Active-Screen Gravity

Conceptual Picture

We explore the possibility that gravity is not a fundamental constant interaction but an emergent response of microscopic degrees of freedom associated with a Planck-scale screen.

In this interpretation the Newton coupling becomes scale dependent $G(\mu)$. Matter fluctuations induce a renormalization flow described by

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

whose solution reads

$$G(\mu)=G0/(1-aG0\ \ln(\mu/\mu0)).$$

The coupling is therefore nearly constant in the infrared but grows toward ultraviolet scales.

Vacuum Energy as Screen Tension

If the microscopic screen defines the gravitational response, its characteristic length obeys $L^2 \propto 1/G$.

The vacuum energy density becomes surface tension energy

$$\rho\Lambda \sim 1/(L^2\ G)$$

leading directly to $\Lambda(\mu) \propto G(\mu)$.

Hence the cosmological constant is not constant but follows the renormalization flow.

Cosmic Expansion

Identifying μ with the Hubble rate H gives $\Lambda(H)=\Lambda0/(1-aG0\ \ln(H/H0))$.

From energy conservation the equation of state becomes

$$w(z) \approx -1+\nu\ \ln(1+z)$$

with $\nu \approx aG0 \approx 10^{-2}$.

The universe therefore mimics ΛCDM at zeroth order while predicting a measurable drift.

Inflation

At very early times H is large and the vacuum energy approaches a quasi constant value.

This generates a de-Sitter phase without introducing an inflaton field.

The slow-roll parameter $\varepsilon \approx aG$ naturally lies near 10^{-3}–10^{-2} producing $N \approx 50$–70 e-folds and spectral index $n_s \approx 0.965$.

Black-Hole Horizons

In strong gravity the scale becomes local $\mu(r) \approx (M/r^3)^{1/4}$.

The running coupling modifies the metric near the horizon, preventing perfect absorption and introducing partial reflection.

The system behaves as a cavity between the photon sphere and the critical RG surface.

Gravitational-Wave Echoes

The round-trip time yields $\Delta t \approx 2 r_s \ln(M/M_{pl})$, about 0.1 s for stellar-mass black holes.

The reflection coefficient $\sim 10^{-2}$ predicts echoes detectable by next-generation detectors.

Unified Picture

A single renormalization flow connects inflation, late cosmic acceleration and horizon microphysics.

Each regime corresponds to a different scale of the same coupling rather than independent mechanisms.

Appendix:

Conceptual Picture

Gravity is treated as an emergent interaction with a scale-dependent Newton coupling $G(\mu)$.

Matter fluctuations induce RG flow $dG/d\ln\mu = a G^2$ with solution $G(\mu)=G_0/(1-aG_0 \ln(\mu/\mu_0))$.

Cosmic Expansion

Identifying $\mu \sim H$ yields $\Lambda(H) \propto G(H)$ and $w(z) \approx -1+\nu \ln(1+z)$ with $\nu \approx aG_0 \approx 10^{-2}$.

Inflation

At large H the vacuum energy becomes quasi-constant generating de Sitter expansion with $n_s \approx 0.965$ and $r \approx 0.01$–0.1.

Black-Hole Echoes

Local scale $\mu(r) \approx (M/r^3)^{1/4}$ modifies near-horizon absorption producing GW echoes with delay ~ 0.1 s for stellar-mass BH.

Appendix A — Detailed Derivations

1. RG Solution

Starting from beta function:

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

Separate variables:

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

Integrate:

$-1/G = a \ln\mu + C$

Using boundary $G(\mu_0)=G_0$:

$C = -1/G_0 - a \ln\mu_0$

Therefore:

$G(\mu)=G_0/(1-aG_0 \ln(\mu/\mu_0))$

2. $\Lambda(H)$ relation

Assume screen length $L^2 \propto 1/G$.

Vacuum energy density:

$\rho_\Lambda \sim 1/(L^2 G) \rightarrow \Lambda \propto G$.

3. Equation of state

$w = -1 - (1/3)\, d \ln\rho_\Lambda / d \ln a$

Since $\rho_\Lambda \propto \Lambda(H)$:

$w(z) \approx -1 + \nu \ln(1+z),\ \nu=aG_0$

4. Slow-roll parameters

$\varepsilon = -d \ln H/dN \approx aG(H)$

$r=16\varepsilon,\ n_s=1-4\varepsilon$

5. Echo delay

Cavity between photon sphere and RG surface:

$\Delta t \approx 2rs \ln(M/Mpl)$