

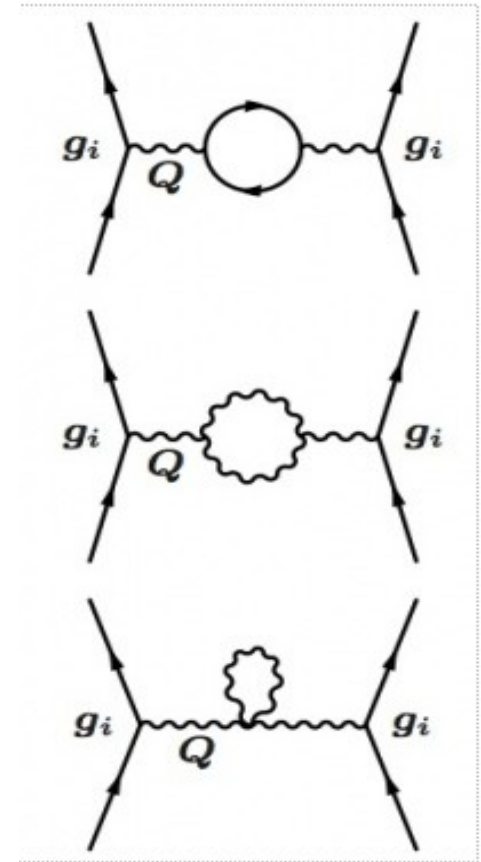
# Open questions/problems

- SM Neutrino is massless
- Is the particle discovered at LHC really the SM scalar ?
- Stable vacuum ?
- Hierarchy problem
- All interactions as predicted by SM ?
- Unification of all interactions (strong/EW + gravity)
- Why 3 generations
- Origin of masses -> why such different Yukawa couplings
- Origin of CP violation and strong CP phase
- Matter/anti-matter asymmetry
- Dark matter

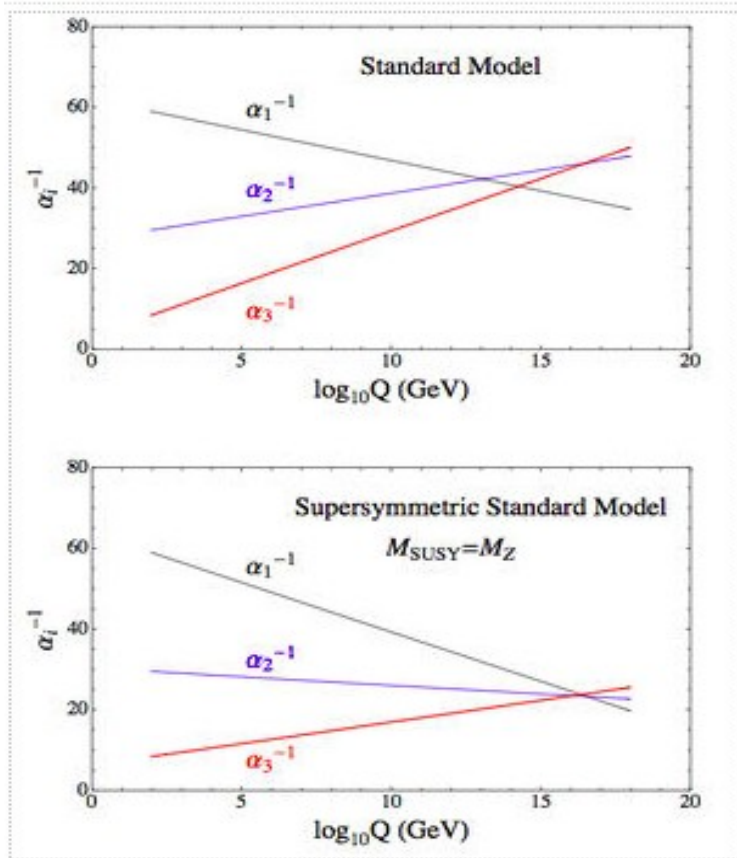
# Unification

- Unification of strong, weak, electromagnetic interactions -> unique coupling at some scale
- Running couplings
  - Coupling constants depend on energy

$$\frac{1}{\alpha_i(Q^2)} = \frac{1}{\alpha_i(M_Z^2)} - 4\pi b_i \ln \frac{Q^2}{M_Z^2},$$



# Unification : not quite



# Stability of Higgs potential

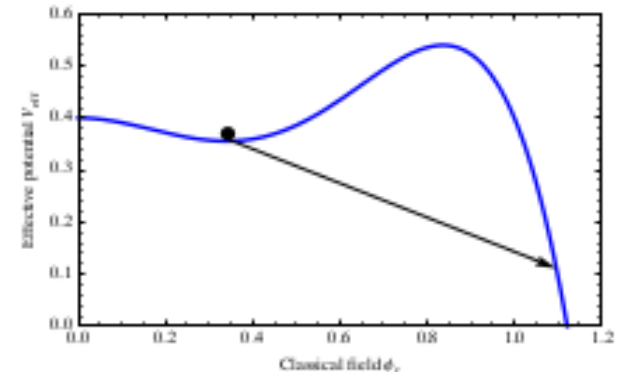
At some scale lambda can run negative leading to new minimum -> stability is lost

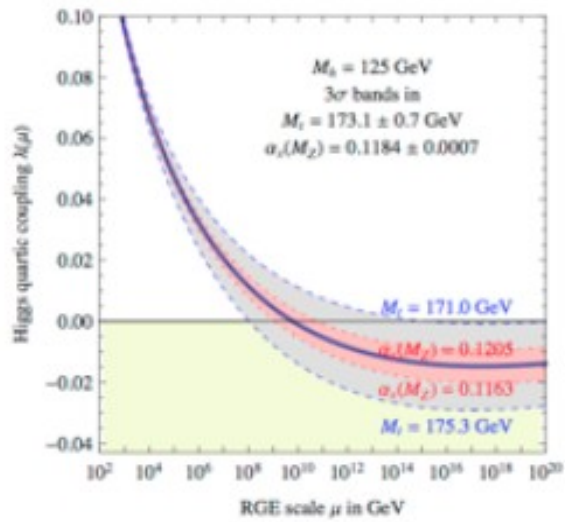
Minimum Higgs mass ( $m_h^2 = 2\lambda v^2$ ) for stability

$$\lambda(\Lambda_0) = \beta_\lambda(\Lambda_0) = 0, \quad \beta_\lambda = \frac{d}{d \ln \mu} \lambda(\mu).$$

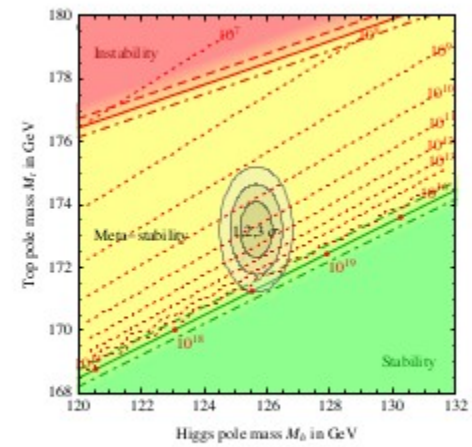
$$V \sim \lambda \phi^4$$

$$\beta_\lambda = \frac{1}{16\pi^2} (4\lambda^2 - 36y_t^4 + 12\lambda y_t^2 + \dots)$$





## NNLO



Buttazzo et al 1307.3536





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Thank you for your attention