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Dynamical System Analysis of Barrow Holographic Dark Energy

Invited Talk

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Abstract

Dynamical systems theory offers a profound framework for understanding the evolution of various physical systems, including cosmological models. At its core, a dynamical system is a set of functions that describe how the state of a system evolves over time according to specific rules, typically represented by differential equations. We investigate the cosmological implications of the Barrow Holographic Dark Energy (BADE) model within the framework of $f(Q, L_m)$ gravity, specifically considering the model $f(Q, L_m) = \alpha Q + \beta L_m$, where α and β are free parameters. Here, $f(Q, L_m)$ is a general function of the non-metricity scalar Q and the matter Lagrangian L_m. Using a dynamical system approach for both non-interacting and interacting scenarios, we identify critical points corresponding to different phases of the Universe's evolution, including matter domination, radiation domination, and dark energy-driven accelerated expansion. Our analysis reveals two stable critical points in the non-interacting case and three stable critical points in the interacting case, each indicating a transition to a stable phase dominated by BADE. The phase plots clearly demonstrate the evolution of the Universe's dynamics toward these stable points. At these stable points, the deceleration parameter is negative, consistent with accelerated expansion, and the equation-of-state parameter suggests that BADE behaves as a dark energy component. These findings highlight the BADE model's strength as a viable explanation for the Universe's late-time acceleration within $f(Q, L_m)$ gravity and provide novel perspectives on the cosmic development of dark energy–matter interactions.

Keywords: Dynamical systems, Barrow holographic dark energy, modified gravity, phase-space analysis, cosmic acceleration

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