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Energy Extraction from Black Holes

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Detection of cosmic rays with very high energies, up to 10^{20} eV, has been present in the literature for a long time [1]. Many processes have been proposed as sources for these high energy particles but no fully satisfactory explanation has been provided. The Penrose process [2,3] makes use of the possibility to have negative energy particles in the ergoregion of a rotating black hole to extract energy from the latter. This mechanism was suggested as a possible source for high energy jets of particles, however, since the process is unlikely to take place from an astrophysical point of view, this gives no solution to the problem of ultra high energy cosmic rays [4]. Still, other variants of the Penrose process which also rely on the possibility of extracting rotational energy from spinning black holes may be more plausible and hence contribute to the explanation of how these particles are being produced. A particular case we want to study is that of the radiative Penrose process [5]. If a black hole is immersed in an asymptotically uniform magnetic field, which has been observed experimentally, and a charged particle is moving in the black hole's ergoregion then it could radiate negative energy photons, which are absorbed by the black hole. The particle will in turn gain energy and be accelerated by the radiation reaction force, contrary to what happens in flat space. For this masters thesis we aim to understand if the radiative Penrose process is a viable candidate to solve the problem at hand, as well as investigate other mechanisms of energy extraction from black holes.

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