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Cosmological implications of massive galaxy surveys on dark energy

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We investigate whether dark energy deviates from the cosmological constant (ΛCDM) by analyzing baryon acoustic oscillation (BAO) measurements from the Data Release 1 (DR1) and Data Release 2 (DR2) of DESI observations, in combination with Type Ia supernovae (SNe) and cosmic microwave background (CMB) distance information. We find that with the larger statistical power and wider redshift coverage of the DR2 dataset the preference for dynamical dark energy does not decrease and remains at approximately the same statistical significance as for DESI~DR1. Employing both a shape-function reconstruction and non-parametric methods with a correlation prior derived from Horndeski theory, we consistently find that the dark energy equation of state $w(z)$ evolves with redshift. While DESI DR1 and DR2 BAO data alone provide modest constraints, combining them with independent SNe samples (PantheonPlus, Union3, and the DES 5-year survey) and a CMB distance prior strengthens the evidence for dynamical dark energy. Bayesian model-selection tests show moderate support for dark energy dynamics when multiple degrees of freedom in $w(z)$ are allowed, pointing to increasing tension with ΛCDM at a level of roughly 3σ (or more in certain data combinations). Although the methodology adopted in this work is different from those used in companion DESI papers, we find consistent results, demonstrating the complementarity of dark energy studies performed by the DESI collaboration. Although possible systematic effects must be carefully considered, it currently seems implausible that ΛCDM will be rescued by future high-precision surveys, such as the complete DESI, Euclid, and next-generation CMB experiments. These results therefore highlight the possibility of new physics driving cosmic acceleration and motivate further investigation into dynamical dark energy models.

Collaboration you are representing

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