Summary of research

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Black hole perturbation theory :

Among black hole perturbation theory, we have been involved in the development of analytical methods for understanding the dynamics of massive bosonic fields (massive scalar/vector/tensor fields) on black hole spacetimes, which are considered to be important in a wide range of contexts of astrophysics and verification of string theory.

In black hole perturbation theory, one of the goals is to reduce the field's equations into a set of second-order ordinary differential equations (master equations) that are easier to analyze. In the case of massless bosonic fields, it is known that all field's equations can be reduced into the master equations, even on the rotating black hole spacetimes which are the most complicated spacetimes. On the other hand, the analytical studies of massive bosonic fields are very difficult because, for example, even the separability of the field variables is nontrivial for massive tensor fields. Therefore we focused on the relatively simple extremal Reissner-Nordström black hole spacetime, and we found that the master equations for the massive vector field and the massive tensor field describes which all dynamical degrees of freedom can be derived by using the perturbatiion expansion method [1,2].

Dynamics of charged particles on dyonic black hole :

In the context of cosmic censorship, it is interesting to investigate whether an extremal black hole can become a super extremal black hole and whether a naked singularity can be formed. Whereas, in the Blandford-Znajek mechanism, which is expected to be useful for clarifying the structure of unified theory of active galactic nuclei, a monopole magnetic field appears in the zeroth-order of approximation of the Grad-Shafranov equation. Under such background, the we focused on the case where the background spacetime is a dyonic-Reissner-Nordström black hole spacetime with magnetic charge instead of electric charge, and analyzed the dynamics of charged particles. Thanks to the symmetry of the spacetime, when the angle θ of the spherical coordinates is constant, the motion of the particle can be reduced to a one-dimensional problem only of the radial coordinate . Using this property, we restricted the spacetime to the extremal black hole and clarified the conditions that restrict the energy, mass, and charge of the falling particle into the black hole and we also derived the conditions that makes the black hole over extremal. As the next step, we are now examining whether the same argument can be conducted when the background spacetime is the dyonic-Kerr-Newman spacetime.

[1] K. Ueda and A. Ishibashi, Phys. Rev. D **97**, 124050 (2018).

[2] V, Cardoso, T. Igata, A. Ishibashi, and K. Ueda, Phys. Rev. D **100**, 044013 (2019).