Unifying Gravity and EM or GEM by sweetser@alum.mit.edu

Start with the EM action in a (possibly curved) vacuum

$$S_{\rm EM} = \int \sqrt{-g}\, d^4x (\nabla^\mu A^\nu - \nabla^\nu A^\mu)(\nabla_\mu A_\nu - \nabla_\nu A_\mu)$$

EM symmetries

$$\delta S_{\rm EM} = \int \sqrt{-g}\, d^4x (\nabla^\mu A^\nu - \nabla^\nu A^\mu)(\nabla_\mu A_\nu - \nabla_\nu A_\mu)\, \delta\psi$$

Vary	Conserve
δt: $t \rightarrow t' = t + \delta t$	Energy: $m \frac{dt}{d\tau}$
δR: $R \rightarrow R' = R + \delta R$	Momentum: $m \frac{dR}{d\tau}$

Not the complete story of 4-change of a 4-potential

$(\nabla^\mu A^\nu - \nabla^\nu A^\mu)$ has 6 parts of 16 part story

GEM action in a vacuum

$$S_{\rm GEM} = \int \sqrt{-g}\, d^4 x ((\nabla^\mu A^\nu - \nabla^\nu A^\mu)(\nabla_\mu A_\nu - \nabla_\nu A_\mu) + (\nabla^\mu A^\nu + \nabla^\nu A^\mu)(\nabla_\mu A_\nu + \nabla_\nu A_\mu))$$

GEM Symmetry

$$\delta S_{\rm GEM} = \int \sqrt{-g}\, d^4x\, \mathfrak{L}_{\rm GEM}\, \delta\psi$$

Vary How 4-change in the 4-potential is measured.

Example: From flat Euclidean spacetime to curved spacetime:

$\delta(\partial^\mu A^\nu)$: $(\partial^\mu A^\nu) \rightarrow (\partial^\mu A^\nu)' = (\partial^\mu A^\nu) - \delta({\Gamma_\sigma}^{\mu\nu} A^\sigma)$

Conserve: Mass charge $\frac{d\,\mathrm{trace}(g_{\mu\nu}\nabla^\mu A^\nu)}{d\tau}$, mass breaks gauge symmetry.

Field equations in a vacuum, vary A^μ, fix $g_{\mu\nu}$ up to a diffeomorphism.

$$\Box^2 A^\mu = 0$$

Vacuum Solutions

$A^\mu = (\frac{1}{R}, \vec{0})$ and $g_{\mu\nu} = \begin{pmatrix} 1 & 0 \\ 0 & -\hat{1} \end{pmatrix}$ so $\nabla^2 \frac{1}{R} = 0$ ✓

$A^\mu =$ constants and $g_{\mu\nu} = \begin{pmatrix} \exp(-2GM/c^2R) & 0 \\ 0 & -\hat{1}\exp(2GM/c^2R) \end{pmatrix}$ static, diagonal

so $0 = \partial_\mu {\Gamma_\sigma}^{0\mu} A^\sigma = \nabla g_{00}\, g^{00,\vec{R}} = \nabla^2 \frac{GM}{c^2 R} = 0$ ✓

The Rosen exponential metric = Schwarzschild to 1st order PPN accuracy, not 2nd order PNN, so it is consistent with current first order tests, and could be confirmed or rejected for higher order tests. Example: GEM predicts 0.8 μarcseconds more bending by the Sun than GR.

Quantization

Gupta/Blueler quantization of a 4D wave equation with a twist.

Spin 1 field is 2 transverse modes of EM, like charges repel

Spin 2 field is scalar, longitudinal mode of Gravity, like charges attract.