Physics of Trans-Planckian gravity

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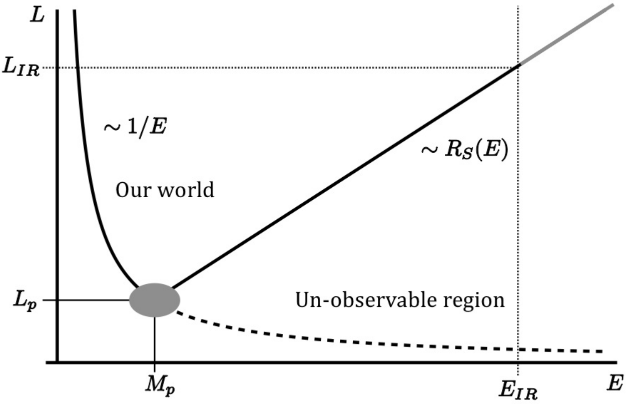
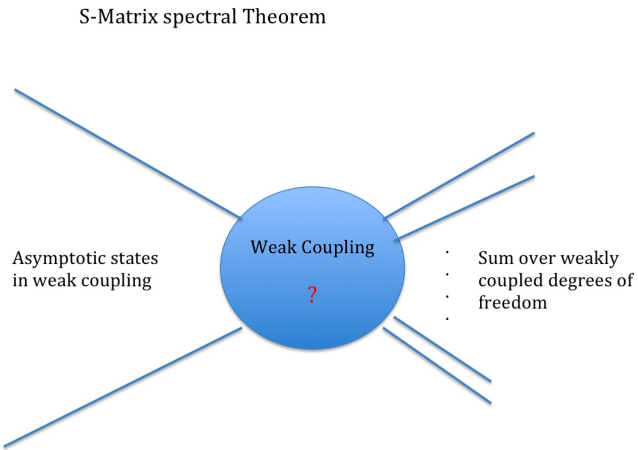
IV Black Hole Conference, Aveiro, Portugal

Based on Dvali, Folkerts, CG 1006.0984 (PRD)

Main point: For *any* healthy theory of gravity



Suppose we want to describe a scattering of two particles



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- Matter *energy conditions* are not violated
- The theory of gravity is not necessarily GR but at IR approaches GR

S-Matrix

(one-graviton) scattering amplitude of two *external* sources
(only gravity involved)

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Note: gravitons are massless spin-2 only in GR!

Spectral decomposition theorem:

$A(p)$ is a sum over massive and massless spin-0,2 with *spectral densities* $\rho_{0,2}$

$$A(p) = \frac{1}{M_p^2}\left\{ \underbrace{\frac{T_{\mu\nu}\tau^{\mu\nu} - \frac{1}{2}T\tau}{p^2}}_{\text{massless spin 2}} + \right.$$

$$\left. + \underbrace{\int_0^\infty ds\,\rho_2(s)\frac{T_{\mu\nu}\tau^{\mu\nu} - \frac{1}{3}T\tau}{p^2+s}}_{\text{massive spin-2}} + \underbrace{\int_0^\infty ds\,\rho_0(s)\frac{T\tau}{p^2+s}}_{\text{spin-0}} \right\}$$

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In absence of ghosts

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More than GR dof exchanged $\Rightarrow$ stronger than GR interaction

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For *any* theory of gravity BH horizons size (R_H)

$$\boxed{R_H(M_{BH}) \geq R_{GR}(M_{BH})}$$

$R_{GR}(M_{BH})$ is the Schwarzschild radius for a given mass M_{BH}

Consequence for the effective Planck mass

The one-graviton exchange may be re-parameterized as

$$A(p) = \frac{\alpha(p)}{(p^2)^2}\left(T_{\mu\nu}\tau^{\mu\nu} + b(p)\,T\tau\right)$$

α is the effective (dimensionless) gravity coupling

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In GR: $\alpha_{GR} \equiv 16\pi G_N p^2$

$$\Downarrow$$

$$\boxed{G_N^{eff}(p) \geq G_N}$$

Gravity may be asymptotically safe only if strongly coupled!!!

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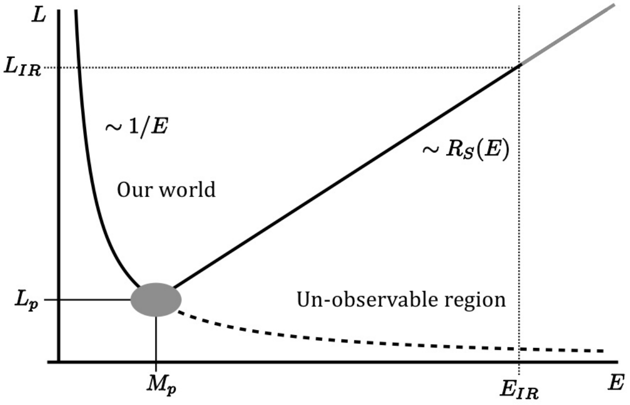
UV gravity turn around and become IR

We proved the main point: For *any* healthy theory of gravity



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It is a BH!

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$\boxed{\text{No scattering can probe sub-Planckian distances!}}$

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They give exponentially suppressed contribution!

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$\boxed{\text{BH formation cannot be stopped}}$

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$\boxed{\text{The Compton wavelength of the experiment is inside a BH!}}$

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Gauss law $\Rightarrow$ whenever a Trans-Planckian signal is emitted

A BH is formed!

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Thank you!