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Ferreira-Hill-Ross:

Weyl Symmetry = Scale Symmetry in gravity. Unique.

Usual definition $\delta x^\mu = \epsilon(x)x^\mu$ $\delta\phi(x) = -\epsilon(x)\phi(x) + \epsilon(x)x^\mu\partial_\mu\phi(x)$

BAD: blends into the diffeomorphism invariance of general relativity. Current vanishes.

Weyl definition $\delta x^\mu = 0$ $\delta\phi(x) = -\epsilon(x)\phi(x)$ $\delta g_{\mu\nu}(x) = 2\epsilon(x)g_{\mu\nu}(x)$

GOOD: Length is defined by the metric; coordinates are just numbers.

Theorem (CTH): the Weyl current $K_\mu = \partial_\mu K(\phi_i, g, \dots)$ is a derivative of a scalar (true for any WI theory) $K(\phi_i, g, \dots)$ is the "kernel"

Phenomena:

Initial Pre-Planckian chaotic universe will expand

$K(\phi_i, g, \dots) \rightarrow \bar{K}(\phi_i, g, \dots) = \text{constant}$ establishes mass scales, eg Planck mass

Spontaneous breaking (annealing) of Weyl Symmetry

$\bar{K}(\phi_i, g, \dots) = 2f_\sigma^2$ decay constant of dilaton: $K_\mu = f_\sigma\partial_\mu\sigma$

Dilaton decouples from all but gravity!

Fields slow roll on "ellipsoid" $\bar{K}(\phi_i, g, \dots) = \text{constant}$

Potential $W(\phi_i)$ flat direction intersects the "ellipsoid"; defines vacuum minimum.

Weyl invariant RG $\ln\left(\frac{M^2}{\mu^2}\right) \rightarrow \ln\left(\frac{\bar{K}}{\mu^2}\right)$ preserves Weyl invariance.

Loop divergences: $\int d^4k \sim \Lambda^4 \rightarrow \lambda(\Phi^\dagger\Phi)^2$ at Landau pole
 $H^\dagger H \int d^4k \frac{1}{k^2} \sim \Lambda^2 H^\dagger H \rightarrow \lambda H^\dagger H \Phi^\dagger\Phi$ at Landau pole

Naturalness issues change, replaced by new interactions; divergences replaced by Landau poles of coupling constants.

Black Hole Ring Down emission of dilatons?
Weyl gauge field B as dark matter?
Local Planck mass fluctuations?
Generation of hierarchies?
Ghosts?

Scalars and gravity go together naturally in Weyl Invariance.

Many Higgs bosons? (Hill, Machado, Turner, Thomsen)
Unification \rightarrow Weinberg Asymptotic Safety?
Concordance of RG $g_{top} = 1$ Infrared quasi- Fixed Point (Hill, Thomsen)
Concordance of RG $\lambda = 1/4$ (Higgs mass)

Predict new Higgs H_b with $g \approx g_{top} = 1$ at $M \leq 5.5$ TeV
discoverable at LHC or LHC energy Doubler.

Simplicity III at Perimeter Institute a big success!!!
(G. 't Hooft, J. Bardeen, N. Turok, L Funcke, ...)

(watch a video of my talk with G. 't Hooft as my session moderator)