

The Standard Model of elementary particle physics consists of the electroweak and strong interactions. The electroweak theory unifies the electromagnetic and weak interactions within a chiral gauge theory where spontaneous symmetry breaking generates masses for the fermions and weak gauge bosons. This spontaneous symmetry breaking is most simply described by the Higgs mechanism, which postulates the celebrated Higgs boson. Despite the success of the standard model, the Higgs boson has not yet been found and a large experimental effort at the LHC is dedicated to its discovery. The Standard Model also contains puzzles which indicate that it may not be a fundamental theory, prompting many Beyond the Standard Model (BSM) scenarios.

Our work focuses on various properties of the Higgs boson determined non-perturbatively from Monte Carlo simulations of a lattice Higgs-Yukawa model. Recent developments in lattice techniques have enabled us to maintain an exact chiral symmetry at finite lattice spacing, which is crucial to preserve the chiral nature of the theory.

BSM scenarios with an additional heavy fourth generation of quarks have recently gained attention, partly because they may provide an explanation of the matter-antimatter asymmetry of the universe due to the large Yukawa couplings present in the model. A heavy fourth generation of quarks must therefore be studied non-perturbatively using the techniques described above. It is the plan of the project to perform a comprehensive investigation of the dependence of the Higgs boson mass bounds in the presence of a heavy fourth generation of quark ranging from 190 GeV to 700 GeV. In addition, we wish to study the fourth generation model at non-zero temperature and compare non-perturbatively obtained values for the critical temperature with perturbation theory.