

This thesis presents recent studies on test scalar and vector fields around black holes in the classical theory of General Relativity. It is separated in two parts according to the asymptotic properties of the spacetime under study.

In the first part, we investigate scalar and Proca fields on an asymptotically flat background. For the Proca field, we obtain a complete set of equations of motion in higher dimensional spherically symmetric backgrounds. These equations are solved numerically, both to compute Hawking radiation spectra and quasi-bound states. In the former case, for the first time, we carry out a precise study of the longitudinal degrees of freedom induced by the mass of the field. This can be used to improve the modeling of evaporation of black holes coupled to massive vector fields, and black hole event generators currently used at the Large Hadron Collider to probe TeV gravity models with extra dimensions. Regarding quasi-bound states, we find arbitrarily long lived modes for a charged Proca field in a Reissner-Nordstrom black hole. As a comparison, we also find such long lived modes for a charged scalar field.

The second part of this thesis presents research on superradiant instabilities of scalar and Maxwell fields on an asymptotically anti-de Sitter background. For the scalar case, we introduce a charge coupling between the field and the background, and show that superradiant instabilities do exist for all values of the total angular momentum in higher dimensions. This result corrects a statement in the literature that such instabilities only appear in even dimensions. For the Maxwell case, we first propose a general prescription to impose boundary conditions on the Kerr-anti-de Sitter spacetime, and obtain two Robin boundary conditions which give two different quasinormal modes even in a simpler Schwarzschild-anti-de Sitter black hole. Then these two boundary conditions are implemented to study superradiant unstable modes and vector clouds. In particular, we find that the new branch of quasinormal modes may be unstable in a larger parameter space. Furthermore, the existence of vector clouds indicates that one may find a vector hairy black hole solution for the Einstein-Maxwell-anti-de Sitter system at the nonlinear level, which implies, in such system, that the Kerr-Newman-anti-de Sitter black hole is not a unique solution.