(2) Plan of future research

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I would like to contribute to progress of science, making use of numerical techniques that I acquired so far and of deep understanding on physical phenomena in strong gravity. I would choose the research issues that deepen our understanding of general relativity, and have possibility to find new physics. In the next few years, I will study the following topics.

Behavior of light around a black hole:

Currently, I have been proceeding with the research on optical image of a star under gravitational collapse (to be submitted soon). In this research, we have developed a formalism for predicting the observed image for arbitrary types of radiation of the star surface. Although we are assuming the collapsing star to be spherically symmetric with zero pressure, various extensions can be expected, such as how the image changes if the model of the star or the theory of strong gravity is modified. We are going to study such extensions in fiscal year of 2019.

The optical image of the gravitationally collapsing star is primarily generated by photons that orbit around the photon surface. We have developed an analytic method to approximate such orbits in the case of the Schwarzschild spacetime. Since this method can be extended to other systems, I am planning to study such extension and application with Prof. Hideki Ishihara.

System of a black hole and axion field

I continue the research of Ref. [I-4]. Although this issue was mentioned also in the plan of the last fiscal year, the progress is delayed because I spent time and energy to the above theme. But, currently I have taken a lot of numerical data on the axion field around a rotating black hole, and have determined the final state of the axion cloud. For this reason, I plan to study the following issue in this year:

- Calculation of gravitational waves from an axion cloud;

  By completing the code for calculating gravitational waves for the case that a black hole is rotating, I will give prediction on the waveform of emitted gravitational radiation. The wave form calculated here will be used as templates for analyzing observational data at the gravitational wave interferometers like the aLIGO and the KAGRA.

- Time evolution of parameters of the system of a black hole with an axion cloud;

  Because the axion cloud extracts the energy and angular momentum of the black hole, their values change in time. I will calculate this process and provide a prediction on the distribution of mass and angular momentum of observed black holes.

I point out that although there are other groups studying the system of a black hole with massive scalar fields, they ignore self-interaction of scalar fields. I am aiming at making a research with originality by including the effects of self-interaction.

Other topics:

If I have time, I would challenge other topics, such as the determination of existence/nonexistence of static black hole solution in the Randall-Sundrum scenario, or calculation of gravitational waves emitted from merger of binary black holes/neutron stars in the Einstein-Cartan theory, where "torsion" degree of freedom is added to the theory of general relativity.

I am also interested in discussing and collaborating with group members. Other than the collaboration with Prof. Ken-ichi Nakao and his student, Mr. Kazuma Takahashi in particle physics group, I am discussing the behavior of light around binary black hole with Prof. Hideki Ishihara and his student Mr. Nobuyuki Asaka in astrophysics group. I will contribute to activity of the groups by motivating and energizing students.