Referee Report

Ph.D. Thesis title: "Mathematical theory of perturbations in cosmology"

Author of the Thesis: Mgr. Jan Novák

The thesis is devoted to the Cosmological Perturbation Theory.

The Standard General Relativity (SGR) in higher dimensions is studied in Chapter 2. The author stressed there the usefulness of the Geroch-Held-Penrose (GHP) formalism, which is used in Chapter 3 and applied to perturbations of homogeneous and isotropic cosmologies.

Chapter 3 is devoted to the Friedmann-Lemaitre-Robertson-Walker (FLRW) spacetimes in the GHP formalism, where the methods of algebraic reformulations are applied to standard cosmologies.

The methods of reformulations by tetrad formalisms are introduced in Chapters 2 and 3. These methods were found to be useful in the context of perturbation theory in four and higher-dimensions.

The scalar perturbations in f(R)-cosmologies are studied in Chapter 4. The formalism can be applied to the cell of homogeneity of order 150 Mpc, where the hydrodynamic approach is not applicable due to the essentially discrete character of gravitating matter at such scales. It is the generalization of the well-known mechanical approach for the case of cosmological background.

The main method used in Chapter 4 is the mechanical approach and the quasi-static approximation. The perturbation equations are firstly investigated in the astrophysical approach in these f(R)-cosmologies, where the time derivatives are dropped and the background is the Minkowski spacetime. The next approach is the large scalaron mass approximation, where the reduction to SGR is provided in this limit.

The f(R)-cosmologies are investigated in the late Universe deep inside the cell of uniformity. It is possible to make the Taylor expansion close to the de Sitter point. f(R)-models with these points are needed because the author intends to simulate the accelerated expansion of the Universe, as well as the Cosmological Inflation. The examples of such models are the Starobinsky, Hu-Sawicky and Miranda models, which have stable de Sitter points.

The clusters of galaxies are clustered inside the box of homogeneity like point-like matter sources, which perturb the homogeneous FLRW background. The peculiar velocities of galaxies are small inside this box. Therefore the work could be divided into two steps: the defined gravitational potentials could be then used to obtain the dynamical behavior of galaxies. The obtained in Chapter 4 models form a promising formalism to simulate the accelerated expansion of the Universe, so this thesis should contribute to new research in this direction. The further investigations based on the results of Chapter 3 could be applicable also to the Cosmological Inflation.

There are some critical remarks regarding the form of the thesis. Unfortunately, the typos and grammar in the text leave a lot to be desired. I would also mention the perceptible lack of literature references, especially in the introductory part. The proper bibliography could make the introduction less incoherent.

Nonetheless, these critique remarks do not repeal the original scientific results, achieved by the author and presented in the thesis. **These results prove the author's ability for performing creative scientific work.** The main achievement of the work, which is presented in Ch. 4 and published in EPJC, is a new promising approach in cosmology.

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