Dynamical gravitational corrections to the conformal anomaly

Raquel Santos-Garcia Work in collaboration with E. Alvarez and J. Anero

Instituto de Física Teórica UAM-CSIC, Universidad Autónoma de Madrid, Spain

Idea

Can we tell if **gravity is dynamical or not** by computing the conformal anomaly?

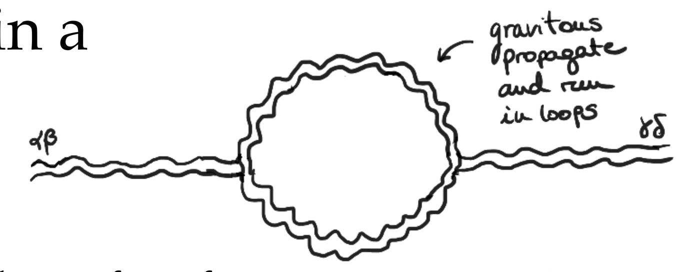
Is gravity a fundamental interaction?

Existence of gravitons

Einstein's general relativity (GR) ⟶ Theory for the gravitational field

Fierz-Pauli lagrangian for free spin 2 particles

When interactions are included in a consistent way ⟶ GR



Gravitational waves discovered but far from measuring an analogous of the Compton effect

Entropic origin

Dictionary between BH laws and thermodymacial laws

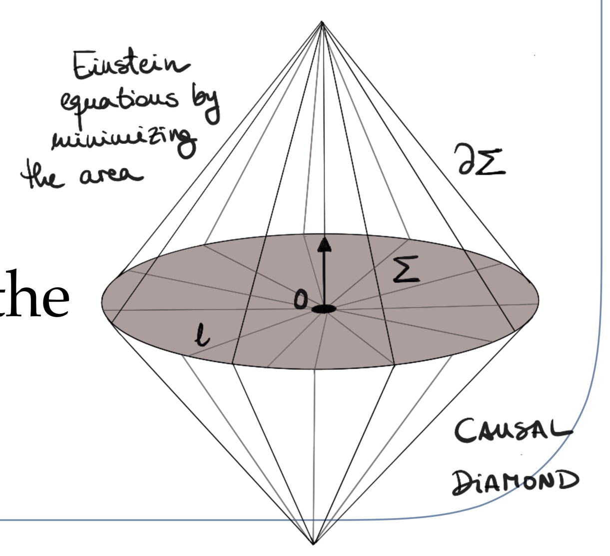
$$\delta S = \delta A$$

Instead of thinking in the fundamental dof ⟶ Entropic force

Jacobson, Padmanabhan, Verlinde,…

Gravity as an emergent phenomena

Einstein equations arise from minimising the entropy (the area) with a fixed volume



Conformal anomaly

In the UV intuitive idea that masses should be unimportant ⟶ Scale invariance

Three realizations of the symmetry

Scale invariance (flat spacetime)	$x^\mu \to \lambda\, x^\mu$
Conformal invariance (flat spacetime)	Conformal group
Weyl invariance (curved spacetimes)	$g_{\mu\nu} \to \Omega(x)^2\, g_{\mu\nu}$

Renormalization procedure, introduces an energy scale ⟶ Conformal (Weyl) anomaly

Anomaly in the trace of the energy momentum tensor

$$< T^\mu_\mu > = a_2$$

Proportional to the one-loop counter term

If gravity is dynamical or just a background is important in the path integral

$$\int \mathscr{D}\phi_i\, \mathscr{D} g_{\mu\nu}$$

Sensitive to the graviton dynamics

Background vs dynamical gravity

We expand the gravitational field in a background and a perturbation

$$g_{\mu\nu} = \underbrace{\bar{g}_{\mu\nu}}_{\text{Background field}} + \kappa \underbrace{h_{\mu\nu}}_{\text{Quantum field}}$$

(constant curvature spaces for simplicity)

We take for example an scalar field coupled to gravity

Two "types" of dynamical gravity

	Lagrangian	Anomaly
Non-dynamical	$\sqrt{\bar g}\,\bar\nabla_\mu\phi\,\bar\nabla^\mu\phi$	$\frac{\sqrt{\bar g}}{(4\pi)^2}\frac{29}{135}\lambda^2$ (curvature of CCS)
Non-dynamical	$\sqrt{\bar g}\left(\bar\nabla_\mu\phi\,\bar\nabla^\mu\phi + \frac{1}{6}\phi^2\bar R\right)$ (Non-minimal coupling)	$-\frac{\sqrt{\bar g}}{(4\pi)^2}\frac{\lambda^2}{135}$
Dynamical	$\sqrt{\bar g}\left(\nabla_\mu\phi\,\nabla^\mu\phi + \frac{1}{6}\phi^2 R\right)$	0
Dynamical	$\sqrt{\bar g}\left(\nabla_\mu\phi\,\nabla^\mu\phi + R^2_{\mu\nu} - \frac{1}{2}R^2\right)$ (Quadratic gravity)	$\frac{\sqrt{\bar g}}{(4\pi)^2}\frac{1078}{135}\lambda^2$

Outlook

Can we measure the conformal anomaly and be sensitive to the character of the gravitational field?

Starobinsky's inflation driven by the trace anomaly of conformally coupled matter fields

Precisely models with the coupling of scalar fields to gravity. If the effect of the dynamical gravitational corrections is big enough, possible to contrast with the fitting of the parameters of inflationary models

Transport effects due to conformal anomaly (similar to the ones due to chiral anomalies)

Measurements of scale transport, SEE and SME, in Weyl semimetals

Work ongoing regarding same type of computations for fermions

arXiv:1906.XXXXX