Information-Coupled Gravity Theory

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1 Core Equation

The modified Einstein field equation with information coupling:

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi G \left(T_{\mu\nu} - \alpha \nabla_\mu \nabla_\nu S\right) \tag{1}$$

where:

- $S \equiv I/I_0$ is dimensionless information density ($I_0 = c^5/G\hbar$)
- $\alpha = \hbar/c^2\ell_p^2 \approx 1$ (dimensionless coupling constant)

2 Simplified Forms

2.1 Natural Units ($c = \hbar = G = 1$)

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi(T_{\mu\nu} - \nabla_\mu \nabla_\nu S) \tag{2}$$

2.2 Symmetric Tensor Form

$$D_{\mu\nu} \equiv \frac{1}{2}(\nabla_\mu \nabla_\nu S + \nabla_\nu \nabla_\mu S) \tag{3}$$

$$G_{\mu\nu} = 8\pi(T_{\mu\nu} - D_{\mu\nu}) \tag{4}$$

3 Physical Interpretation

3.1 Matter-Energy vs. Information

- **Matter** ($T_{\mu\nu}$): Traditional energy-momentum sources

$$E = mc^2 \Rightarrow \text{Curvature source} \tag{5}$$

- **Information Gradient** ($\nabla\nabla S$):

$$\text{Encodes how information density shapes spacetime geometry} \tag{6}$$

3.2 Spacetime Curvature

The metric tensor $g_{\mu\nu}$ solutions represent:

$$ds^2 = g_{\mu\nu} dx^\mu dx^\nu \Rightarrow \begin{cases} > 1 & \text{Timelike separation} \\ = 0 & \text{Lightlike} \\ < 1 & \text{Spacelike} \end{cases} \tag{7}$$

4 Key Predictions

4.1 Black Holes

At event horizons ($S \to \infty$):

$$G_{\mu\nu} \approx -\nabla_\mu \nabla_\nu S \tag{8}$$

4.2 Flat Space Limit

For constant information density:

$$\nabla_\mu \nabla_\nu S = 0 \Rightarrow \text{Standard GR recovered} \tag{9}$$

5 Dimensional Analysis

$$\begin{aligned} [\nabla_\mu \nabla_\nu S] &= L^{-2} \\ [G_{\mu\nu}] &= L^{-2} \\ [T_{\mu\nu}] &= EL^{-3} = L^{-2} \quad \text{(in natural units)} \end{aligned}$$

6 Conclusion

The theory unifies matter and information geometry:

$$\boxed{\text{Spacetime curvature}} = \boxed{\text{Matter content}} - \boxed{\text{Information gradients}} \tag{10}$$