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Distortion Gravity (DG) is a metric-affine framework for gravity formulated by Luca Eliseo Pavesi in which the affine connection $\Gamma^\rho{}_{\mu\nu}$ is promoted to an independent dynamical field. The deviation from the Levi-Civita connection $\tilde{\Gamma}^\rho{}_{\mu\nu}$ is encoded in the **distortion tensor** $D^\rho{}_{\mu\nu}$. The theory propagates a massless graviton and two massive vector fields (the trace vector V_μ and the axial torsion vector a_μ) and has been shown to be ghost-free.[1]

Distortion Gravity provides a four-dimensional realisation of the ER = EPR conjecture: the same distortion tensor that sustains a traversable wormhole (ER bridge) also controls the entanglement (EPR) via the quantised flux of the axial torsion.[1][2]

Mathematical formulation

The distortion tensor and its vectors

In metric-affine geometry, the distortion tensor is

$$D^\rho{}_{\mu\nu} = \Gamma^\rho{}_{\mu\nu} - \tilde{\Gamma}^\rho{}_{\mu\nu},$$

encoding both torsion $T^\rho{}_{\mu\nu} = D^\rho{}_{\mu\nu} - D^\rho{}_{\nu\mu}$ and non-metricity $Q_{\rho\mu\nu} = \nabla_\rho g_{\mu\nu}$.

Under the general linear group $GL(4, \mathbb{R})$, $D^\rho{}_{\mu\nu}$ decomposes into irreducible parts.[3] The dynamical sector consists of two vectors:

$$V_\mu = D^\alpha{}_{\mu\alpha}, \qquad a_\mu = \frac{1}{6}\varepsilon_{\mu\nu\rho\sigma}D^{\nu\rho\sigma}.$$

Action

The ghost-free action for Distortion Gravity is

$$S_{\mathrm{DG}} = \int d^4x\sqrt{-g}\left[\frac{1}{2\kappa}\tilde{R} + \mathcal{L}_V + \mathcal{L}_a + \alpha_1 I_1 + \alpha_2 I_2 + \alpha_3 I_3\right],$$

where $\tilde{R}$ is the Riemann scalar of the Levi-Civita connection, $\mathcal{L}_V$ and $\mathcal{L}_a$ are Proca Lagrangians for the trace and axial vectors, and $I_{1,2,3}$ are quadratic invariants of $D^\rho{}_{\mu\nu}$.[1]

Spontaneous symmetry breaking

For a homogeneous configuration $V_\mu = (V_0, \vec{0})$, the potential is

$$V(V_0) = \frac{1}{2} m_V^2 V_\mu V^\mu + \frac{\lambda_V}{4} (V_\mu V^\mu)^2 = -\frac{1}{2} m_V^2 V_0^2 + \frac{\lambda_V}{4} V_0^4,$$

using the metric signature $(-,+,+,+)$. When $m_V^2 < 0$ the potential has a double-well shape with minima at $V_0 = \pm v$, where $v = \sqrt{|m_V^2|/\lambda_V}$. The Levi-Civita point $V_0 = 0$ becomes a saddle point.

In curved spacetime the effective mass becomes curvature-dependent,

$$m_{V,\text{eff}}^2(r) = m_V^2 + \lambda_{\text{curv}} \frac{r_0^2}{r^2},$$

with $\lambda_{\text{curv}} > 0$ and r_0 the wormhole throat radius. Near the throat ($r \sim r_0$) the mass squared is negative (SSB phase), while far away ($r \gg r_0$) it is positive (symmetry restored). This localises the NEC violation at the throat and recovers GR asymptotically.[1]

Traversable wormhole solution

Modified ansatz

A static, spherically symmetric wormhole is described by the metric

$$ds^2 = -e^{2\Phi(r)} dt^2 + \frac{H(r)}{e^{2\Phi(r)} \left(1 - \frac{b(r)}{r}\right)} dr^2 + r^2 (d\theta^2 + \sin^2\theta \, d\phi^2),$$

where $\Phi(r)$ is the finite redshift function, $b(r)$ the shape function with $b(r_0) = r_0$, and $H(r)$ a curvature-dependent compression factor,

$$H(r) = 1 + \lambda(r) \left(e^{2\Phi(r)} - 1\right),$$

with $\lambda(r)$ a double Gaussian localised at the throat:

$$\lambda(r) = A_1 \exp\left(-\frac{(r - r_0)^2}{2\sigma_1^2}\right) + A_2 \exp\left(-\frac{(r - r_1)^2}{2\sigma_2^2}\right).$$

When $\Phi(r) < 0$ (gravitational blueshift) near the throat, $e^{2\Phi} < 1$ and $H(r) < 1$, compressing the proper distance. The double Gaussian allows independent control of the throat and the region where $b(r)/r$ approaches unity, preventing the wormhole from pinching off.[1]

Field equations

The Einstein equations with the Proca energy-momentum tensors yield

$$b'(r) = \kappa r^2 \rho(r), \qquad \Phi'(r) = \frac{b(r)/r + \kappa r^2 p_r(r)}{2r(1 - b(r)/r)},$$

where $\rho(r)$ and $p_r(r)$ are the total energy density and radial pressure. The Proca equations for the vector fields in the wormhole background are

$$V_0'' + \left(\frac{2}{r} + \frac{H'}{2H}\right) V_0' - \frac{m_{V,\text{eff}}^2(r)}{g_{rr}^{-1}} V_0 + \frac{\lambda_V}{g_{rr}^{-1}} V_0^3 = 0,$$
$$a_\phi'' + \left(\frac{H'}{2H} + \frac{2}{r}\right) a_\phi' - \frac{m_{a,\text{eff}}^2(r)}{g_{rr}^{-1}} a_\phi + \frac{\lambda_a}{r^2 g_{rr}^{-1}} a_\phi^3 = 0,$$

with $g_{rr}^{-1} = e^{2\Phi}(1 - b/r)/H(r)$.[1]

Numerical exploration

The coupled system was solved numerically using the SciPy `solve_ivp` routine (RK45). A total of 7,600 configurations were tested over a 13-dimensional parameter space. A wormhole is considered valid if it satisfies: throat condition, flaring-out, openness ($b(r) < r$ for all $r > r_0$), traversability (proper crossing time $\Delta\tau < \pi r_0$), and angular stability. 57% of the configurations yielded fully valid traversable wormholes, with the best crossing time $\Delta\tau = 0.1035\, r_0/c$, about three times shorter than the GR collapse timescale πr_0. The NEC is violated at the throat and restored asymptotically.[1]

ER = EPR realisation

Entanglement entropy and axial torsion flux

In Distortion Gravity, the effective Newton constant is modified by the background vector fields,

$$G_{\text{eff}} = \frac{G_N}{1 + \alpha V_\mu V^\mu + \beta a_\mu a^\mu}.$$

The entanglement entropy across the wormhole is given by the Ryu–Takayanagi formula

$$S_{\text{EE}} = \frac{A_{\text{throat}}}{4G_{\text{eff}}} = \frac{\pi r_0^2}{G_{\text{eff}}}.$$

The axial torsion field a_μ generates a quantised flux through the throat,

$$\Phi = \oint_{S^1} a_\mu dx^\mu = 2\pi a_\phi(r_0) = 2\pi n v_a r_0, \quad n \in \mathbb{Z}.$$

The entanglement entropy is proportional to this flux,

$$S_{\text{EE}} \propto \Phi.$$

Thus both the geometric connectivity (wormhole area) and the quantum correlations (entanglement) are controlled by the same integer n.[1]

Quantum simulation

The ER = EPR mechanism was tested on the Qiskit platform using a two-qubit circuit. A Bell state was prepared and subjected to Aharonov–Bohm phase shifts determined by the torsion flux. The von Neumann entropy remained maximal ($S_{\mathrm{EE}} = 1$ bit) for all integer winding numbers $n = 0, \ldots, 5$, confirming that torsion preserves quantum correlations. A CHSH Bell test showed a continuous modulation of Bell violations by the torsion gradient, without any violent "firewall".[1][4][5]

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External links

- Luca Eliseo Pavesi's personal website (https://lucapavesi.netlify.app/)
- SSRN (Elsevier) author page (https://papers.ssrn.com/sol3/results.cfm?n=10&q=%22Luca+Eliseo+Pavesi%22)
- ScienceOpen profile (https://www.scienceopen.com/search#%7B%22order%22%3A%22relevance%22%2C%22type%22%3A%22all%22%2C%22terms%22%3A%22Luca%20Pavesi%22%7D)