Summary of research

Kodai Ueda

Background

Dark matter and dark energy are the biggest mysteries in modern physics, and several strong candidates have been proposed. In particular, CDM candidates such as supersymmetric particles or axions, and modified gravity, which is one of the models to explain dark energy, are described by the massive bosonic fields. With the recent rise of multi-messenger astronomy, it is expected that black holes will be utilized as targets for observations to verify the massive bosonic fields. On the other hand, in the context of AdS/CFT correspondence, a varisous bosonic fields on asymptotic AdS black hole spacetimes have been studied as applications to CFT from the gravity theory side. Therefore, it is important to understand the massive bosonic fields on black hole spacetimes in broad context such as astrophysics and string theory, and I have been mainly involved in the study to construct analytical methods to understand the dynamics.

Research contents

In general, the analysis of the dynamics of linear perturbation fields on black hole spacetime consists of the following steps: (i) we perform the separation of variables for the field equations. (ii) We reduce the field equations to a set of decoupled ordinary differential equations (master equations) for each field variable. (iii) We attempt to construct global solutions of the derived master equations. (iv) If we cannot solve the master equations directly, we attempt to use appropriate approximation methods. (v) Finally, we perform the stability analysis and the quasinormal modes analysis.

Research results

In our work [1, 2], we found that for the massive vector/tensor fields on (near) extremal static black hole spacetimes, a newly developed perturbation expansion method enables us to obtain a set of decoupled master equation system for all the dynamical degrees of freedom (step (ii) above was accomplished). In addition, we found that the variables of the massive vector/tensor fields can be separated on $(m+n)$-dimensional warped product-type geometry including the wide class of spacetime such as static black hole spacetimes (step (i) above was accomplished), and we found that decoupled master equation can be obtained for the vector-type components of the massive vector field and the tensor-type components of the massive tensor field (step (ii) above was partially accomplished). Furthermore, by using the results obtained in step (ii) above in the results [1, 2], we performed the analysis to step (v) above (currently writing the paper). However, since the master equation is generally difficult to solve analytically, we used the $(2+n)$-dimensional pure AdS spacetime, which is the simplest spacetime that enable us to construct the global solution and is important as an application to AdS/CFT correspondence. We performed the stability analysis and quasinormal mode analysis for spin 0, 1, and 2 massive fields by focusing on the massless topological black hole spacetime with the sectional curvature $K = -1$.

[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).