Recent results on inflation, dark energy and quasinormal modes of rotating black holes

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Here I present my recent results on theoretical study and analysis of observational data on inflation and dark energy in the Universe, as well as on quasinormal modes of rotating black holes.

1. Two-parametric family of inflationary models in the Einstein, scalar-tensor and $f(R)$ gravities is determined which is most favoured by recent CMB observational data, namely which have the slope of the primordial scalar power spectrum $n_s = 1 - 2/N$ and the tensor-to-scalar ratio $r \ll 8|n_s - 1|$. They all have $r \sim 10/N^2$ with the preferred value $r = 12/N^2$ for the simplest one-parametric models including the pioneer $R + R^2$ model and the Higgs inflation model [1].

2. In general scalar-tensor gravity, all exact de Sitter solutions in the Jordan frame with a non-constant scalar field are found. For these solutions, a scalar field potential are uniquely determined by a coupling function up to one free integration constant. However, the condition of the boundedness of the potential from below greatly diminishes the number of physically interesting solutions [2].

3. Effective Newton constant is derived for a model where a multiplet of scalar fields interacts non-minimally with gravity. It is shown that this constant (the same which is measured in the laboratory Cavendish-type and solar-system experiments) does not depend on the multiplicity of the scalar field [3].

4. New exactly solvable case of fast-roll inflation is found where the second time derivative of an inflaton scalar field is proportional to its first one times the Hubble parameter. Scalar and tensor perturbation spectra generated in this model are investigated numerically [4].

5. New viable cosmological models using $f(R)$ gravity for combined description of both primordial and present dark energy in the Universe are constructed and their most distinctive observational tests are determined. These models have a very specific intermediate stage after the end of inflation during which strongly non-linear oscillations of the scalar curvature R occur [5].

6. New method for the search of systematic errors in observational data on photometric distances to supernovae and on angular distances to galaxy clusters is developed which is based on the use of the cosmic duality between photometric and angular distances and the previously developed crossing statistics. The advantage of the method is its independence on assumptions about LFRW background evolution [6].

7. Massless scalar field perturbations of Kerr-Newman black holes are studied. It is shown that the set of damped quasinormal modes of these black holes have branching in the near-extremal regime which merges to a single damped set in the extremal limit. This agrees with a previously found instability in the extremal case in the linear approximation which is developing at the black hole horizon and is not seen by an external observer. Quasinormal modes of a massive scalar field in the Kerr background are reconsidered, too, to investigate how arbitrary long living modes (quasi-resonances) behave under the approach of the extremal rotation.

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