Gravitationally produced Top Quarks and the Stability of the Electroweak Vacuum During Inflation

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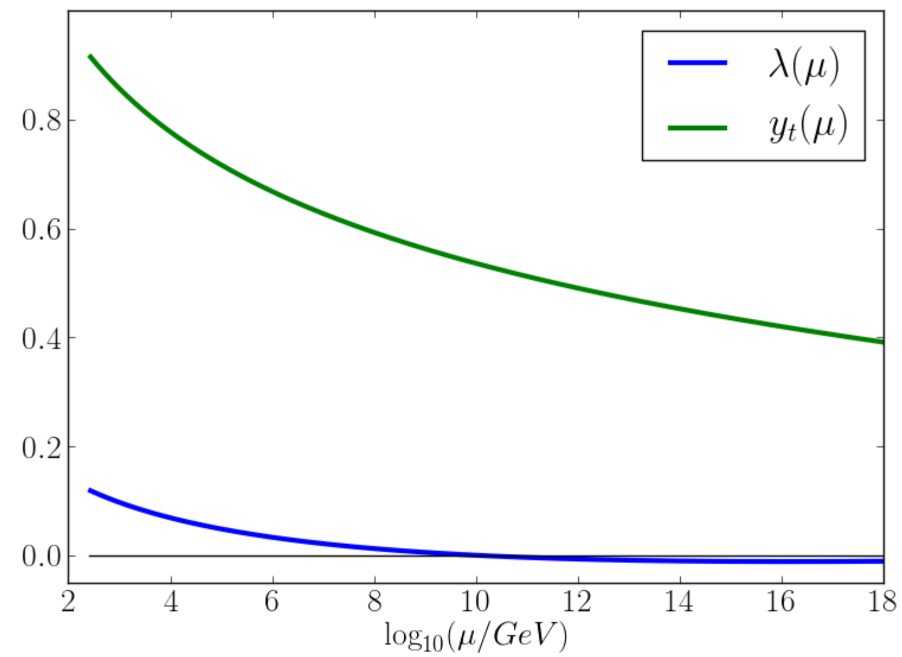
Stability EW vacuum

- Higgs quartic coupling becomes negative at large energy values



- During Inflation Higgs field moves stochastically

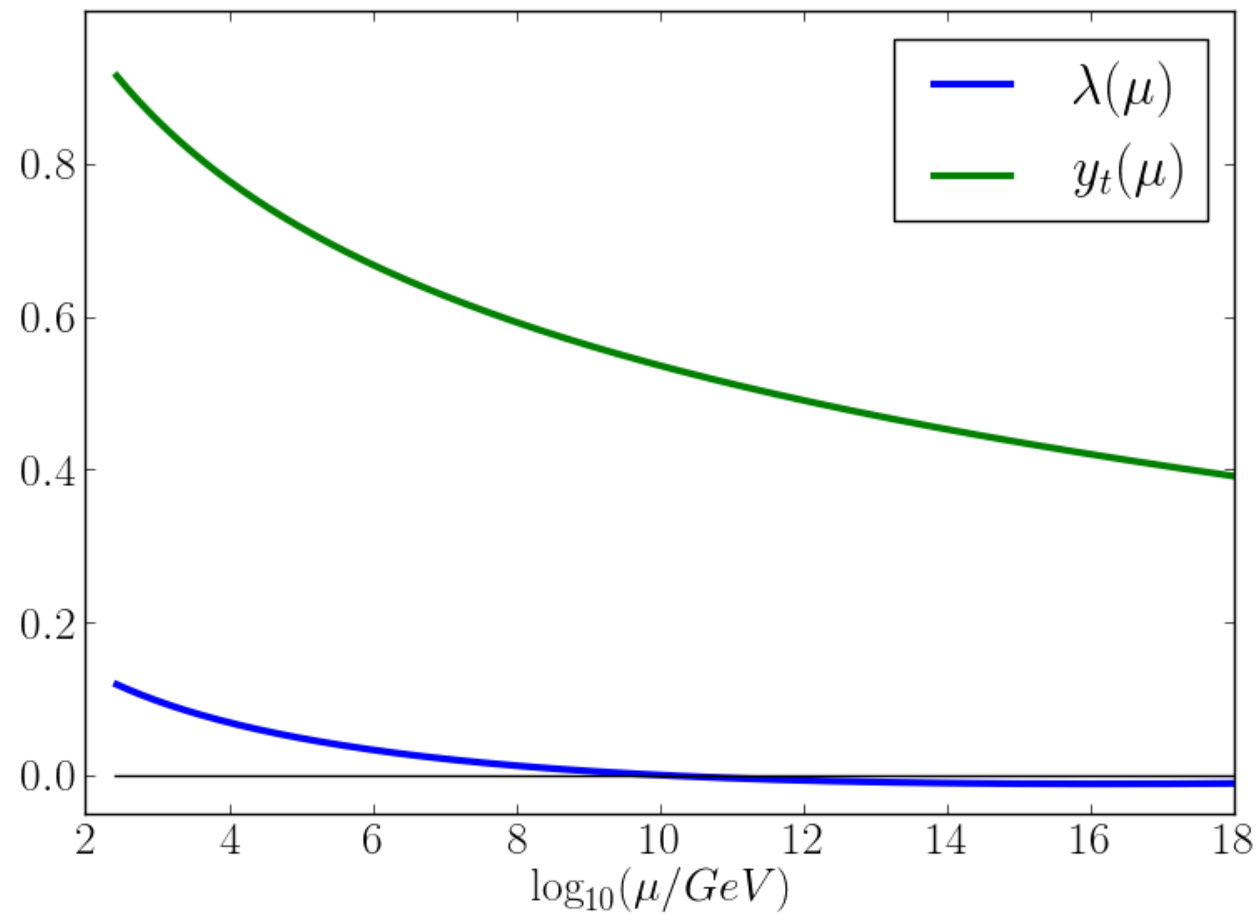
$$\langle h^2 \rangle = \left(\frac{H}{2\pi}\right)^2 N_e$$

- Choice of scale:

$$\mu = \sqrt{h^2 + H^2} \qquad \mu \approx h$$

Stability EW vacuum

- Higgs quartic coupling becomes negative at large energy values



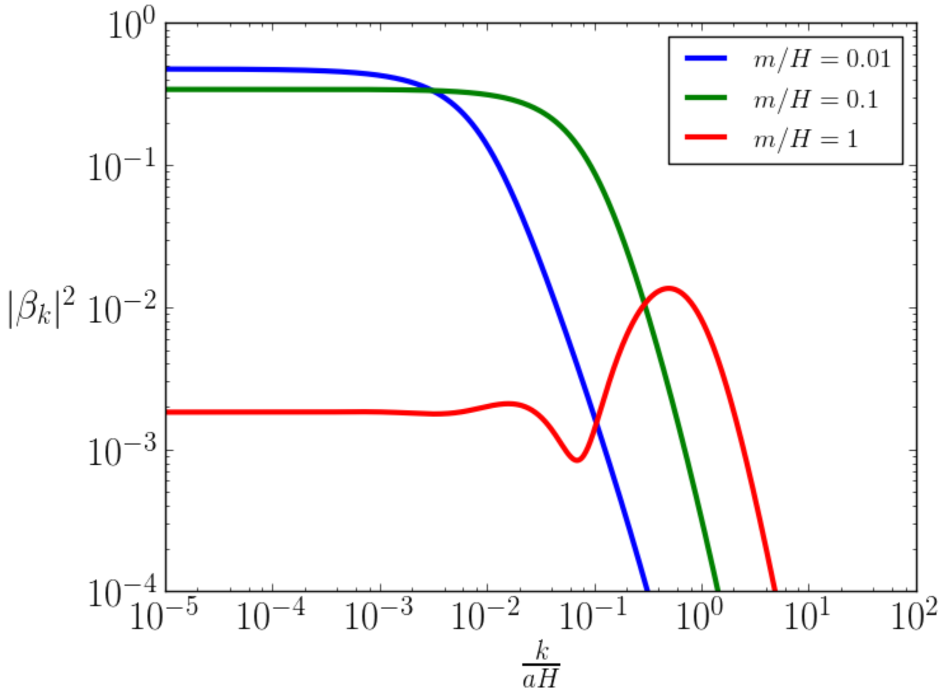
$$\mathcal{L}_{\text{Higgs \& top}} = \frac{1}{2}\partial_\mu h \partial^\mu h - \frac{\lambda}{4}h^4 - y_t \frac{h}{\sqrt{2}}\bar{\psi}\psi + i\bar{\psi}\gamma^a e_a^\mu \nabla_\mu \psi$$

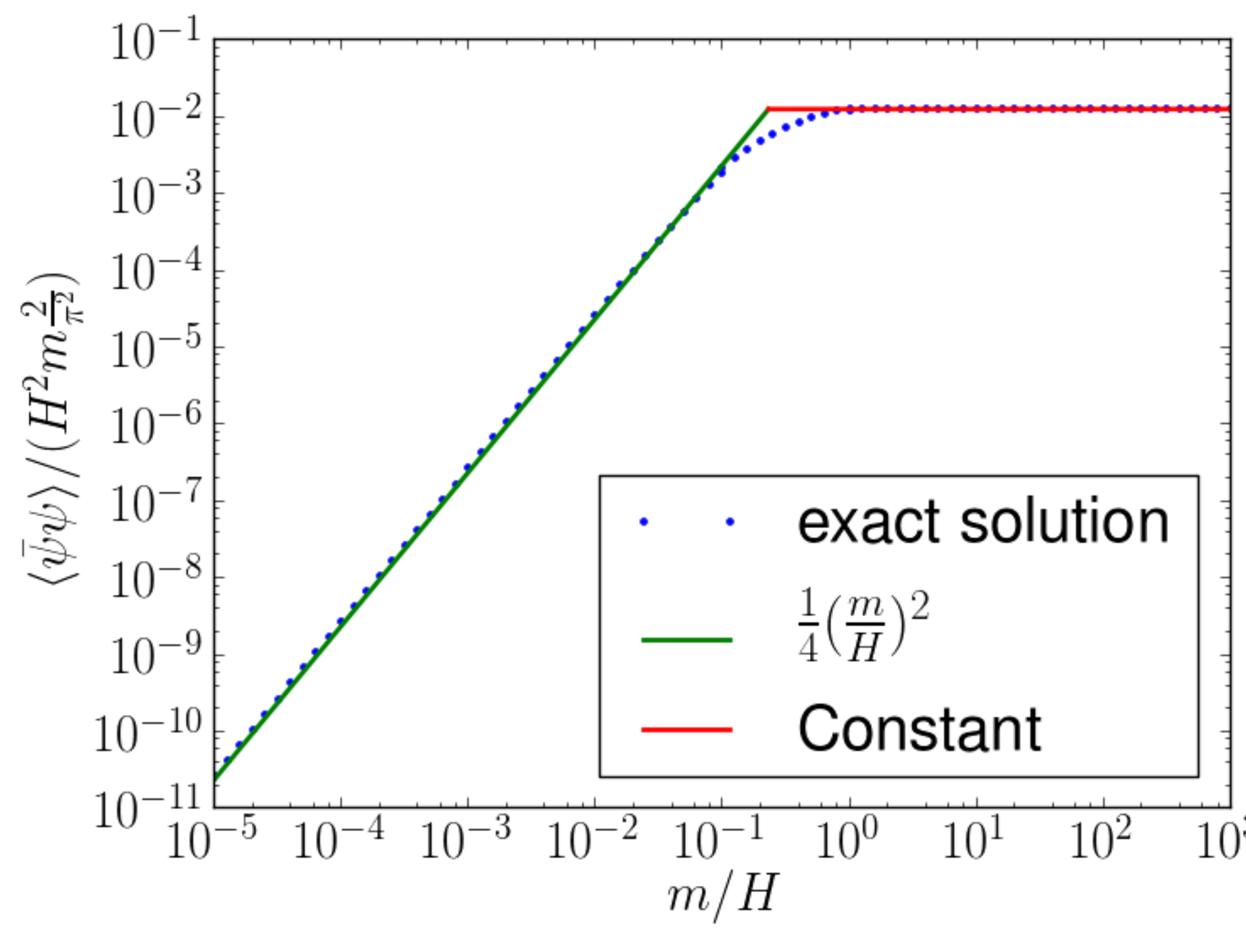
Production massive fermions

- Definition of vacuum in CS background is not unique and leads to production of particles

$$\langle vac|\tilde{a}_i^{+}\tilde{a}_i|vac\rangle = \sum_j |\beta_{ij}|^2$$

- Measure instantaneous number of particles on a Bunch-Davies vacuum





Higgs+Top quark

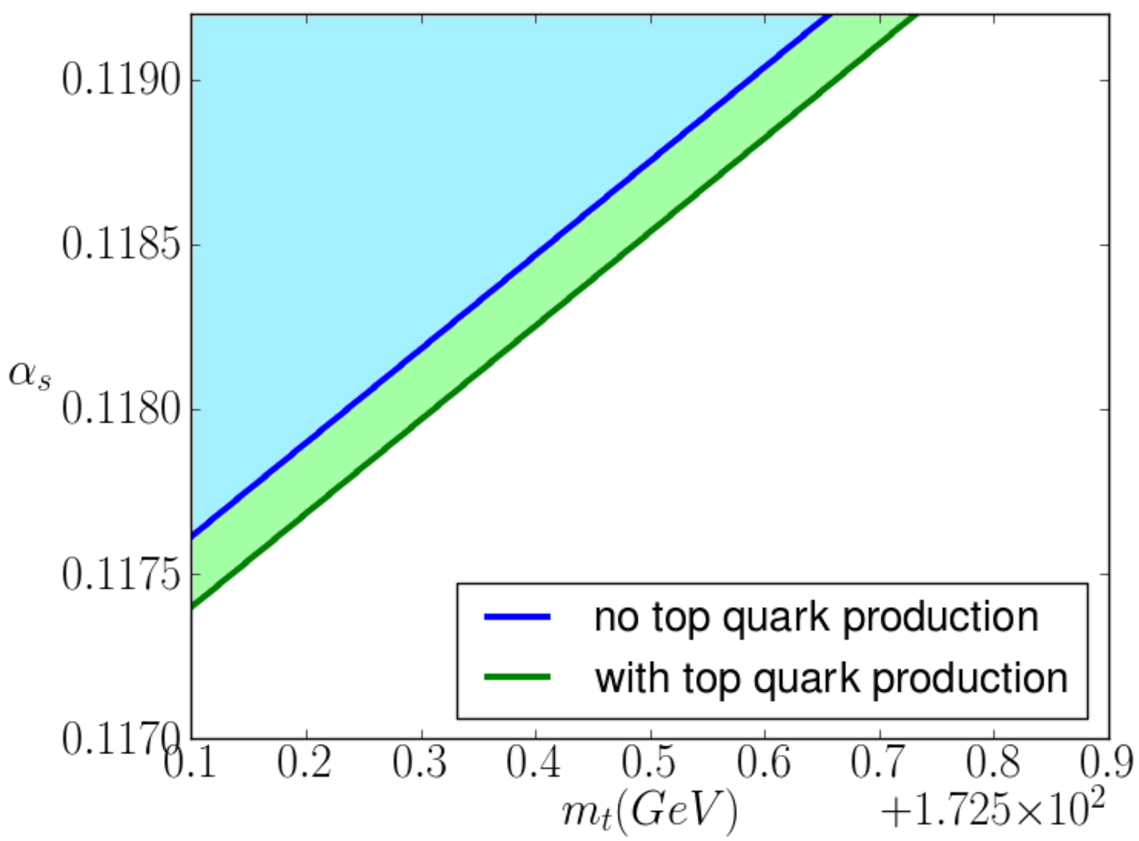
$$\mathcal{L}_{\text{Higgs \& top}} = \frac{1}{2}\partial_\mu h \partial^\mu h - \frac{\lambda}{4}h^4 - y_t \frac{h}{\sqrt{2}}\bar{\psi}\psi + i\bar{\psi}\gamma^a e_a^\mu \nabla_\mu \psi$$

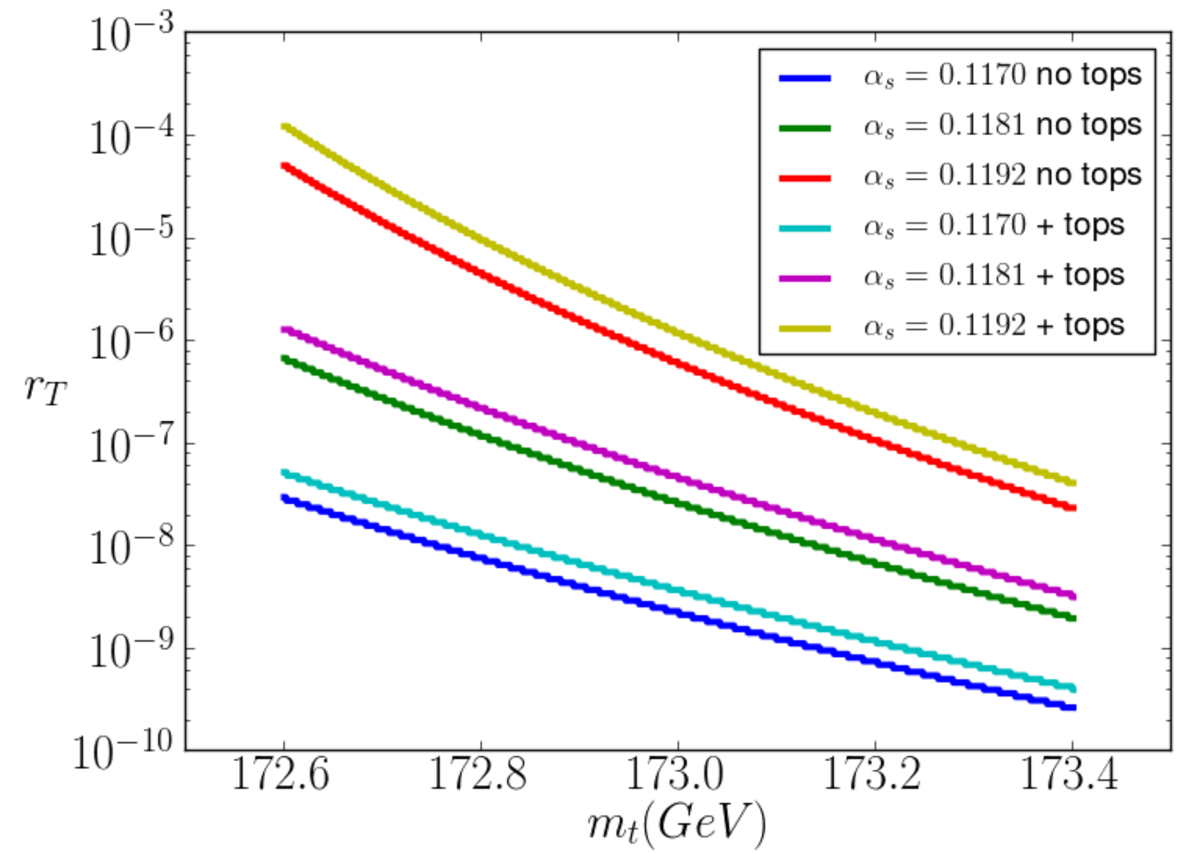
$$V(h) = \frac{\lambda}{4}h^4 + y_t \frac{h}{\sqrt{2}}\bar{\psi}\psi = \frac{\lambda}{4}h^4 + \begin{cases} 0.01 \cdot (y_t h)^4 & \text{if } y_t h \le 0.3H, \\ 0.001 \cdot (y_t h H)^2 & \text{if } y_t h \ge 0.3H. \end{cases}$$

Stable if

$$\boxed{\sqrt{\frac{2 \cdot 0.001}{-\lambda(\mu)}}\, y_t(\mu) > \frac{1}{2\pi}\sqrt{60}}$$

Stability study





$H = 10^{11}\ GeV$ and $m_h = 125.18\ GeV.$

Extended stability without new physics.