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Black hole perturbations in modified gravity as a first-order system

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The study of perturbations around a black hole is crucial for the investigation of stability of the solution, as well as the modelization of gravitational waves emitted during the ringdown phase of a binary black hole merger. In general relativity, such perturbations are recast into two decoupled Schrödinger equations; in modified theories of gravity, this is often no longer possible due to the existence of additional fields. In this work, we reformulate the perturbation equations into a first-order system for GR and various modified gravity theories. This allows us to systematically define the proper boundary conditions for the computation of quasi-normal modes in these theories, using an algorithm that decouples the perturbation equations asymptotically. We illustrate this method by numerically computing quasi-normal modes in the Minimal Theory of Massive Gravity (MTMG).

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