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Modified gravity interpretation of the evolving dark energy in light of DESI data

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The Dark Energy Spectroscopic Instrument (DESI) collaboration has recently released measurements of baryon acoustic oscillation (BAO) from the first year of observations.A joint analysis of DESI BAO, CMB, and SN Ia probes indicates a preference for time-evolving dark energy. We evaluate the robustness of this preference by replacing the DESI distance measurements at $z < 0.8$ with the SDSS BAO measurements in a similar redshift range. Assuming the $w_0 w_a$CDM model, we find an evolution of the dark energy equation of state parameters consistent with ΛCDM. Our analysis of χ^2 statistics across various BAO datasets shows that DESI's preference for evolving dark energy is primarily driven by the two LRG samples at $z_{\rm eff} = 0.51$ and $z_{\rm eff} = 0.71$, with the latter having the most significant impact.

Taking this preference seriously, we study a general Horndeski scalar-tensor theory, which provides a physical mechanism to safely cross the phantom divide, $w = -1$. Utilizing the Effective Field Theory of dark energy and adopting the $w_0 w_a$CDM background cosmological model, we derive constraints on the parameters $w_0 = -0.856 \pm 0.062$ and $w_a = -0.53^{+0.28}_{-0.26}$ at 68% CL. from Planck CMB, Planck and ACT CMB lensing, DESI BAO, and Pantheon+ datasets, showing good consistency with the standard $w_0 w_a$CDM model. The modified gravity model shows a preference over ΛCDM at the 2.4σ level, while for $w_0 w_a$CDM it is at 2.5σ. We conclude that modified gravity offers a viable physical explanation for DESI's preference for evolving dark energy.

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