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Probing Extra Dimensions through Scalar Perturbations in Rotating Black Hole Spacetimes

The general theory of relativity (GR) states that black holes can possess three hairs, namely mass, charge, and angular momentum. Nevertheless, modifications to GR have the potential to alter the spacetime geometry by introducing additional hairs. In light of a potential solution to the so-called hierarchy problem in the standard model of particle physics, GR may be modified through the addition of an extra warped spatial dimension in the theory. Such a modified theory of gravity s yield intriguing consequences for various aspects of black holes. Therefore, we have conducted an investigation into massive scalar perturbations of four-dimensional Kerr-like black holes, incorporating an additional property, the tidal charge, within the Randall-Sundrum braneworld framework. The tidal charge of the black hole contains information pertaining to the extra spatial dimension in the braneworld model. These black hole spacetimes are also noteworthy because they permit the black hole's rotation parameter to exceed unity, a circumstance forbidden by the general theory of relativity. Consequently, they offer valuable insights into exploring the repercussions of modifications to Einstein's theory through future observations. Our approach involves the numerical solution of the perturbed field equations using the continued fractions method to ascertain the quasi-normal mode spectra of the braneworld black hole. We also investigate the existence of quasibound states and, consequently, the superradiant stability of the spacetime when perturbed by a massive scalar field. In comparison to four-dimensional black holes, we have detected distinctive signatures of the tidal charge and the rotation parameter, which manifest as signals of the extra dimension in both the quasinormal modes and the quasibound states. Furthermore, we will engage in a discussion regarding the physical implications of our findings.

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