Research Plans

Name: Yohsuke Takamori

I consider two plans as follows.

Analysis of stationary black hole Mangetospheres with the Motion of Plasma

It is considered that there exist plasma around black holes and accretion disks would be constructed surrounding the black holes. Therefore, the motion of plasma is important to study more realistic astrophysical cases. In order to consider the motion of plasma, I want to study general relativistic magnetohydrodynamics (GRMHD) which is the most simplest case considering the motion of plasma. For axisymmetric and stationary cases, configurations of magnetic fields are determined by the Grad-Shafranov (GS) equation. In this case, there exist singular points of the GS equation, which are called the Alfvén surfaces. By virtue of the singular surfaces, it is difficult to solve the GS equation. In order to solve the GS equation and construct global magnetoshperes, I consider the following two steps.

1. Studying black hole magnetospheres near the event horizon

As a first step, I want to consider a region near the event horizon. In order to construct a magnetic field configuration, it is useful to consider a slow-rotating black hole. In this case, one can use the slow-rotating black hole approximation. However, it is non-trivial whether this approximation is valid near the event horizon. I want to consider a method to construct a magnetic field configuration under the slow-rotating approximation by using the method which was discussed in Takamori et al. (2011b) to construct a magnetic field configuration near the evet horizon. In addition, as for the application, I want to consider evolution of the black hole's spin by the magnetic fields.

2. Studying black hole magnetospheres near the event horizon

Next, I want to construct a numerical method to solve the GS equation in a global region including the Alfvén surfaces. The GS equation are derived from Maxwell's equations and the equation of motion of magneto-fluid. Thus, we can decompose the GS equation into Maxwell's equations and the equation of motion of magneto-fluid. It is well known that solving Maxwell's equations with stationarity becomes a boundary value problem, and it would be easier than solving the GS equation. One should recall that there is an electric current density caused by the motion of magneto-fluid. Thus, I want to consider a numerical method to solve Maxwell's equations with the motion of magneto-fluid considered.

2. Investigation of test particles around black objects

Since the uniqueness theorem is well known in general relativity in 4-dimension, a black hole solution is uniquely determined if its mass, angular momentum, and electric charge are specified. In the case of higher dimensional spacetimes, there does not exist such uniqueness theorem. Therefore, it is important to study characteristics of spacetimes in a higher dimensions so as to understand their difference in detail. In our previous works, we investigated geodesics around black rings in 5-dimensions. As a result, we showed that there exist stable bound orbits around the black ring, which is different from black holes in 5-dimensions. In this study, thanks to the symmetries of the black rings, the problem became the extreme value problem of a two-dimensional effective potential. Our analysis can be used other black objects in higher dimension. There are many black objects in higher dimension, e.g., multi black objects that have black holes and black rings, and Kalza-Klein black holes that have a compact extra dimension. I want to investigate geodesics in various black object geometries and study the characteristics for each black object.