Future Research Plans

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Dynamics of charged particles on dyonic black hole :

We have already analyzed the Penrose process for charged particles around a rotating magnetic monopole black hole, assuming that a particle initially at rest in the ZAMO frame undergoes splitting, and considering a scenario in which two photons collide near the supermassive black hole in the vicinity of M87, leading to electron-positron pair production.

As the next step, it is necessary to examine a more general case where the particle is not initially at rest in the ZAMO frame. Additionally, we will focus on Penrose processes involving decay processes other than electron-positron pair production, such as β-decay. Furthermore, while previous studies have considered only the Penrose process in which a single particle splits into two, we will also discuss the collisional Penrose process, which is not only of great interest but also closely related to the BSW effect, a phenomenon expected to serve as an alternative to particle accelerators.

Dark matter exploration around Sgr A* through observations of S-stars :

At the center of the Milky Way Galaxy, there exists a cluster of stars known as S-stars, which orbit around the supermassive black hole Sgr A*. Observations of these stars, particularly the detailed study of the orbit of S2, have played a crucial role in understanding the physical properties of Sgr A*. These observations have confirmed that Sgr A* has a mass of approximately four million solar masses and have provided strong evidence that it is a black hole. In addition to characterizing Sgr A*, the orbital motion analysis of S-stars also offers a powerful means to probe the mass distribution of dark matter in the central region of the Milky Way Galaxy. An important upcoming opportunity arises with the periapsis passage of the S24 star, which is expected to provide new observational data for dark matter searches.

In this study, before acquiring detailed observational data on S24, we first consider what types of dark matter candidates could be present around Sgr A*. Specifically, we investigate physically plausible models that describe the distribution of dark matter candidates such as axion fields and Proca fields, which are among the leading theoretical possibilities. By constructing these models in advance, we aim to compare them with actual observational data and perform model fitting. The ultimate goal of this research is to elucidate the mass distribution of dark matter in the central region of the Milky Way Galaxy.