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Lattice study of the Higgs-Yukawa model in and beyond the Standard Model

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We consider a chirally-invariant Higgs-Yukawa model as a limiting case of the Standard Model (SM) and investigate the model using lattice simulation. We present result of the study of the model near the mean-field using Renormalisation Group (RG) improved finite-size scalling. We derived formulae for such scaling behaviour by including the contribuations of the leading logarithms. Results for the magnetisation, susceptibility and Binder's cumulant are tested against the lattice simulation data performed with small bare scalar-quartic and Yukawa couplings. In these tests we found the predicted logarithmic volume dependence of those observables. The technique we establish in this work can be applied to an extensive investigation of the phase structure of the Higgs-Yukawa models. In particular, it can be used to study the possibility of having non-trivial fixed points in such models.

In a different aspect of our work, we have also included a $(\phi^\dagger\phi)^3$ term to investigate effects of a higher dimensional operator in this model. Such a higher-dimensional operator can originate from physics beyond the SM. With the zero temperature phase structure established in our previous work, it is worthwhile to study the finite temperature properties of such a model.

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