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A Test of the Standard Cosmological Model with Geometry and Growth

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We perform a general test of the ΛCDM and wCDM cosmological models by comparing constraints on the geometry of the expansion history to those on the growth of structure. Specifically, we split the total matter energy density, Ωm , and (for wCDM) dark energy equation of state, w, into two parameters each: one that captures the geometry, and another that captures the growth. We constrain our split models using current cosmological data, including type Ia supernovae, baryon acoustic oscillations, redshift space distortions, gravitational lensing, and cosmic microwave background (CMB) anisotropies. We focus on two tasks: (i) constraining deviations from the standard model, captured by the parameters $\Delta\Omega m \equiv \Omega m\hat{}\{grow\} - \Omega m\hat{}\{geom\}$ and $\Delta w \equiv w\hat{}\{grow\} - w\hat{}\{geom\}$, and (ii) investigating whether the S8 tension between the CMB and weak lensing can be translated into a tension between geometry and growth, i.e. $\Delta\Omega m \neq 0$, $\Delta w \neq 0$. In both the split ΛCDM and wCDM cases, our results from combining all data are consistent with $\Delta\Omega m = 0$ and $\Delta w = 0$. If we omit BAO/RSD data and constrain the split wCDM cosmology, we find the data prefers $\Delta w < 0$ at 3.6σ significance and $\Delta\Omega m > 0$ at 4.2σ evidence. We also find that for both CMB and weak lensing, $\Delta\Omega m$ and S8 are correlated, with CMB showing a slightly stronger correlation. The general broadening of the contours in our extended model does alleviate the S8 tension, but the allowed nonzero values of $\Delta\Omega m$ do not encompass the S8 values that would point toward a mismatch between geometry and growth as the origin of the tension.

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