

Higgs Criticality Of Beaches and Sandpiles

Maximilian Detering

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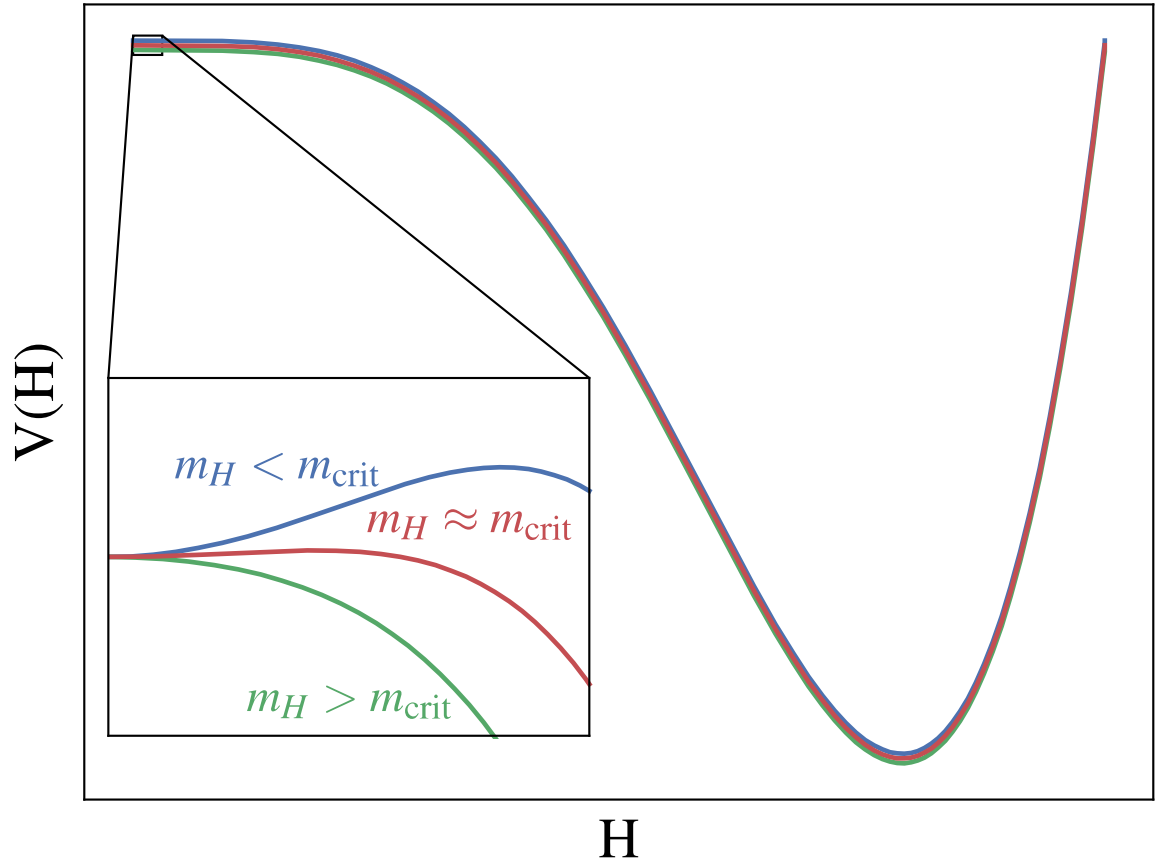
Supervised by Tevong You

The Puzzle – Higgs Hierarchy Problem

- What is the origin of the Electroweak scale?
- How can we explain a small mass scale from a large mass scale?
- Many great ideas, generally with visible new physics effects
- Paradox: small Higgs mass but no signatures of new physics

The Idea – Fine-tuning through Criticality

- Smallness of Higgs mass parameter as **critical point**
- Quantum phase transition through change of external parameter
- Sets metastability bound on Higgs mass
$$m_H^2 < m_{crit}^2 = -\frac{1}{2} e^{-\frac{3}{2}} \beta_\lambda(\mu_I) \mu_I^2$$
- **Dynamical** explanation of small Higgs mass



The Explanation – Self-organised Criticality

- Criticality can act as an attractor: self-organised criticality
- DIY experiment on the beach (*suitable for theorists*)
- Incarnation in particle physics: Self-organised localisation
- Background field ϕ varies and is coupled to some operator O whose expectation value changes as ϕ passes through some critical value ϕ_c
$$V = (\phi - \phi_c)O$$
- If $\langle O \rangle$ changes across ϕ_c , stochastic evolution could localise ϕ near ϕ_c
- Other mechanisms exist too
 - General consequence: near-critical Higgs mass

The Consequences

- Metastability bound in SM not constraining: $m_h \leq 10^{10} \text{GeV}$
- Deformation of the Higgs potential from the SM
- Signs of new physics such as
 - Vector-like fermions
 - Axions

Thank you!