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Vacuum gaps in black holes magnetospheres

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We consider particle acceleration in the vacuum gaps in split-monopole magnetospheres of slow and maximally rotating black holes, embedded in the radiatively-inefficient accretion flow (RIAF) environment. The gap height is limited by the onset of gamma-gamma pair production on the infrared photons originating in the RIAF.

We numerically calculate the acceleration and propagation of charged particles by taking the detailed structure of the electric and magnetic fields in the gap and in the entire black hole magnetosphere into account, as well as the radiative energy losses and interactions of gamma rays produced by the propagated charged particles with the background radiation field of the RIAF.

We show that the presence of the vacuum gap has clear observational signatures almost independent on the black hole angular momentum. The spectra of emission from gaps embedded in a relatively high-luminosity RIAF are dominated by the inverse Compton emission with a sharp, super-exponential cut-off in the very-high-energy gamma-ray band. The cut-off energy is determined by the properties of the RIAF and is largely independent of the structure of magnetosphere and geometry of the gap. The spectra of the gap residing in low-luminosity RIAFs are dominated by synchrotron or curvature emission with the spectra extending into 1-100~GeV energy range.

We also consider the effect of possible acceleration of protons in the gap and show that both for a slow and for a maximally rotating black hole the proton energy could reach the ultra-high-energy cosmic ray (UHECR) range only in extremely low-luminosity RIAFs with magnetic field in the magnetosphere reaching the Eddington limit.

Summary

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