Evolution of particles density and temperature within models of self-interacting dark matter.

Popular description of the project

One of the greatest successes of 20th-century physics is the explanation of the structure of surrounding us matter and interactions between its components. Thanks to numerous proposed theoretical models and their subsequent verification in particle colliders with larger and larger energies, the standard model of elementary particles was established. It describes elementary particles that make up matter, such as quarks and leptons, and particles responsible for strong (gluons) and electroweak (Z, W and photons) interactions. The studies of the standard model were crowned by discovery of the Higgs particle by the experiments at the Large Hadron Collider.

The Standard Model is formulated in the language of quantum field theory. This is a theory that describes the results of experiments in terms of physical field permeating the space, whose excitations are observed as elementary particles. There is no reason to believe that the scope of this theory is limited to processes happening in the labs on earth. On the contrary, for example, the calculation of interactions between particles occurring a few seconds after the Big Bang led to the explanation of the abundance of the lightest elements in the Universe, which is one of the greatest achievements of cosmology.

Despite the numerous successes of the standard model, the studies of the evolution of the Universe as a whole and the astrophysical observations of structures in it, such as galaxies and their clusters, have shown that the known forms of matter account for only a fraction of the energy in the Universe ($4,9\%$). The rest is a mysterious dark energy (69.2%) and the so-called dark matter (25.9%), which can be made of particles from the Standard model.

We know that dark matter does not interact with light, or in other words electromagnetic radiation, but it can communicate with us in different ways. As part of this project, we will investigate possible interactions between dark matter and Standard Model particles: occurring in the early Universe and those that currently happen in galaxies. They will be used to analyze the evolution of dark matter density and temperature, resulting in an observable amount of dark matter particles. We will study what was the role of temperature difference between visible matter and dark matter on the formation of its relic density and introduce corrections to the known models. We will also examine the characteristics of dark matter that affect the distribution of matter in galaxies and the size of the dwarf galaxies surrounding the Milky Way. Research will be used to build new dark matter models that meets known experimental limitations and can lead to next interesting predictions.