

Research Plans

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Recently, a considerable number of studies have been conducted on the application of the AdS/CFT correspondence to realistic strongly coupled systems such as quark-gluon plasma in QCD, superconductor in condensed matter physics, and so on. It is non-trivial and intriguing problem whether one can extend the concept of the AdS/CFT correspondence to time-dependent systems which are not at thermal equilibrium. I will investigate dynamics and thermodynamics of higher dimensional black holes in details and explore physics of holographic systems in terms of dual geometries from the gravitational side.

Non-equilibrium holographic systems:

The non-equilibrium process of strongly correlated systems such as superconductors is not fully understood because of difficulties in its theoretical treatment, and has been attracting much attention. The AdS/CFT correspondence offers a novel approach to this longstanding problem. To understand non-equilibrium process of strongly correlated systems, we should simply solve classical dynamics of gravitational systems in the bulk thanks to the duality. I will study time-dependent systems in asymptotically AdS spacetime analytically and numerically. In order to describe various holographic systems by using dual gravitational theory, we should treat not only gravitational field but also various D-branes and anti-symmetric fields. I would like to establish the way to numerically solve dynamics of such objects under asymptotically AdS boundary conditions. Moreover, I would like to solve dynamical black holes in the AdS space in order to investigate thermalization processes in the boundary field theory, which is holographically modeled by formation of the bulk black hole and its equilibration into a stationary state. I will develop numerical and analytical methods to treat dynamical black holes in the AdS space.

Thermodynamic properties of dynamical black holes:

The AdS/CFT correspondence opened up new insights about thermodynamic properties of black holes. In this context we expect that thermodynamic properties of CFT matter on the boundary would respect those of black holes in the bulk. It is interesting to study if such thermal properties persist when time dependence is turned on. Recently, I and my collaborator have showed that the surface gravity of the past horizon governs the thermal spectrum of the Hawking radiation observed by asymptotic observers in non-stationary cases. Many of thermodynamic properties of black holes, however, tend to be associated with the future event or apparent horizon in the previous works, not with the past horizon. It is open to discussion how these points of view are related to each other. I would like to study how the surface gravity of the past horizon is related to other probes of the black hole spacetime and how our approach is related to other derivations of the Hawking radiation, such as the tunneling approach.

I believe it is important to reveal thermodynamic properties of non-stationary black holes if we will apply the AdS/CFT correspondence to time-dependent phenomena.