

DESCRIPTION FOR THE GENERAL PUBLIC

The essence of physics is the search for knowledge, discovery and understanding of the laws governing the world around us. Beginning from rules that determine the behavior of subatomic particles to those governing stars, galaxies, and even the whole visible Universe. One of the tools in the arsenal of a physicist particularly suited for this challenge are effective theories. Properly designed, they allow to link the available experimental data to these theoretical predictions which, due to technological limitations, cannot yet be verified experimentally. At the same time, they force the scientists to remember that our description of the world is always imperfect due to an enormous complexity of Nature. The prime example of the effective field theory is the Standard Model of particle physics. It allows to understand properties of the smallest among the currently known components of matter. At the other end of the spectrum of sizes of the examined phenomena are the issues of cosmology and astrophysics. The basis of our understanding of these is the Einstein's General Theory of Relativity. Built over a century ago, it allowed to explain the properties of the gravitational field in terms of the geometry of spacetime.

The aim of the proposed project is to develop a methodology that allows to extend the universal effective action formalism (a mathematical way of writing the effective field theory), so that it could be used in curved spacetime. The resulting universal effective action in curved spacetime formalism will be used to take into account the presence of a gravitational field in the description of selected quantum matter models. An influence of the spacetime curvature on the problem of the vacuum stability and matter-antimatter asymmetry generation will be investigated in detail. In addition, the resulting effective theories describing models of dark matter will be analyzed for the possible existence of massive exotic objects, such as stars composed of dark matter.

The research methodology developed in this project can contribute to the discovery of new and deepening of our knowledge of already known phenomena at the interface of physics of small particles and of big Universe. This is particularly important from the point of view of cosmology and astrophysics.