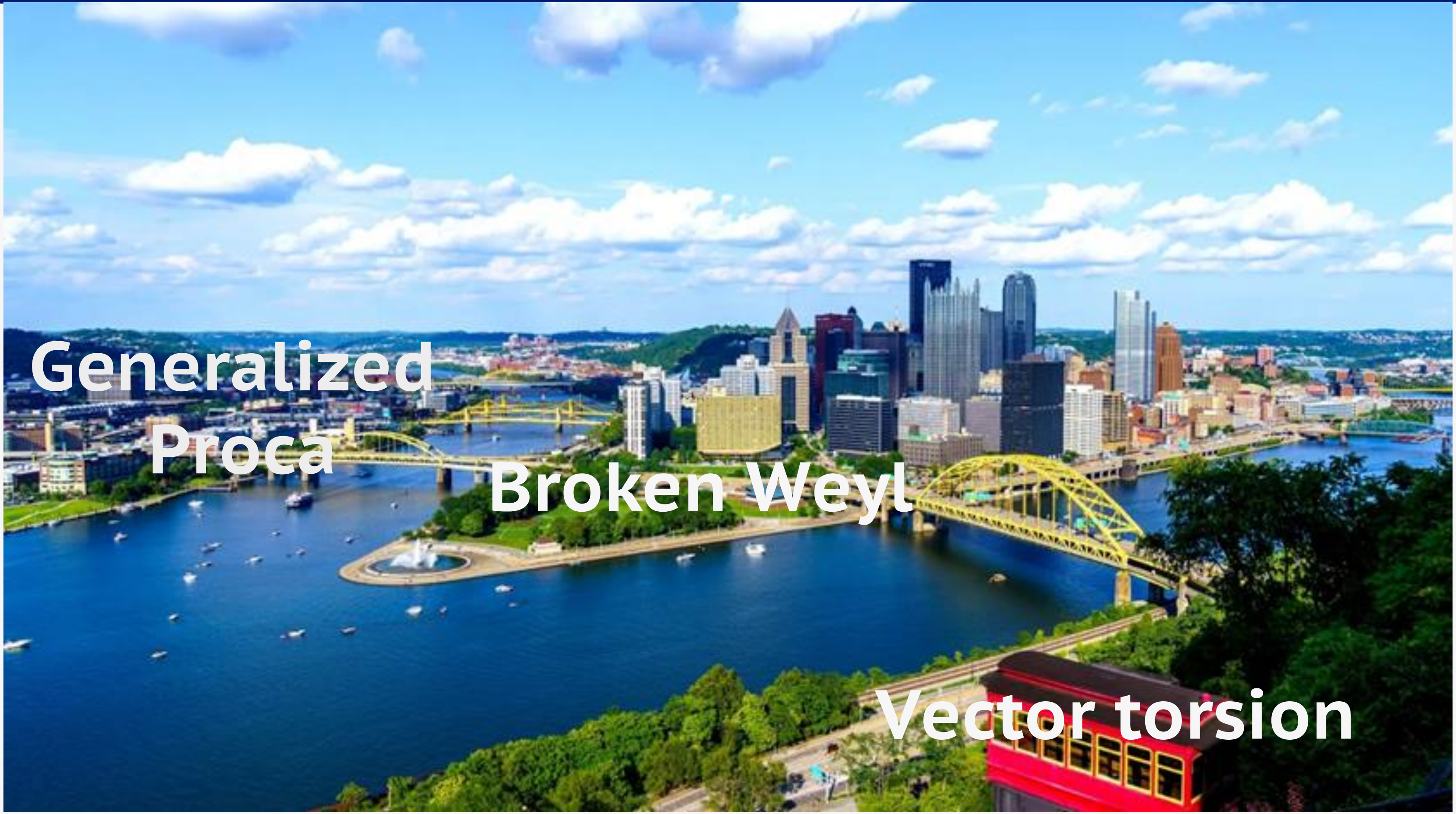
Generalized
Proca
Broken Weyl
Vector torsion

Broken Weyl Gravity

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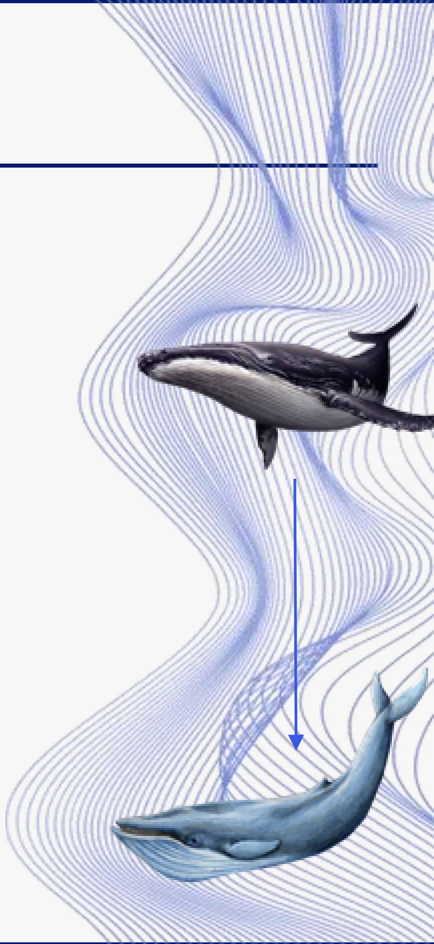
Work with Irvin Martinez [2509.xxxxx]

Weyl Transformations

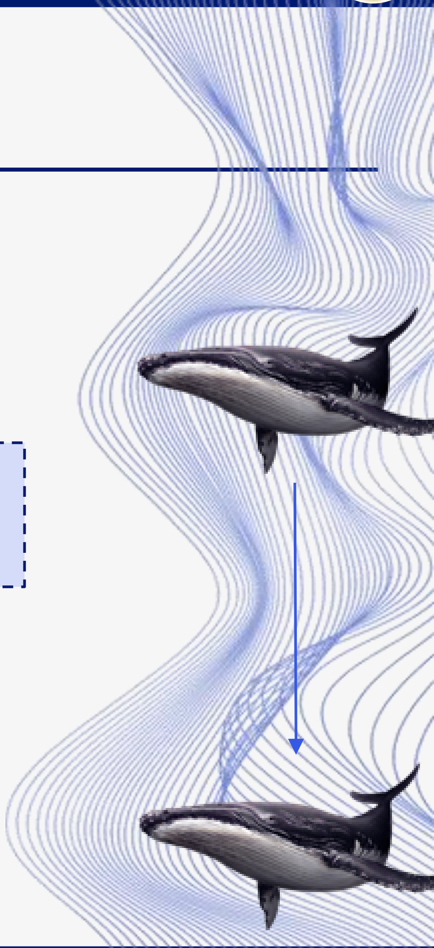
$$g_{\mu\nu}(x) \to \Omega^2(x) g_{\mu\nu}(x)$$

$$\phi(x) \to \Omega^{-\Delta}(x) \phi(x)$$



Route to Weyl invariance

Iorio et. al. [9607110]



CCWZ Coset construction Callan, Coleman, Wess & Zumino (1969)

$$g = e^{ix_a P^a} e^{i\pi_\alpha(x) Z^\alpha}$$

$$g^{-1}dg = e^a P_a + \omega^\alpha Z_\alpha + \omega^A T_A$$

Algebra

$$[P_\mu, D] = -iP_\mu$$

Weyl breaking

$$g^{-1}\mathrm{D}g = \mathrm{d} + ie^a P_a + \frac{i}{2}\omega^{ab} J_{ab} + i\nabla\varphi D$$

$$\mathcal{T}^a = \mathrm{d}e^a - e^b \wedge \omega^a{}_b + e^a \wedge A$$

$$\mathcal{R}^{ab} = \mathrm{d}\omega^{ab} + \omega^{ac} \wedge \omega_c{}^b \quad \mathcal{F} = \mathrm{d}A$$

*Exercise of my 1st amendment rights

Results 1: Mass

$$R = \det(e)\left(\bar{R} + 6\nabla_\mu A^\mu - 6A_\mu A^\mu\right)$$

2: Torsion

Barker, Zell, [2306.14953]

$$T^{(1)\lambda}{}_{\mu\nu} \equiv \frac{1}{2}T^{\lambda}{}_{\mu\nu} + \frac{1}{2}T^{\lambda}{}_{\nu\mu} + \frac{1}{6}g_{\mu\nu}T^{(2)\lambda} - \frac{1}{6}\delta^{\lambda}{}_{\nu}T^{(2)}_{\mu} + \frac{1}{3}\delta^{\lambda}{}_{\mu}T^{(2)}_{\nu}$$

$$T^{(2)}_{\mu} \equiv T^{\lambda}{}_{\lambda\mu}$$

$$T^{(3)}_{\mu} \equiv \frac{1}{6}\varepsilon_{\mu\nu\sigma\lambda}T^{\nu\sigma\lambda}$$

Torsion

$$\mathcal{T}^a = 0 \leftrightarrow T_\mu^{(2)} \sim A_\mu$$

3: Generalized Proca L. Heisenberg [1402.7026]

- Interacting massive vector theory
- Interactions tuned so EOMs are second order in derivatives
- No Ostrogradsky ghosts

$$\mathcal{L}_2 = G_2(A_\mu, F_{\mu\nu}, \tilde{F}_{\mu\nu})$$

$$\mathcal{L}_3 = G_3(X)\nabla_\mu A^\mu$$

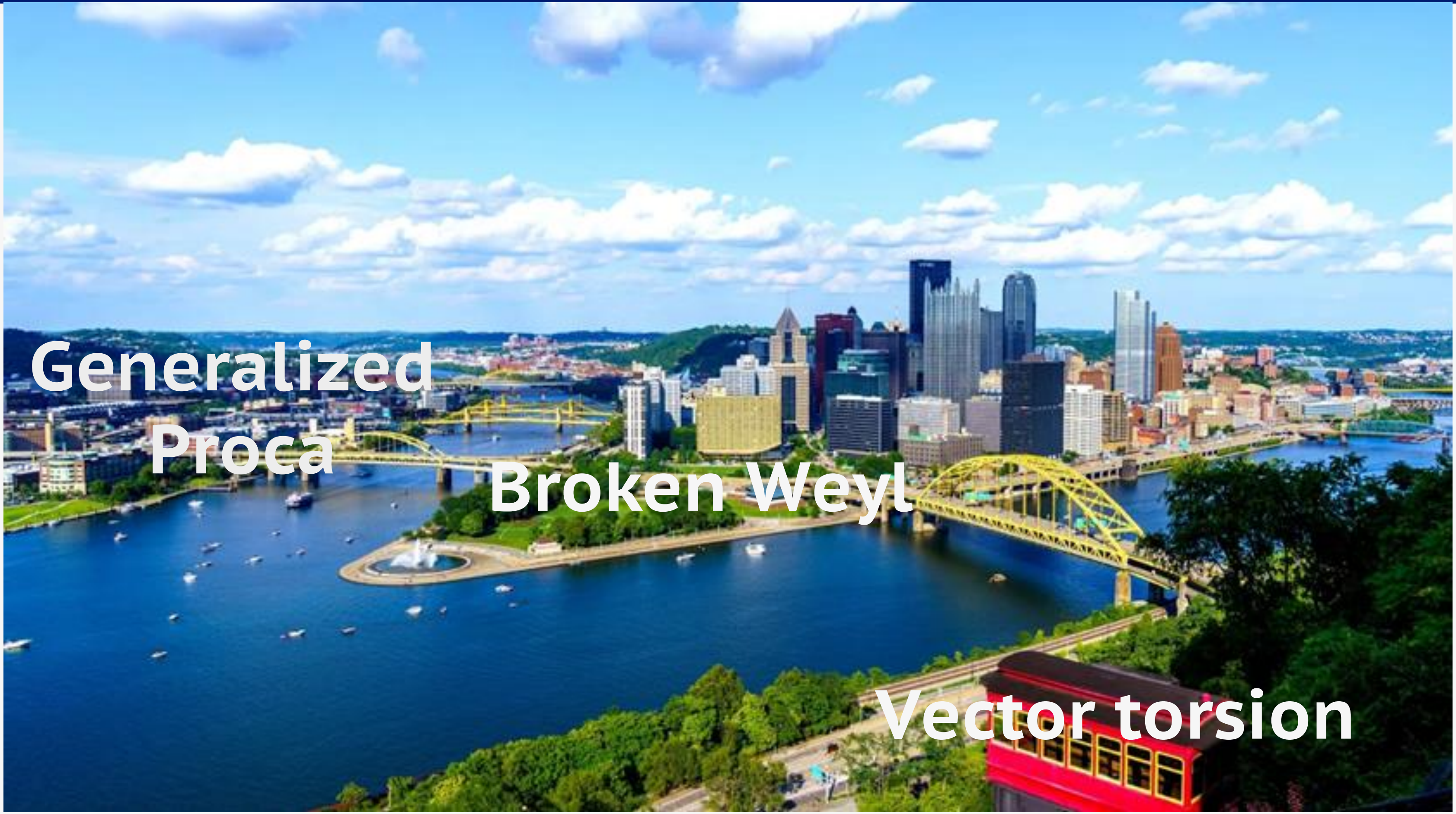
$$\mathcal{L}_4 = G_4(X)\bar{R} + G_{4,X}\left[(\nabla_\mu A^\mu)^2 - \nabla_\rho A_\sigma \nabla^\sigma A^\rho\right]$$

$$\mathcal{L}_5 = G_5(X)\bar{G}_{\mu\nu}\nabla^\mu A^\nu - \frac{1}{6}G_{5,X}\left[(\nabla \cdot A)^3 + 2\nabla_\rho A_\sigma \nabla^\gamma A^\rho \nabla^\sigma A_\gamma - 3(\nabla \cdot A)\nabla_\rho A_\sigma \nabla^\sigma A^\rho\right] - g_5(X)\tilde{F}^{\alpha\mu}\tilde{F}_\mu{}^\beta \nabla_\alpha A_\beta$$

$$\mathcal{L}_6 = G_6(X)\mathcal{L}^{\mu\nu\alpha\beta}\nabla_\mu A_\nu \nabla_\alpha A_\beta + \frac{G_{6,X}}{2}\tilde{F}^{\alpha\beta}\tilde{F}^{\mu\nu}\nabla_\alpha A_\mu \nabla_\beta A_\nu$$

Broken Weyl $\subset$ Generalized Proca*

*Ask me about the caveat if interested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Thank you for listening !

Effective theory

$$\mathcal{S} = \int \epsilon_{abcd} \left(\Lambda e^a \wedge e^b \wedge e^c \wedge e^d + \frac{M_{Pl}^2}{2} R^{ab} \wedge e^c \wedge e^d \right) - \frac{1}{4} F \wedge \star F - m^2 A \wedge \star A$$

$$+ \mathcal{L}_{\mathcal{RR}} + G_2(X) + R_{ab} \wedge F \wedge \star \left(F \wedge e^a \wedge e^b \right) + \cdots$$

Relative Lie Algebra cohomology