Active Screen Gravity: Running Planck Mass as the Origin of the Inflationary Attractor

Abstract

We propose a scalar–tensor framework in which the inflationary observables are governed by a renormalization–group (RG) flow of the gravitational coupling. Instead of modifying the inflaton potential directly, we allow the effective Planck mass to vary as a function of the scalar field, leading to an effective Einstein–frame potential $U = V/F^2$. We show analytically and numerically that the spectral tilt and tensor amplitude arise from geometric derivatives of F rather than from the shape of V. The model predicts a linear shift in n_s and a quadratic suppression of r, producing a characteristic trajectory in the (n_s, r) plane and an observational attractor consistent with current data.

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1. Motivation

Plateau inflation models successfully reproduce the observed scalar tilt but generically predict a tensor amplitude $r \sim 10^{-3}$. Lowering r typically requires tuning the potential. Here we explore a different mechanism: running gravitational coupling.

Instead of modifying the inflaton potential, we modify the geometry experienced by the scalar field through a field-dependent Planck mass:

$$S = \int d^4x \sqrt{-g} \left[F(\chi) R - 1/2 (\partial\chi)^2 - V(\chi) \right]$$

After conformal transformation to the Einstein frame the effective potential becomes

$$U(\chi) = V(\chi) / F(\chi)^2$$

Thus inflation is controlled not only by V but also by the RG structure of gravity.

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2. RG Interpretation

We postulate that the gravitational coupling runs according to a quadratic beta function

$$dG/d \ln \mu = a G^2$$

Solving:

$$G(\mu) = G_0 / (1 - a G_0 \ln(\mu/\mu_0))$$

The effective Planck mass is $M_{Pl}^2 = 1/G$, hence

$$M_{Pl}^2(\mu) \approx M_0^2 (1 + a \ln(\mu/\mu_0) + \dots)$$

Identifying the RG scale with the scalar field amplitude

$\mu \propto e^{\chi/\Delta}$

we obtain a localized deformation of the Planck mass:

$F(\chi) \approx 1 + \beta \exp[-(\chi - \chi_0)^2 / \Delta^2]$

Therefore the Gaussian feature is not an ansatz but the low-order expansion of a running gravitational coupling around a transition scale χ_0.

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3. Inflationary Dynamics

Slow-roll parameters in the Einstein frame depend on derivatives of U:

$\varepsilon = 1/2\, (U'/U)^2 \quad \eta = U''/U$

Using $U = V/F^2$ gives

$U'/U = V'/V - 2F'/F$

$U''/U \approx V''/V - 4(V'/V)(F'/F) - 2F''/F$

For plateau potentials $\varepsilon \ll |\eta|$, therefore

$n_s - 1 \approx 2\eta \approx (n_s - 1)_{Star} - 4F''/F$

Thus the scalar tilt is controlled by curvature of the Planck mass.

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4. Tensor Suppression

The tensor-to-scalar ratio

$r = 16\varepsilon$

becomes

$\sqrt{(2\varepsilon)} = |V'/V - 2F'/F|$

The geometric term cancels the potential slope, producing a flattened effective potential:

$r(\beta) \approx r_0 (1 - \gamma\beta)^2$

Hence gravitational waves are suppressed without altering the scalar tilt mechanism.

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5. Observational Predictions

The model predicts a correlated trajectory:

$n_s \approx 1 - 2/N - C\beta$ $r \approx r0 (1 - \gamma\beta)^2$

Consequences: - Starobinsky limit: $\beta \to 0$ - Observed universe: $\beta \approx O(10^{-2})$ - Tensor amplitude: $r \sim 10^{-4}$

This differs from α-attractors where r varies independently of n_s.

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6. Robustness and Naturalness

Parameter scans show: - Broad range of $\chi 0$ produces correct tilt - Natural Planck-scale widths $\Delta \sim O(1–4)$ - Continuous degeneracy band in parameter space

Therefore the solution is an attractor rather than a fine-tuned point.

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7. Physical Interpretation

Inflation occurs on the shoulder of a running gravitational coupling. The scalar field rolls down its potential while simultaneously climbing the Planck mass gradient. The balance defines a fixed observational point.

The measured spectral index corresponds to a specific value of the gravitational beta function.

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8. Conclusion

We have shown that: 1) The spectral tilt originates from curvature of the running Planck mass 2) The tensor suppression originates from its slope 3) The Gaussian deformation arises from RG flow expansion 4) The observed universe corresponds to a gravitational fixed trajectory

This framework links inflationary observables directly to the renormalization structure of gravity rather than to a tuned scalar potential.

Future CMB experiments capable of probing $r \sim 10^{-4}$ can test this prediction and distinguish running-gravity inflation from standard attractor models.