
NIKY KAMRAN, McGill University, Montreal, Canada

The Penrose process and the wave equation in Kerr geometry

In 1969, Roger Penrose proposed a geometric mechanism for extracting energy and angular momentum from a rotating black hole by exploiting the presence of an ergosphere, that is a region outside the event horizon in which the conserved energy along time-like geodesics can be negative. Soon after the publication of Penrose's paper, Christodoulou established an upper bound for the amount of energy which can be extracted by this process. The wave analogue of the Penrose process, which is called super-radiance, was then investigated by Zel'dovich and Starobinsky for separable solutions of the wave equation corresponding to individual modes.

We will review the Penrose process and super-radiance from the perspective of the Cauchy problem for the scalar wave equation in Kerr geometry, and show that super-radiance can be put into a rigorous mathematical framework. We will quantify the maximal energy gain and show that Christodoulou's bound also holds for scalar waves.

This is joint work with Felix Finster, Joel Smoller and Shing-Tung Yau.