

Flavor physics in searches for Standard Model extensions (abstract for general public)

Research project objectives/hypothesis

Discovery of the Higgs boson at LHC collider provided the final experimental evidence confirming the theoretical structure of the Standard Model of particle physics (SM). Its success has been phenomenal - since invention over 40 years ago the SM was able to reproduce all experimental results, in spite of their growing precision. Only the recent cosmological observation that the “dark matter” and “dark energy” constitute most of the mass of the Universe cannot be accommodated within the SM. This observation, together with theoretical SM limitations, suggests that it cannot be the Theory of Everything. Thus, it is of crucial importance for our understanding of Nature to search for the more general theory. Such searches can be performed in high energy colliders, where new particles could be directly produced, or analyzing the precise measurements collected at lower energies. In the latter case one may hope to find effects of quantum corrections from new particles (even if their masses are too high for the discovery in current colliders!). In this project we follow the second plan, using precision *flavor physics*, i.e. physics of processes changing one species of quarks and leptons (distinguished by the quantum number called “flavor”) into another, as a probe of physics beyond the SM (BSM).

LHC is the first collider in which heavy top quarks and Higgs bosons are produced copiously enough to measure and examine their non-standard couplings. In addition, the new precise measurements of very rare heavy B meson decays have been performed by the LHCb, Babar and Belle experiments (reporting even some unconfirmed yet deviations from the SM predictions).

In our project we plan to conduct the theoretical research based on such new and incoming data from flavor physics aiming towards discovering evidence for heavy particles and their interactions.

Research project methodology

Our research will go into three general directions. We shall start from the investigations independent of the choice of the concrete BSM theory - it could be done by adding to SM *all* possible interactions, which could arise as the effective low energy limit of BSM models, and compare them with experimental data to find bounds on allowed magnitudes of new couplings. Such estimates are quite general but not too strong - usually they could be tightened within specific types of BSM models. Thus, in the next stage of our research we analyze range of the most promising BSM models - exhibiting new symmetries (like supersymmetry), containing more than one Higgs boson or additional bosons carrying new superweak interactions, or even more exotic particles - so called leptoquarks or vector-like fermions. Our analysis will help to discriminate which BSM models reproduce data best.

Based on our research, we plan also to develop and publish the computer libraries facilitating the calculations (numeric and symbolic) in the flavor physics for all community of high energy physicists.

Research project impact

Understanding the energy scale and structure of BSM interactions, addressing the SM deficiencies, is the main goal of the contemporary particle physics. Our project follows this goal by searching for traces of the BSM physics in the precise measurements of flavor transitions. Finding some indirect hints for new particle, their masses and couplings, will also provide a valuable information on their “signatures” (typical production and decay patterns) which should be investigated in direct searches at LHC collider.