Two non-normal spectral problems in black hole spacetimes

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Abstract

The spectral theorem provides a powerful tool to study physical systems controlled by a self-adjoint or, more generally, normal operator. The situation changes qualitatively when the normal character of the operator is lost. Issues such as spectral instability or the assessment of the spectral expansions in terms of eigenfunctions become more delicate. Here we discuss two non-normal spectral problems occurring naturally in black hole settings. The first one concerns the MOTS-stability operator controlling the dynamics of apparent horizon world-tubes, a non-selfadjoint operator for rotating black holes. Specifically, it is shown that such operator is non-normal whenever the rotation (Hajicek) form is not Killing. The resulting (moderate) spectral instability may play a role in recent eigenvalue analyses of "apparent horizon jumps" in binary black hole mergers. The second problem concerns the study of scattering resonances in an asymptotically flat (spherically symmetric) black hole spacetime. More specifically, such quasi-normal mode problem is cast in terms of a non-selfadjoint operator (properly defined on a Hilbert space), by compactifying along hyperboloidal slices that implement outgoing boundary conditions at future null infinity. As it has been shown in the asymptotically AdS case, this type of formulation offers a rich avenue towards quasi-normal modes, in particular with potential insights into completeness issues in resonant expansions.