Name: Nuno M. Santos

Affiliation: Instituto Superior Técnico & Universidade de Aveiro

Title: A bound on energy extraction (and hairiness) from superradiance

Abstract: The possibility of mining the rotational energy from black holes has far–reaching implications. Such energy extraction could occur even for isolated black holes, if hypothetical ultralight bosonic particles exist in Nature, leading to a new equilibrium state – a black hole with synchronised bosonic hair – whose lifetime could exceed the age of the Universe. A natural question is then: for an isolated black hole and at maximal efficiency, how large is the energy fraction ϵ that can be extracted from a Kerr black hole by the superradiant growth of the dominant mode? In other words, how hairy can the resulting black hole become? A thermodynamical bound for the total superradiance efficiency, $\epsilon \lesssim 0.29$ (as a fraction of the initial black hole mass), has long been known, from the area law. However, numerical simulations exhibiting the growth of the dominant mode only reached about one third of this value. We show that if the development of superradiant instabilities is approximately conservative (as suggest by the numerical evolutions), this efficiency is limited to $\epsilon \lesssim 0.10$, regardless of the spin of the bosonic field. This is in agreement with the maximum energy extraction obtained in numerical simulations for a vector field and predicts the result of similar simulations with a scalar field, yet to be performed.