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Comparing Dark Energy Models in Extended Theories of Gravity

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The wide range of modified gravity theories proposed to address the limitations of General Relativity (GR) presents a challenge in distinguishing between them. In particular, the Geometric Trinity of Gravity - comprising General Relativity, based on curvature; Teleparallel Gravity, which relies on torsion and Symmetric Teleparallel Gravity, which is formulated in terms of nonmetricity- are dynamically equivalent. This raises fundamental questions about the underdetermination of the geometric nature of spacetime and whether observational distinctions between these frameworks are possible.

Since these theories are phenomenologically equivalent to GR, obtaining deviations from it requires considering extended versions, where the Lagrangian is an arbitrary function of the corresponding geometric invariants: $f(R)$, $f(T)$ and $f(Q)$.

We compare these three classes of modified gravity theories by evaluating which of them are compatible with a CDM expansion history using a reconstruction approach.
Our main objective is to determine which of these theories can account for cosmic acceleration without invoking a cosmological constant.
We show that for these theories, an exact CDM behavior can only be reproduced with a cosmological constant. This motivated extending the analysis to more general theories that incorporate boundary terms and matter couplings.

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