Constraining asymptotically safe scalar-gravity theories

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Based on work with A. Eichhorn and G. P. de Brito

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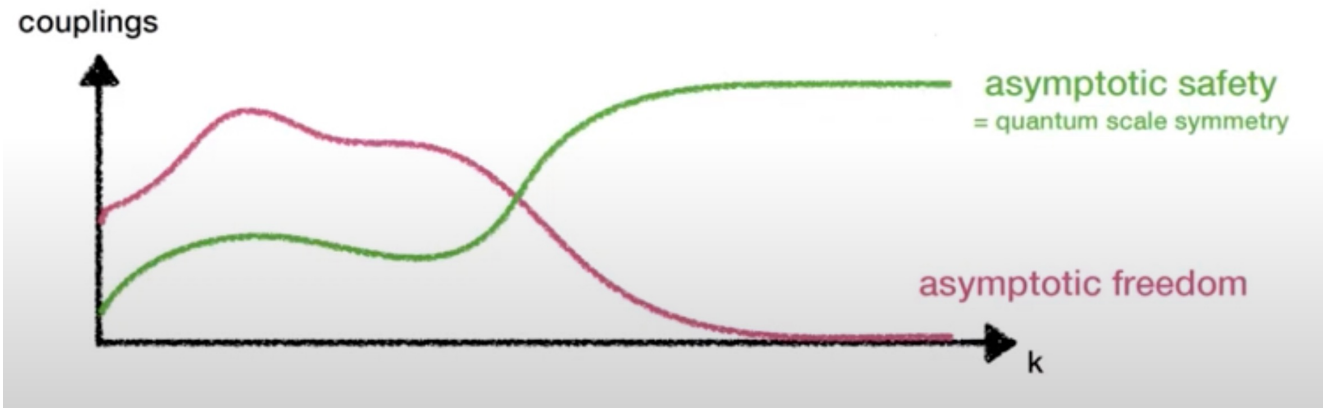
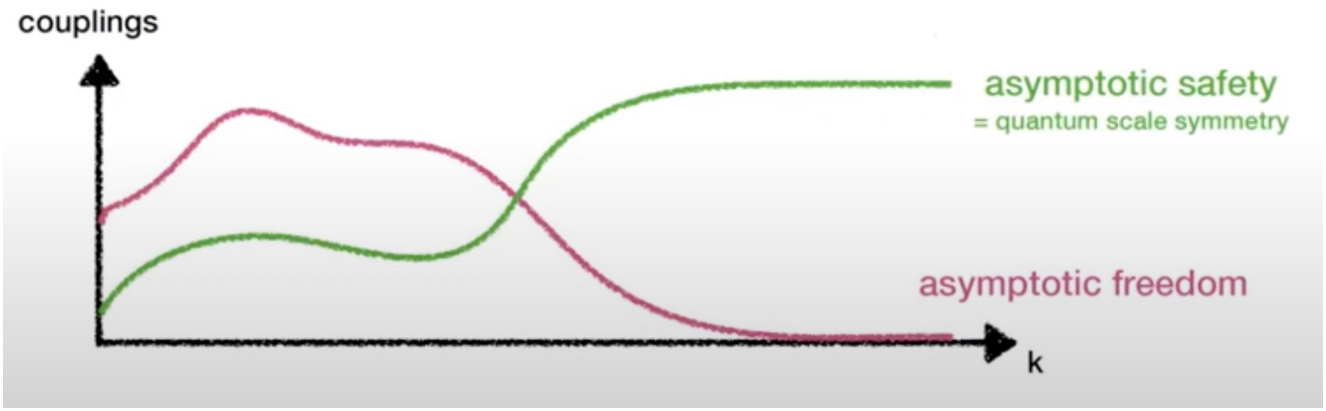
Asymptotic safety



Asymptotic safety: scalar-gravity model



$$\Gamma_k = \frac{Z_\phi}{2}\int d^4x\sqrt{g}g^{\mu\nu}\partial_\mu\phi\partial_\nu\phi + \frac{\bar{g}}{8}\int d^4x\sqrt{g}g^{\mu\nu}g^{\kappa\lambda}\partial_\mu\phi\partial_\nu\phi\partial_\kappa\phi\partial_\lambda\phi$$
$$-\frac{1}{16\pi G_N}\int d^4x\sqrt{g}\left(R-2\bar{\Lambda}\right)+S_{\rm gf},$$

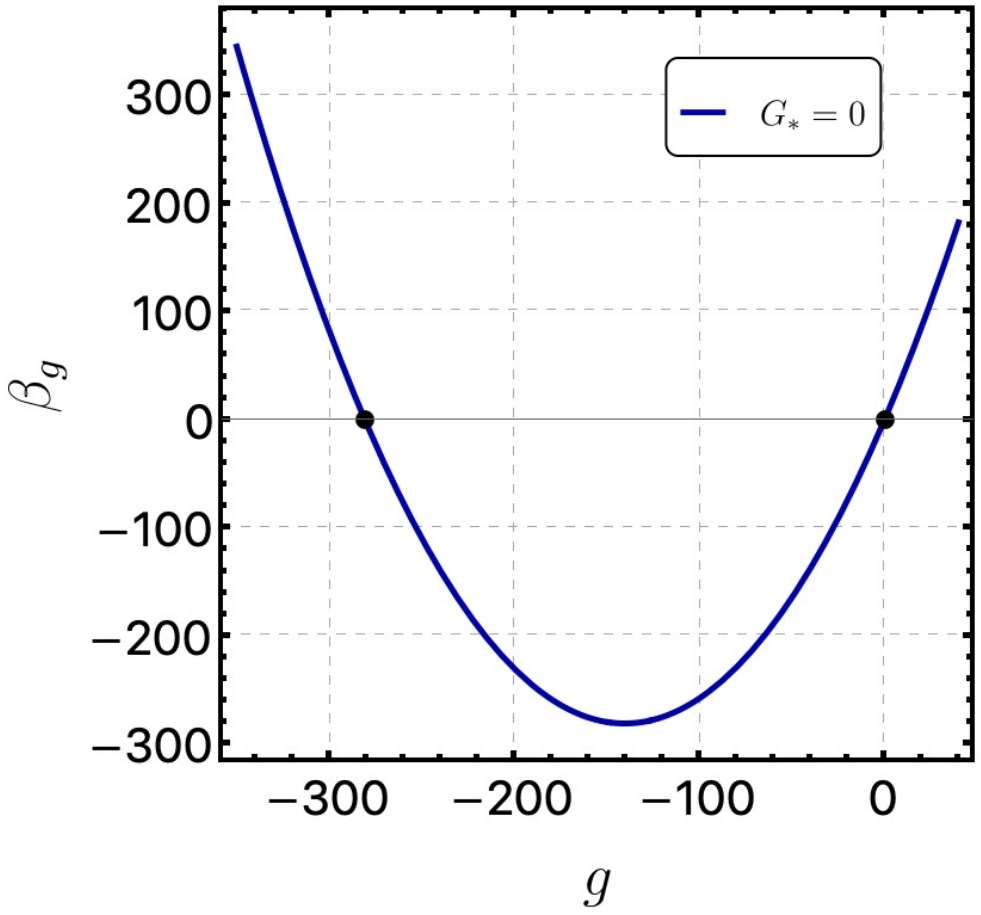
$$g=\bar{g}k^{-4},\quad G=G_N\,k^2,\quad \Lambda=\bar{\Lambda}\,k^{-2}.$$

ASQG: Astrid's lectures

Weak gravity bound

Quartic interaction coupling

$$\beta_g \equiv k\partial_k g$$

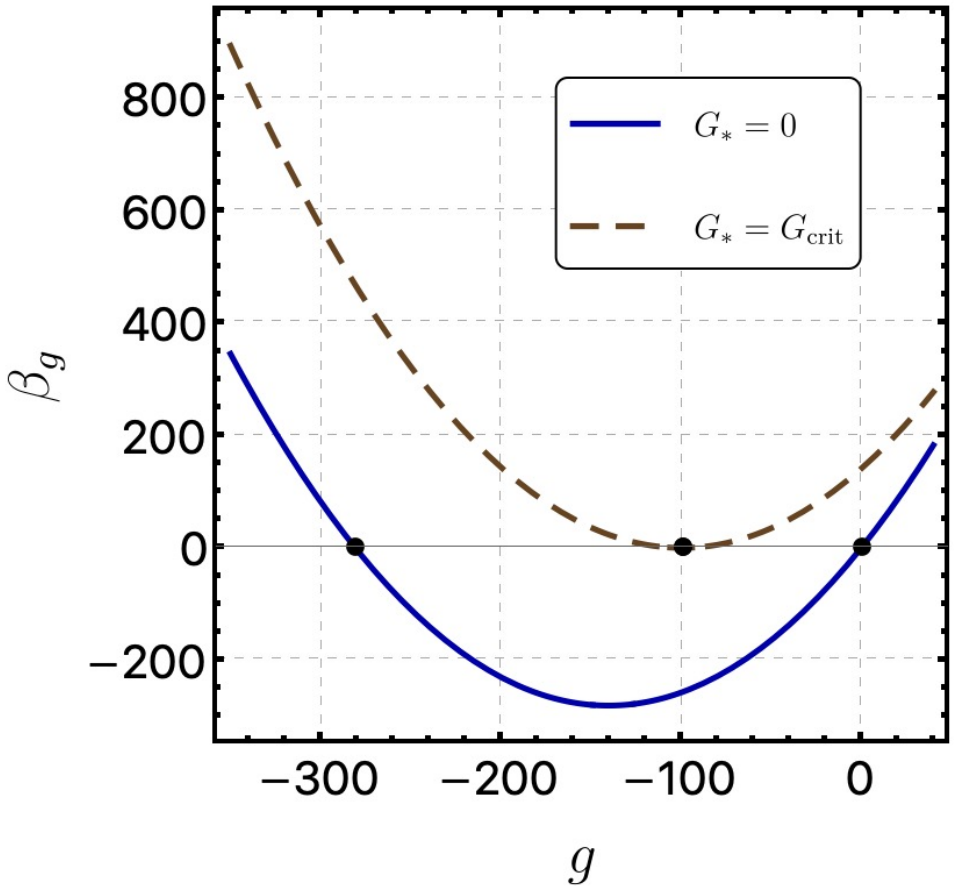


$$\beta_g \sim A + B\,g + C\,g^2$$

Weak gravity bound

Quartic interaction coupling

$$\beta_g \equiv k\partial_k g$$



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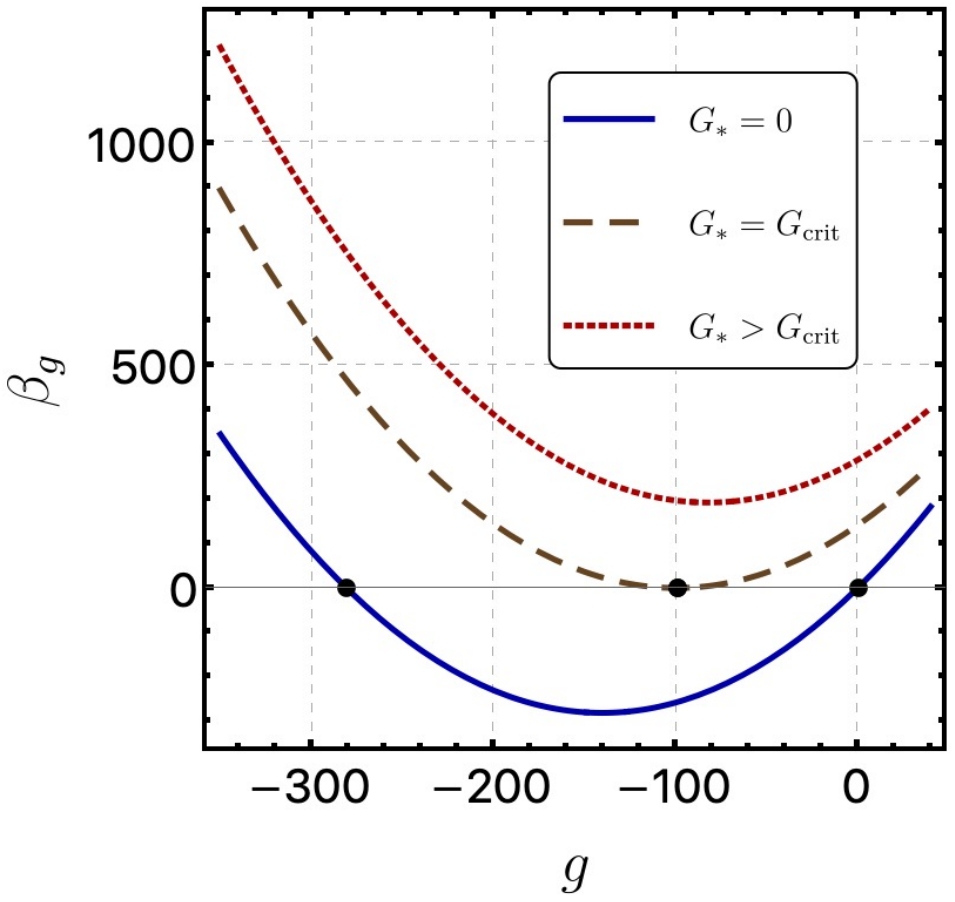
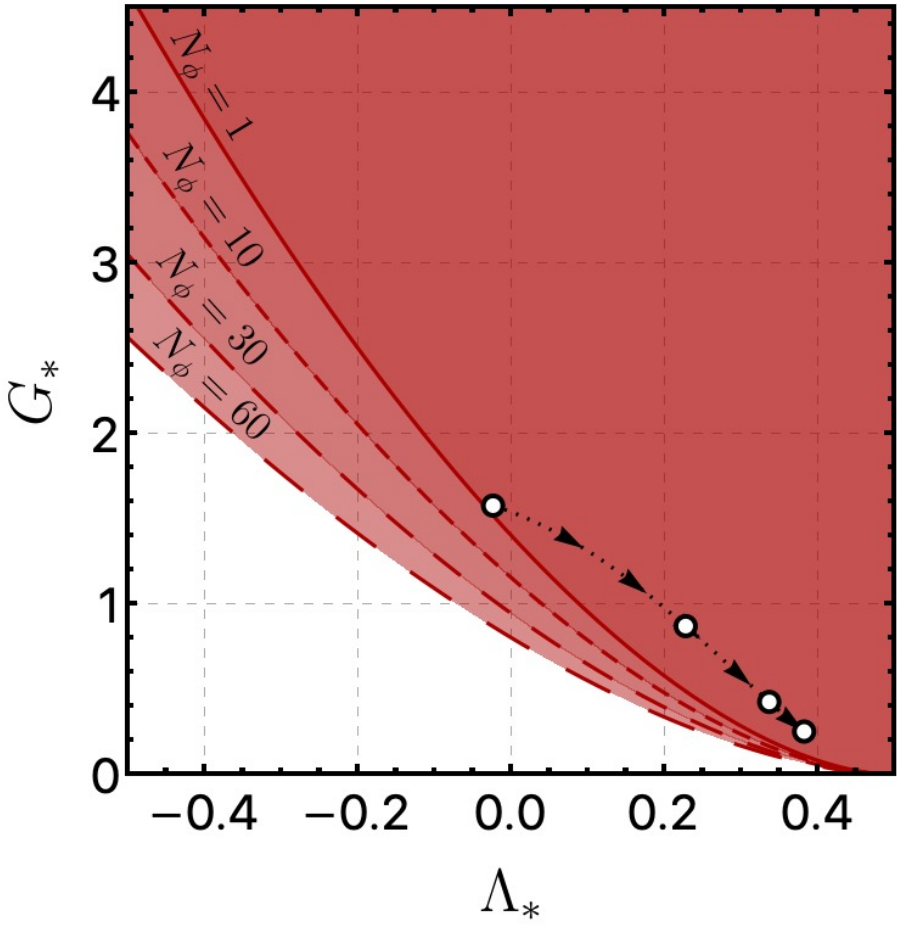


$$\beta_g \sim A + B\,g + C\,g^2$$

Result: asymptotic safety constrains the gravitational strength

Weak gravity bound: O(N)

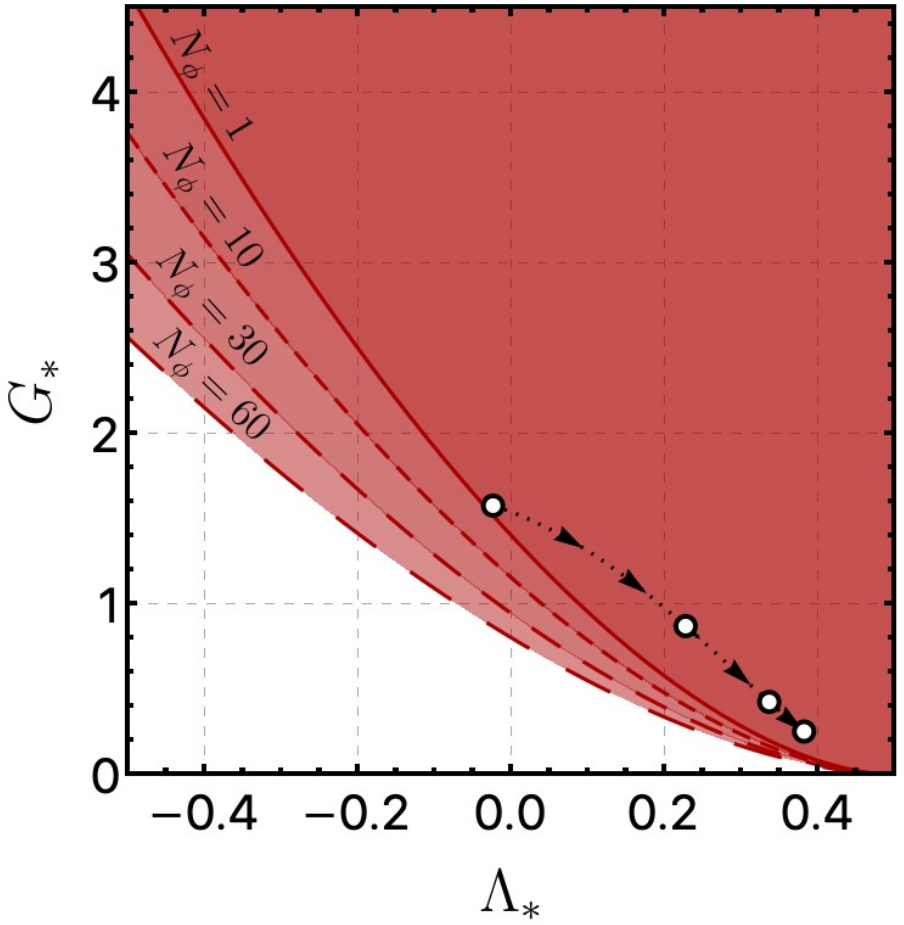
From one to multiple scalar fields



Details on arXiv soon

Weak gravity bound: O(N)

Result: asymptotic safety requires fermions and/or vectors



Details on arXiv soon

Fixed points from Eichhorn, Held 18'

Thank you!

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Exact FRG equation: $$k\partial_k\Gamma_k = \frac{1}{2}\,\mathrm{Tr}\left[(\Gamma_k^{(2)} + \mathbb{R}_k)^{-1} k\partial_k \mathbb{R}_k\right],$$

[Wetterich 93', Morris 94', Reuter 98']

Litim regulator: $$\mathbb{R}_{k,i}(p^2) = Z_k \Pi_i (k^2 - p^2)\theta(k^2 - p^2).$$

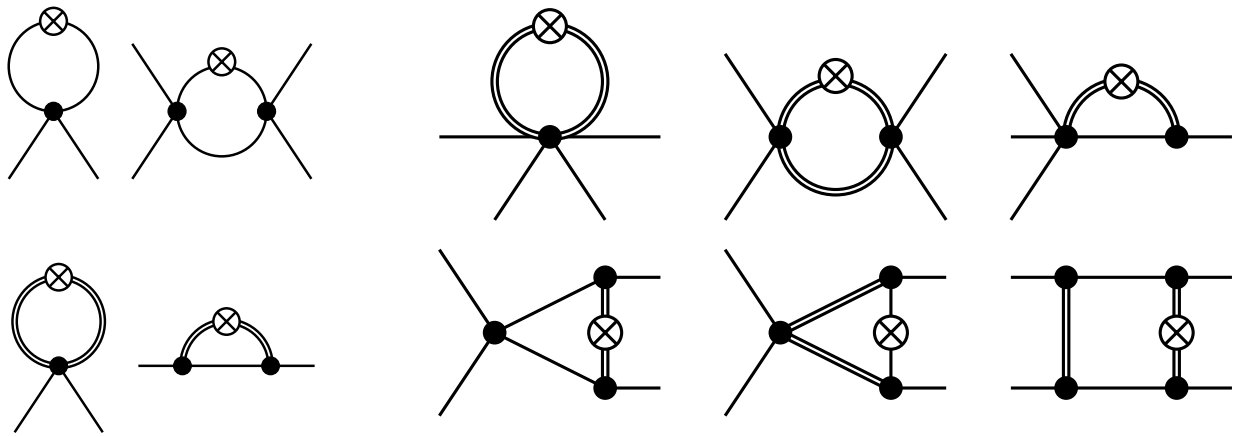
[Litim 02']

Functional renormalization group

Pedagogical reviews: Gies 12', Reichert 20'

$$\beta_g = 4g + \frac{9}{64\pi^2}g^2 - \left(\frac{10}{3\pi(1-2\Lambda)^2} - \frac{5}{18\pi(1-4\Lambda/3)^2} - \frac{4}{9\pi(1-4\Lambda/3)}\right) g\,G$$
$$+ \left(\frac{640}{9(1-2\Lambda)^3} + \frac{4}{9\,(1-4\Lambda/3)^3} + \frac{4}{9\,(1-4\Lambda/3)^2}\right) G^2\,,$$

Beta function for g



Diagrams

Continuous lines: scalar

Double continuous lines: graviton

Crossed circle: regulator insertion

$$\Gamma_k^{\rm EH} = -\frac{1}{16\pi G_N}\int d^4x\sqrt{g}(R-2\bar{\Lambda}),$$

$$g_{\mu\nu} = \delta_{\mu\nu} + \sqrt{32\pi G_N Z_h}h_{\mu\nu}, \qquad Z_h \to 1,$$

$$S_{\rm gf}[h] = \frac{1}{\alpha}\int d^4x\sqrt{g}\delta^{\mu\nu}F_\mu F_\nu, \quad F_\mu = \partial^\nu h_{\mu\nu} - \frac{\beta+1}{d}\partial_\mu h, \quad \beta \to \alpha, \alpha \to 0.$$

Gravitational sector