Structure of the bimetric gravity models within noncommutative geometry

Description for the general public

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Modern theory of gravity, though very successful in the description of the movements of planetary systems, black holes and gravitational waves, still do not fully solve problems which appear on large scales like the origin and role of the dark matter and dark energy. There are several theories that have been proposed as a possible explanation for these issues. One class of them are the bimetric gravity models.

The goal of this project is the analysis of the bimetric gravity models using methods originated from the noncommutative geometry. The description of existing bimetric gravity models contains parameters that are undetermined by the structure of these models. For some class of these models it is possible to find values of these coefficients in such a way that the resulting theory will be consistent with observational evidences, especially its predictions can be consistent with the standard cosmological model, i.e. the ΛCDM model. On the other hand since these parameters are a priori arbitrary there can exist models in which the cosmological scenarios deviate from the standard cosmological model. Finding and deeper understanding the fundamental mathematical structure behind these classes of models will restrict the range of possible values of parameters of these models and will allow for the determination of relations between values of particular cosmological quantities that can be compared with the observational data.

In this project the fundamental mathematical structure we start with is a so-called spectral triple, that in the case of usual Riemannian geometry contains the whole information about the metric structure of the space. Its generalizations describe the so-called noncommutative geometries, which particular example will be used here. Applying methods of noncommutative geometry, analogous for what was done by Connes for a description of the Standard Model of particle physics, especially the methods for computing the so-called spectral action, we will derive the action for the bimetric gravity models. As it is known from recent applications of these methods in the particle physics they allow for extracting the information about the undetermined, in other approaches, parameters of a model. The relations between these parameters and cosmological quantities allow to express values of the last one by these parameters, and therefore parameters in bimetric gravity models computed using methods of noncommutative geometry will be used to predict possible cosmological scenarios. These predictions can be compared with the available data from astronomical observations.

Furthermore, the necessity of the extension of known computational tools for the case of our spectral triples requires the development of new methods for effective calculation of several quantities, and therefore we end up with a series of intriguing mathematical problems. Solutions of them and their generalizations may have an influence on the development of other branches of mathematics and physics.