Summary of research

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Dynamics analysis of charged particles around a dyonic black hole :

The energy source of relativistic jets observed in various active galactic nuclei, including M87, remains unresolved, although several candidates have been proposed. Among them, the Blandford-Znajek mechanism, which extracts rotational energy from a black hole via electromagnetic fields, is considered a strong candidate. However, the Penrose process has also attracted attention as an alternative energy extraction mechanism. In the case of a Kerr black hole, when considering the split of neutral particles, the Penrose process is subject to the Bardeen and Wald velocity limit, which imposes a strict constraint on the relative velocity of test particles at the moment of split. On the other hand, in the Penrose process with electromagnetic fields, such a velocity restriction does not apply, making it a promising candidate for a more realistic energy extraction model.

In this study, based on a previous work [1] analyzing the dynamics of test charged particles around a dyonic Kerr-Newman black hole, we investigated the possibility of the Penrose process for test charged particles around a rotating magnetic monopole black hole. In this scenario, due to the influence of the electromagnetic field, the velocity restriction imposed in the Penrose process for a Kerr black hole does not exist, making efficient energy extraction feasible. To simplify the system, we assumed that a particle initially at rest in the ZAMO frame undergoes split. As a realistic splitting model, we considered a scenario in which two photons collide and induce electron-positron pair production near the supermassive black hole at the center of M87, assuming a magnetic field strength of approximately 10^3G. From the perspective of the effective potential of test particles, we determined the conditions under which the splitting products either fall into the black hole or escape to infinity. As a result, we found that if the splitting products escape to infinity, an energy of the order of (10^{20}eV), comparable to ultra-high-energy cosmic rays (UHECRs), can be extracted. This finding suggests that rotating magnetic monopole black holes could serve as a potential energy source for high-energy astrophysical phenomena.

[1] C. Dyson, D. Pereñiguez, Phys. Rev. D **108**, 084064 (2023).