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Cover Story (Issue 1, 2026): A focused review of quintom cosmology: from quintom dark energy to quintom bounce

Author: Zu-Hui Fan (South-Western Institute for Astronomy Research, YNU, Kunming)

The dark energy (DE) is the dominant component in the present Universe. Understanding its nature is ultimately important and has long been one of the key challenges in the 21st century. The recent Baryonic Acoustic Oscillation (BAO) measurements from DESI DR2 combined with PLANCK cosmic microwave background radiation (CMB) and supernovae data have marked an important milestone in DE studies. The derived constraints, either from the parameterized equation of state of DE [1] or non-parameterized analyses [2], strongly suggest that DE should be dynamical with its equation of state parameter w crossing the cosmological constant boundary (CCB) $w=-1$. This is in line with the characteristic property of the Quintom dark energy model proposed by Prof. Xinmin Zhang and his team about 20 years ago, motivated by the observational analyses back then.

Given the importance of the observational advance, the article entitled "A Focused Review of Quintom Cosmology: From Quintom Dark Energy to Quintom Bounce" by Qiu, T.T., Cai,Y.F., Liu,Y., Li, S.Y., Evslin, J. and Zhang, X.M. [3] presents a timely and very stimulating review that will benefit the community profoundly. This article is the second review from the team with the first one [4] presenting the Quintom DE model constructions that can overcome the no-go theorem to realize the $w=-1$ crossing.

The current review focuses on the extension of the Quintom theory to the early Universe, namely Quintom Bounce, that can effectively mitigate the singularity problem of the Big Bang Theory. Three most representative Quintom theories, the two-field model, the single field model with higher derivative and the modified gravity model, are discussed. In all these cases, the background evolution shows a nonsingular bounce behavior. Furthermore, in this scenario, the cyclic Universe can be realized, in which the Universe avoids singularity not only once but forever by alternate domination of the quintessence and phantom components in the two-field model. This can lead to a fundamental change of the view of our Universe: it may live forever, instead of crashing into catastrophic fate of big crunch or big rip.

The authors further review the perturbation theory within the quintom bounce framework. It is shown that perturbations can have nearly scale-invariant power spectrum. In extremely large scales, the contraction and bounce era will give rise to a suppression of the angular power spectrum, which can potentially explain the CMB anomalies from PLANCK observations.

In summary, this article reviews excellently the essence of the quintom bounce scenario, from the background evolution to the perturbations, and from the single bounce to the infinite cyclic. What is particularly inspiring is that the Quintom framework can provide a unified understanding for both the late-time DE and the early-time singularity problem.

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