Indirect searches for the Standard Model extensions (abstract for general public)

Research project objectives/hypothesis

Since its formulation in early 70-ties of last century, Standard Model of elementary interactions (SM) is able to describe all results of experiments in Earth laboratories, in spite of their growing precision and increased energy range accessible in accelerators. This remarkable success was crowned by the discovery of the Higgs boson at CERN in 2012. Nevertheless, cosmological observations of dark matter and dark energy, constituting most of the mass of the Universe, cannot be explained within the SM.

These astronomical data, together with some theoretical deficiencies of the SM, suggests that it is also only an approximation, a part of more general theory describing Nature. Searches for such underlying theory are key to deepening of our understanding of the basic laws governing the Universe. It is a difficult task, which could be realised in different ways. Most spectacular would be the direct discovery of the new heavy particles in the high-energy colliders. Unfortunately, such discovery has not been done yet and the construction of new more powerful devices could take many years. Another approach relies on the analysis of the precision measurements performed in already existing experiments, searching for the effects of quantum corrections from new particles to interactions of known objects. They can manifest themselves in this way even if the new particles are too heavy to be produced in currently active accelerators.

In our project we will follow the second path and perform theoretical research aimed at finding the clues of existence of physics beyond the SM using the precision data from the current experiments and the ones planned to be built in near future.

Our goal is particularly actual, as the new generation of experiments directed at increasing the accuracy of measurements (mostly due to larger statistics of particles observed in detectors) already works or will start operating within few years, long before the new accelerators able to extend the range of direct searches can be built. In particular, our research will be based on the the results from planned “High Luminosity” phase of LHC upgrade, from “factories” of the heavy B mesons (Belle-II, BaBar), from the new large neutrino detectors (HyperK, Dune) and from many others. They already reported some results suggesting (if confirmed) existence of certain anomalies comparing to the SM predictions in the rare decays of B mesons.

Research project methodology

Our research will be concentrated on the three main tasks. Two of them concern the analysis of the phenomena particularly sensitive to effects of new interactions - one class of them are processes of scattering and decays of the heavy vector bosons and of the Higgs boson, second class are transitions between various types (generations) of leptons and neutrinos. As our basic tools we will use the Effective Field Theory (EFT) formalism, independent of the choice of particular model extending the SM. Our third task will be the development of the computer packages facilitating the calculations within the EFT, available for wide society of the high-energy physicists.

Research project impact

Extending our knowledge of the basic laws of Nature is since centuries the most important goal of all researchers. Our project will help to move closer to this goal and to understand energy scale and structure of “new physics” interactions, by searching for their manifestations in the precision measurements of processes involving the particles constituting the SM. Collected information about the allowed range of the masses and couplings of the new particles will also facilitate their direct searches at LHC or in the future super-colliders.