Constraining the Timing and Sharpness of the Cosmic Acceleration Transition

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Cosmic acceleration is usually described by the transition redshift, which marks when the universe changed from slowing down to speeding up. This study examined whether the transition could also be characterized by how suddenly it happened, in addition to when it occurred. This study combined cosmic chronometer and baryon acoustic oscillation measurements of the expansion rate H(z) and applied Gaussian process modeling to reconstruct model-independent smooth expansion histories. From these reconstructions, this study calculated the deceleration parameter q(z) identified the first transition to acceleration below redshift 0.8, and introduced a slope-based metric, delta z dyn, to quantify how gradual or abrupt the transition was. Across multiple reconstruction models, the transition redshift consistently remained between 0.47 and 0.49, while delta z dyn ranged from 0.41 to 0.57. These values were compared to analytical predictions from the standard cosmological model Lambda CDM with Omega m equal to 0.30, which predicts a transition redshift of 0.67 and delta z dyn of 1.67. The data-driven reconstructions indicate an earlier and sharper transition than predicted by Lambda CDM. Robustness tests showed that these results remained stable across different modeling choices and redshift limits. These results demonstrate that delta z dyn provides a practical and complementary method to characterize the onset and dynamics of cosmic acceleration, which allows for more detailed comparisons between observational data and cosmological models. Improving understanding of this transition’s dynamics can help refine models of dark energy and the future behavior of cosmic expansion.

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