XXIII Simposio Chileno de Física
Chile, 22-24 noviembre 2022 Física de Partículas, Campos y Altas Energías

Exact scalar and Dirac (quasi-)normal modes of black holes and solitons in gauged SUGRA

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Abstract

In this work we identify a new family of black holes and solitons that lead to the exact integration of scalar probes, even in the presence of a non-minimal coupling with the Ricci scalar which has a non-trivial profile. The backgrounds are planar and spherical black holes as well as solitons of $SU(2) \times SU(2)$ N=4 gauged supergravity in four dimensions. On these geometries, we compute the spectrum of (quasi-)normal modes for the non-minimally coupled scalar field. We find that the equation for the radial dependence can be integrated in terms of hypergeometric functions leading to an exact expression for the frequencies. The solutions do not asymptote to a constant curvature spacetime, nevertheless the asymptotic region acquires an extra conformal Killing vector. For the black hole, the scalar probe is purely ingoing at the horizon, and requiring that the solutions lead to an extremum of the action principle we impose a Dirichlet boundary condition at infinity. Surprisingly, the quasinormal modes do not depend on the radius of the black hole, therefore this family of geometries can be interpreted as isospectral in what regards to the wave operator non-minimally coupled to the Ricci scalar. We find both purely damped modes, as well as exponentially growing unstable modes depending on the values of the non-minimal coupling parameter. For the solitons we show that the same integrability property is achieved separately in a non-supersymmetric solutions as well as for the supersymmetric one. Imposing regularity at the origin and a well-defined extremum for the action principle we obtain the spectra that can also lead to purely oscillatory modes as well as to unstable scalar probes, depending on the values of the non-minimal coupling. We also show that for some of these spacetimes, the Dirac equation can be solved in an analytic manner.

Acknowledgments: This work is partially funded by Beca ANID de Magíster 22221854