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Quasinormal Modes of Slowly Rotating Black Holes in Dynamical Chern-Simons Gravity up to Second Order in Spin

One of the key aims of next-generation gravitational wave detectors is to test General Relativity (GR) in the strong gravity regime. It is expected that gravity is modified in the strong gravity regime. Hence, it is imperative to obtain rotating black hole solutions in modified theories of gravity, look at their quasinormal mode (QNM) signatures, and obtain the difference between the new solutions and the GR solutions. However, it is hard to find exact black hole solutions in modified theories of gravity. We consider dynamical Chern-Simons (DCS) gravity, one of the simplest parity-violating models, in which a scalar field is non-minimally coupled to the Pontryagin density and whose rotating solution is non-Kerr. Slowly rotating blackhole solutions for DCS gravity exist in the literature up to the fifth order in the spin parameter a and quadratic order in the CS coupling parameter (α). In this work, we obtain the linear perturbation equations of these slowly rotating non-Kerr solutions and their QNM frequencies accurate up to $O(a^2, \alpha^2)$. To our knowledge, these have not been obtained. We discuss the implications for Cosmic Explorer and Einstein Telescope.

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