BARYOGENESIS IN REALISTIC UV COMPLETIONS OF THE STANDARD MODEL

POPULAR SCIENCE ABSTRACT

The Standard Model of particle physics widely regarded as the greatest triumph of physics. This is our best theory so far to describe elementary particles and three of the four forces of nature, electromagnetism, the weak nuclear force, and the strong nuclear force. It can successfully explain all the phenomena observed in current particle physics experiments, such as the Large Hadron Collider (LHC) at CERN, within broad range of energies. Despite this enormous success, the Standard Model is not without its problems and cannot be considered a complete theory.

One of the deficiencies of the Standard Model is that it is unable to reproduce the observed asymmetry of matter and antimatter in the Universe, considered one of the largest mysteries of modern physics. The observable Universe consists almost entirely of particles, with a small admixture of antiparticles. Some theory of physics beyond the Standard Model coming with new particles and symmetries has to be used to explain the matter-antimatter asymmetry via the hypothetical mechanism called baryogenesis.

The main idea of our project is to investigate extensions of the Standard Model in the context of baryogenesis. The project will consist of two parts.

Our first goal is to investigate baryogenesis in theories of physics beyond the Standard Model and to examine its consistency with the assumption of the so-called asymptotic safety. Asymptotic safety is a hypothesis about the high-energy properties of gravity formulated by Nobel laureate Steven Weinberg. Such a hypothesis has a significant impact on particle physics models. Most of the beyond the Standard Model physics models introduce new particles, but they are unable to predict the properties of these particles, such as masses and couplings. The assumption of asymptotic safety imposes restrictions on these models, allowing us to accurately predict some particle properties. For example, in the Standard Model, this assumption allows us to predict the mass of the Higgs boson with extremely high precision. We will perform similar calculations in the context of extensions of the Standard Model to obtain specific predictions of particle properties, and then examine which of these extensions are consistent with baryogenesis predictions.

Our second aim is to study Grand Unified Theories. These are models in which the three forces described by the Standard Model, electromagnetism, the weak nuclear force, and the strong nuclear force, are combined into a single force at high energies, just as the electromagnetic force is a unification of electric and magnetic forces. However, the symmetry of the Grand Unified Theory has to be partially broken in the right way to reproduce the Standard Model at low energy scales. We will investigate whether it is possible to obtain such correct symmetry breaking through the mechanism of the so-called radiative symmetry breaking. We intend to extend our results beyond the minimalist SO(10) unification model and to combine them with predictions based on the assumption of asymptotic safety.