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Perturbative analysis of a five-parameter generalization of the teleparallel Hayashi–Shirafuji theory

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The general theory of relativity, presented in 1915, became a revolution in theoretical physics due to the beauty of its formulation and the universality of its applicability to the physics of gravitational and cosmological phenomena.For more than a hundred years, Einstein's theory of relativity, as a relativistic theory of gravitation, has been confirmed in a huge number of experiments.However, along with the huge successes, the general theory of relativity has a number of cosmological problems, primarily related to the need to introduce dark energy and dark matter into the theory, the presence of which, as some hidden mass, is necessary when describing the evolution of the Universe and the behavior of its large-scale structures.Therefore, it is quite natural to raise the question of the possibility of constructing a theory other than Einstein's theory of relativity, which would be consistent with it in reliably verified aspects, but at the same time would adequately describe those phenomena that are within the framework of GRT requires the introduction of additional dark sectors, or requires fine-tuning of the initial data.This paper examines some dynamic aspects of the theory proposed in [3], and slightly supplemented in [4], by Japanese researchers K. Hayashi and T. Shirafuji. They called this theory New general relativity (we will use the abbreviation NGR below), it is the simplest generalization of TEGR—the teleparallel equivalent of relativity theory, that is, a theory dynamically completely identical to GRT, but using torsion instead of curvature as the main geometric characteristic of a spatiotemporal manifold, and the tetrad field as a dynamic variable instead of a metric.First, we define the basic geometric objects to be used in the study, illustrate the general properties of teleparallel theories, construct the Lagrangian density of the action and derive the equations of motion.
Then we show that vacuum static spherically symmetric solutions can be found with arbitrary parameters of the theory. Then we investigate the perturbations of the vacuum equations of motion over a trivial solution —the Minkowski space. This makes it possible to determine the number and nature of all degrees of freedom of each of the theories given by the NGR equations of motion, without completely constructing a canonical Hamiltonian formalism.
Within the framework of this work, using a "convenient"tetrad, which does not generate the antisymmetric part of the field equations, we have found vacuum static spherically symmetric solutions to the field equations of NGR theory, and also discuss some of their properties.

We show that the equations of motion can be integrated explicitly in elementary functions, unlike the nonlinear generalizations of TEGR, where they have not yet been found and will also indicate which of the solutions satisfy the classical Newtonian limit.
In the course of our work, we determined the type of tetrad that does not generate the antisymmetric part of the field equations when searching for vacuum static spherically symmetric solutions in NGR, and showed that the field equations in this case allow integration with arbitrary parameters of the theory. The equations of linearized perturbations of the theory over the Minkowski flat space were obtained and all variables in the tensor, vector and scalar sectors of the tetrad perturbations were classified.

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