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The Klein-Gordon-Fock equation in the curved spacetime of the Kerr-Newman (anti) de Sitter black hole

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Exact solutions of the Klein-Gordon-Fock (KGF) general relativistic equation that describe the dynamics of a massive, electrically charged scalar particle in the curved spacetime geometry of a charged, rotating Kerr-Newman-(anti) de Sitter black hole are investigated. In the general case of a rotating, charged, cosmological black hole the solution of the KGF equation with the method of separation of variables results in Fuchsian ordinary differential equations for the radial and angular parts which contain more than three finite singularities and thereby generalise the Heun differential equations. For particular values of the physical parameters (i.e mass of the scalar particle) these Fuchsian equations reduce to Heun equations and the solutions are expressed in terms of Heun functions. For other values of the parameters some of the extra singular points are false singular points. We derive the conditions on the coefficients of the generalised Fuchsian equation such that a singular point is a false point. In such a case the exact solution of the Fuchsian equation can in principle be simplified and expressed in terms of Heun functions. We also derive the exact solutions of the radial and angular equations for a massive scalar particle in the Kerr-Newman spactime. The analytic solutions are expressed in terms of confluent Heun functions. Moreover, we derived the constraints on the parameters of the theory such that the solution simplifies and expressed in terms of confluent Kummer hypergeometric functions. Starting from the equation obeyed by the derivative, we construct several expansions of the solutions of the Heun equation in terms of generalised hypergeometric functions of Lauricella-Appell. Possible applications, including the gravitational radiation from a hypothetical axion cloud around a charged rotating cosmological black hole, are briefly discussed.

Primary author(s) : KRANIOTIS, GEORGIOS (UNIVERSITY OF IOANNINA)

Presenter(s) : KRANIOTIS, GEORGIOS (UNIVERSITY OF IOANNINA)

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