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Title: Boson clouds around rotating black holes: obstacles in generalizing the no-hair theorems

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Abstract: the existence of boson clouds (i.e. non-trivial regular and localized complex-valued scalar field configurations) around rotating (Kerr) black holes (BH) that were found in the past by Hod, and by Herdeiro and Radu can be understood on heuristic grounds using the integral methods used to prove the well known no-hair theorems. However, here we show that the presence of rotation introduces, within a vanishing integral evaluated in the domain of outer communication of the BH, a term (R) that if negative can compensate the positive semidefinite ones making that this integral can be satisfied even when the scalar-field configuration is not trivial. The nonpositive semidefinite term, R, is not present in the absence of rotation, and in that case the integral vanishes if and only if the scalar field is trivial (this is the well known no-hair theorem for static and spherically symmetric spacetimes). By solving numerically the corresponding Klein-Gordon equation associated with the scalar field in the Kerr background submitted to suitable regularity conditions we show that the boson clouds are precisely those that make the alluded term, R, to be negative in some region of the spacetime and thus, to make the vanishing integral to be satisfied even when such nontrivial clouds exist. This analysis illustrates the obstacles one can encounter when trying to generalize the no-hair theorems to more general spacetimes and to scalar-field configurations with less symmetries. Our analysis includes the extremal and non-extremal scenarios.