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Can Future CMB Data Discriminate Between a Cosmological Constant and Dynamical Dark Energy ?

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Recent cosmological analyses combining Planck CMB data with baryon acoustic oscillation (BAO) measurements from the DESI collaboration have revealed a statistically significant preference for evolving dark energy (DE) models over the standard cosmological constant. In particular, fits using the Chevallier–Polarski–Linder (CPL) parameterization indicate a $\sim 4\sigma$ deviation from a constant equation of state, suggesting a possible departure from the ΛCDM paradigm. In this work, we investigate whether forthcoming cosmic microwave background (CMB) experiments such as CMB-S4 and Simons Observatory (SO) can independently discriminate between ΛCDM and these dynamical dark energy scenarios without relying on external low-redshift data. We perform a detailed Fisher matrix forecast and mock likelihood analysis using fiducial cosmologies consistent with current DESI+Planck-preferred CPL models. Our results show that, under realistic experimental assumptions, next-generation CMB data can place meaningful constraints on DE evolution parameters w_0 and w_a, and potentially detect departures from a cosmological constant at the ~ 2–3σ level. We discuss the implications for model selection and the robustness of CMB-based probes in testing extensions to the standard cosmological model.

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