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Penrose and super-Penrose energy extraction from a Reissner-Nordström black hole spacetime with a cosmological constant through the Bañados-Silk-West mechanism

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The Penrose process consists of transferring energy from a black hole to infinity. This process can be studied in a combined description with the Bañados-Silk-West (BSW) mechanism, which uses collisions of ingoing particles at the event horizon of a black hole to locally produce large amounts of energy. In this talk, the blending of the Penrose process with BSW mechanism is described for a d dimensional extremal Reissner-Nordström black hole spacetime with negative, zero, or positive cosmological constant, i.e., for an asymptotically anti-de Sitter (AdS), flat, or de Sitter (dS) spacetime. In an extremal Reissner-Nordström black hole background, in the vicinity of the horizon, several types of radial collisions between electrically charged particles can be considered. The most interesting one is between a critical particle, with its electric charge adjusted in a specific way, and a usual particle. This gives a divergent center of mass frame energy locally, which is a favorable but not sufficient condition to extract energy from the black hole. To find if energy can be extracted in such a collisional Penrose process, one must consider a collision in general between ingoing particles 1 and 2, from which particles 3 and 4 emerge, with the possibility that particle 3 can carry energy far out from the black hole horizon. One finds that the mass, energy, electric charge, and initial direction of motion of particle 3 can have different values, depending on the collision internal process. However, the different possible values lie within some range. Moreover, the energy of particle 3 can, in some cases, be arbitrarily high but not infinite, which characterizes a super-Penrose process. It is also shown that particle 4 has negative energy, as required in a Penrose process. For zero cosmological constant the results do not depend on the number of dimensions, but they do for nonzero cosmological constant, which also introduces differences in the lower bound for the energy extracted.

Authors: FEITEIRA, Duarte (Department of Physics, University of Helsinki); Prof. P. S. LEMOS, José (Centro de Astrofísica e Gravitação - CENTRA, Departamento de Física, Instituto Superior Técnico - IST, Universidade de Lisboa - UL); Prof. ZASLAVSKII, Oleg B. (Department of Physics and Technology, Kharkov V. N. Karazin National University)

Presenter: FEITEIRA, Duarte (Department of Physics, University of Helsinki)

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