

[ABSTRACT]

The dark energy equation of state parameter w is measured with sufficient accuracy to discover that w must differ from -1 in the flat Λ CDM universes, namely dark energy is not the cosmological constant. A series of large-volume galaxy redshift surveys samples up to redshift ~ 0.8 produced by the Sloan Digital Sky Survey are used in the analysis, and the expansion history of the universe was measured using an extended version of the Alcock-Paczyński test (Park et al. 2019). The test exploits the fundamental fact that gravity is an isotropic force and the statistical pattern of galaxy clustering can be used as a standard shape that is conserved with time.

The new analysis of the SDSS data indicates that the expansion of the universe is indeed accelerating but the acceleration is a little slower than expected in the flat Λ CDM universe. The dark energy equation of state parameter is measured to be $w = -0.903 \pm 0.023$, a 4.2σ deviation from -1 ! This finding of a new "w tension" inevitably leads us to discard the cosmological constant as the source for the accelerated expansion and consider alternative quintessence models. We are now making a more accurate measurement of w using the upcoming DESI survey data to test if w is constant or evolving.