Stability of the Higgs-vacuum as constraint on U(1) extensions of the Standard Model

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Introduction

- In the standard model, the Higgs quartic coupling λ_φ becomes negative (Fig 1.) during its renormalization group flow

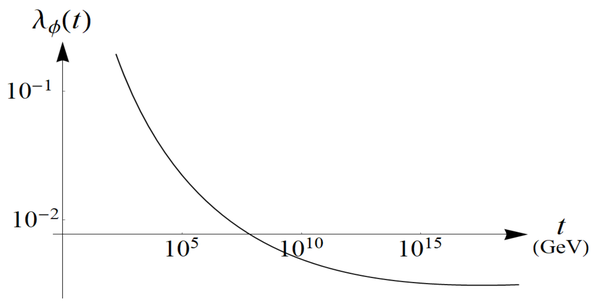

Fig. 1.

- The U(1) extensions of the standard model are popular candidates attempting to explain experimental observations that cannot be interpreted within the SM, such as neutrino masses.
- The extra couplings introduced by the U(1) extension may influence the RG-flow of λ_φ. The scalar potential now includes an extra scalar field χ, which is supposed to be responsible for neutrino masses. The complete scalar potential is

$$(1)\ V = -\mu_\varphi^2 |\varphi|^2 + \lambda_\varphi |\varphi|^4 - \mu_\chi^2 |\chi|^2 + \lambda_\chi |\chi|^4 + \lambda |\varphi|^2 |\chi|^2$$

Method

- The β-functions of the model are derived in perturbation theory in one-loop level
- A numerical code was written to solve the system of β-functions
- The initial conditions of the SM couplings were taken from measurements, at M_t=173.75 GeV one has:
  g_Y=0.3583, g_L = 0.6477, g_S=1.166, c_t = 0.9379, c_b=0.0161, c_τ=0.0100 λ_φ=0.1259, μ_φ =131.5 GeV
- The initial conditions for the extra gauge couplings were set to zero, as they have to be very small in order to preserve the predictions for measurements
- The initial conditions for the remaining couplings (λ_χ, λ and c_υ) were varied
- Trajectories are selected, where the perturbativity and the positivity of λ_χ and λ_φ were met up to the Planck scale

Preliminary Results

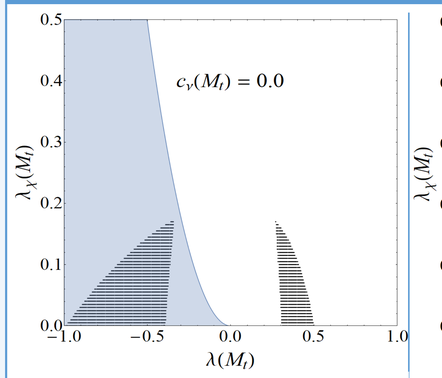

Fig. 2.

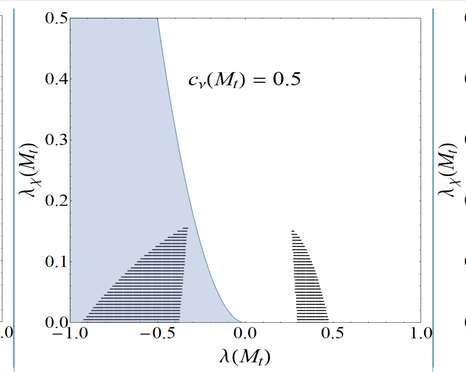

Fig. 3.

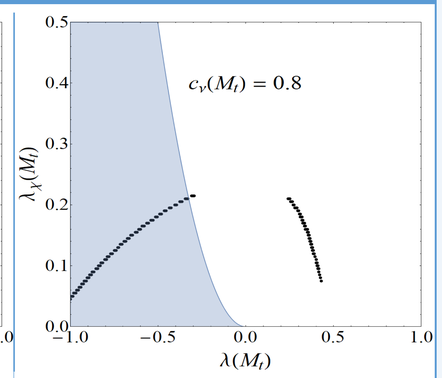

Fig. 4.

Conclusion and outlook

- A finite region was found in the parameter space, where all the conditions are satisfied, with both positive and negative λ
- Scalar potentials of the form (1) are used in models of inflation, such as hybrid inflation
- The constraints presented here can be used to study models for inflation, supported by a renormalization group analysis

References

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