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The Goldstone Awakens: Unimodular dark energy in scale-invariant R^2 gravity

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Abstract

We construct an R^2 cosmology based on scale invariance and unimodular gravity in which the Goldstone boson of dilatations establishes a predictive connection between inflation and dark energy. The conservation of the corresponding Noether current confines the inflationary trajectory to a one-dimensional orbit in field space, freezing the Goldstone direction and rendering the inflationary dynamics effectively single field. After inflation, the system settles on a Minkowski vacuum manifold. The unimodular integration constant, already present in the full theory but negligible during inflation, lifts the flat Goldstone direction, generating an exponential potential for the canonically normalised field. Unlike in phenomenological quintessence models, its slope is not a free dark-energy parameter, but is instead fixed by the field-space geometry inherited from the inflationary attractor. This geometry excludes matter-era tracking and, throughout the inflationary viability region, places the field in the thawing regime compatible with accelerated expansion. For a representative inflationary benchmark, the now pseudo-Goldstone field remains frozen until close to the present epoch, yielding dark-energy equation-of-state parameters $(w_0,w_a)simeq(-0.992,-0.011)$ in the CPL parametrisation $w(a)=w_0+w_a(1-a)$. More generally, the same parameter controlling the inflationary spectral tilt also fixes the slope of the dark-energy potential, leading to a tight correlation between early- and late-Universe observables: increasing the thawing signal lowers n_s, while values of n_s closer to unity drive the model towards $Lambda$CDM.

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