VACUUM ENERGY SEQUESTERING

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TWO RIGOROUS PRINCIPLES

- Vacuum fluctuations
- Equivalence principle

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THE COSMOLOGICAL CONSTANT PROBLEM AND GR

$$\boxed{M_{pl}^2 G^\mu{}_\nu = \tau^\mu{}_\nu - \delta^\mu{}_\nu \Lambda_T}$$

$$T^\mu{}_\nu = \tau^\mu{}_\nu - \delta^\mu{}_\nu V_{\text{vac}}$$

$$\Lambda_T = \Lambda_c + V_{\text{vac}} \leqslant (\text{meV})^4$$

FINE TUNING, FINE TUNING, FINE TUNING, ...

- V_{vac} is badly radiatively unstable
- Power law sensitivity to high energy physics
- Must *repeatedly* fine tune Λ_c

SOLUTIONS?

- Field theory symmetry e.g. SUSY
- Violate the equivalence principle
- Define

$$\langle Q \rangle = \frac{\int d^4x \sqrt{-g}\, Q}{\int d^4x \sqrt{-g}}$$

THE COSMOLOGICAL CONSTANT IS... CONSTANT

$$\Lambda = \langle \Lambda \rangle$$

GR DECOMPOSITION

$$M_{pl}^2 \left(R^{\mu}{}_{\nu} - \frac{1}{4}\delta^{\mu}{}_{\nu} R \right) = \tau^{\mu}{}_{\nu} - \frac{1}{4}\delta^{\mu}{}_{\nu}\tau^{\alpha}{}_{\alpha}$$

$$M_{pl}^2 R = 4(\Lambda_c + V_{\text{vac}}) - \tau^{\alpha}{}_{\alpha}$$

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LOCAL SEQUESTERING ACTION

$$S = \int d^4x\sqrt{-g}\left[\frac{\kappa^2(x)}{2}R - \Lambda(x) - \mathcal{L}_m(g^{\mu\nu}, \Phi)\right]$$

$$+\int dx^\mu dx^\nu dx^\lambda dx^\rho \left[\sigma\left(\frac{\Lambda(x)}{\mu^4}\right)\frac{F_{\mu\nu\lambda\rho}}{4!} + \hat{\sigma}\left(\frac{\kappa^2(x)}{M_{Pl}^2}\right)\frac{\hat{F}_{\mu\nu\lambda\rho}}{4!}\right]$$

where e.g. $F_{\mu\nu\lambda\rho} = 4\partial_{[\mu}A_{\nu\lambda\rho]}$

LOCAL SEQUESTERING EQUATIONS OF MOTION I

$$\kappa^2(x) G^\mu{}_\nu = (\nabla^\mu \nabla_\nu - \delta^\mu{}_\nu \nabla^2)\kappa^2(x) + T^\mu{}_\nu - \delta^\mu{}_\nu \Lambda(x)$$

$$\frac{\sigma'}{\mu^4} F_{\mu\nu\lambda\rho} = \frac{1}{4!}\sqrt{-g}\epsilon_{\mu\nu\lambda\rho}, \qquad \frac{\hat{\sigma}'}{M_{pl}^2}\hat{F}_{\mu\nu\lambda\rho} = -\frac{1}{2\cdot 4!}\sqrt{-g}R\epsilon_{\mu\nu\lambda\rho}$$

$$\frac{\sigma'}{\mu^4}\partial_\mu \Lambda(x) = 0, \qquad \frac{\hat{\sigma}'}{M_{pl}^2}\partial_\mu \kappa^2(x) = 0$$

where we have used $\int d^4x\sqrt{-g} = \int \frac{1}{4!}\sqrt{-g}\epsilon_{\mu\nu\lambda\rho}dx^\mu dx^\nu dx^\lambda dx^\rho$

LOCAL SEQUESTERING EQUATIONS OF MOTION II

$$\kappa^2 G^\mu{}_\nu = T^\mu{}_\nu - \delta^\mu{}_\nu \Lambda_c$$

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$$\frac{1}{4}\kappa^2 \langle R \rangle = -\frac{\mu^4}{2}\frac{\kappa^2 \hat{\sigma}'}{M_{pl}^2 \sigma'}\frac{\int \hat{F}}{\int F} = \Delta\Lambda$$

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$$\Lambda_c = \frac{1}{4}\langle T^\alpha{}_\alpha \rangle + \frac{1}{4}\kappa^2\langle R \rangle = \frac{1}{4}\langle T^\alpha{}_\alpha \rangle + \Delta\Lambda$$

$$\Longrightarrow \boxed{\kappa^2 G^\mu{}_\nu = T^\mu{}_\nu - \frac{1}{4}\delta^\mu{}_\nu \langle T^\alpha{}_\alpha \rangle - \delta^\mu{}_\nu \Delta\Lambda}$$

LOCAL SEQUESTERING DECOMPOSITION

$$\kappa^2\left(R^\mu{}_\nu - \frac{1}{4}\delta^\mu{}_\nu R\right) = \tau^\mu{}_\nu - \frac{1}{4}\delta^\mu{}_\nu \tau^\alpha{}_\alpha$$

$$\kappa^2(R - \langle R\rangle) = \langle \tau^\alpha{}_\alpha\rangle - \tau^\alpha{}_\alpha$$

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$$\star \hat{F}_4 - \langle \star \hat{F}_4 \rangle = \frac{M_{pl}^2}{2\kappa^2 \hat{\sigma}'} (\tau^\alpha{}_\alpha - \langle \tau^\alpha{}_\alpha \rangle)$$
$$\frac{1}{4}\kappa^2 \langle R \rangle = -\frac{\kappa^2 \hat{\sigma}'}{2M_{pl}^2} \langle \star \hat{F}_4 \rangle$$