossing from Unscreened Non-Minimal Coupling to Gravity

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Recent hints of dynamical dark energy, including a possible crossing of the phantom divide inferred from the latest cosmological data, have motivated the search for viable theoretical explanations. Scalar fields non-minimally coupled to gravity with a coupling of the form $F(\varphi) = 1 + \alpha\varphi^2$ are physically motivated and have emerged as promising candidates, providing a significantly improved fit to the data compared to Λ CDM and even outperforming the w_0w_a CDM parametrization. However, in the absence of a screening mechanism, the regions of parameter space examined exhaustively so far in the literature (with $\alpha < 0$) violate stringent local constraints on the strength and time variation of gravity and enhance the amplitude of matter fluctuations at low redshifts and cosmological scales, in tension with galaxy clustering and weak-lensing observations, thereby compromising the actual viability of these solutions. In this work, we investigate a largely unexplored region of parameter space (with $\alpha > 0$) that realizes a crossing of the phantom divide while remaining consistent with Cassini–Huygens bounds and the most recent (and tightest) Lunar Laser Ranging measurements, without introducing higher-derivative terms in the action. This setup, which admittedly is subject to some degree of fine-tuning, fully respects the BBN constraints and leads only to mildly larger values of the effective gravitational coupling in the past, peaking at the onset of dark energy domination at approximately 0.5% above Newton’s constant. We review the background and linear perturbation dynamics of the model, deriving illustrative analytical results that provide physical insight into its behavior, and update the constraints on the model using the latest cosmological data, including the DES–Dovekie supernova sample. We perform for the first time a full-fledged Monte Carlo analysis with $\alpha > 0$, studying also the impact of the variation of G on the supernovae likelihood, and compare the results obtained with $\alpha < 0$.

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