# On the role of scale symmetry in solving the hierarchy problem of the Standard Model of elementary particles

## Description for the general public

When considering models of the fundamental interactions, physicists are often forced to rely on perturbative calculations. The initial description of elementary particles they propose, needs to be supplemented by quantum corrections. Calculating the latter one uncovers a more accurate depiction of studied phenomena. The corrections modify predictions of a model in a quantitative, and sometimes even qualitative way. They change relative strengths of interactions and masses of particles. They can also tell us that the examined physical system is actually unstable and would begin a dynamic evolution. But, aside from a wealth of interesting effects, the corrections can also birth theoretical problems. An example of that is the hierarchy problem in the Standard Model. The Standard Model is the most accurate, established theory, capable of explaining all phenomena observed in particle accelerators. Yet physicists do not rest on their laurels and propose extensions of the Standard Model with new, extremely heavy, unobserved particles in order to explain even more phenomena. In the Standard Model there is only one dimensional parameter, mass of the Higgs boson. Its experimental value, the one which we would like to recover after including the corrections, is relatively small. As it turns out, it is a challenge to propose an extension, where the new, heavy particle does not cause big corrections to the Higgs's mass. In every such naive extension, the nature appears to be conspiring against the researchers, arranging the model's parameters in such a way that the quantum corrections cancel a very substantial part of the massive parameter. Physicists find it hard to accept. It is a universal supposition, that the strive to make the Higgs bosons's mass insensitive to quantum correction, is a valuable clue, when constructing extensions of the Standard Model.

One of the possibilities is to employ the scale symmetry. Scaling indicates here a transformation, which multiplies values of quantum fields (in powers dependent on the field's spin) and proportionally shortens distances in the space-time. Large part of the Standard Model is invariant with respect to this transformation on the classical level. But even so, it breaks the symmetry on the level of quantum corrections.

The goal of this project is to examine a class of models, where the scale symmetry is both present and preserved by quantum phenomena. An exciting aspect of this endeavour will be the usage of an atypical way to calculate the quantum corrections, the so called SI (scale invariant) prescription. Implementation of this method enforces modifications of typical models of fundamental interactions. Thus, the method serves as a guidance in constructing theories which are scale-symmetric even on the quantum level. After examining universal mathematical implications of the SI method, we hope to use it to propose a novel extension of the Standard Model. One that is free of the described hierarchy problem.