Research Summary (Ken Matsuno)

Recently, the brane world models are proposed. The matter fields and the gauge fields except the gravity are assumed to be trapped on the brane embedding in the higher-dimensional bulk spacetime. It is possible that the spacetime has the spatial extra dimensions with the sub-millimeter scale in the brane world models. If our universe is such brane world, the scale of the gravity is unified with those of other gauge fields in the TeV scale and hence it is expected that the higher-dimensional mini-black holes are produced in accelerators.

We considered the five-dimensional black holes for clarifying the physical properties of higher dimensional black holes as the first step. In the five-dimensional spacetime, we impose the asymptotic flatness to the four-dimensional part of the spacetime, while there are various possibilities of the structures of total spacetime with the extra dimension. Thus we studied the five-dimensional black hole solutions with a wide class of asymptotic structures.

Kaluza-Klein Black Holes We constructed charged static Kaluza-Klein black holes with squashed S^3 horizons in the five-dimensional Einstein-Maxwell theory. These black holes were fully five-dimensional in the vicinity of the black hole while effectively four-dimensional with a compact extra dimension at the infinity. In the degenerate horizon limit, we obtained Kaluza-Klein multi-black holes on the Gibbons-Hawking space. The spatial cross section of each black hole horizon was admitted to have the topology of a different lens space $L(n;1) = S^3/\mathbb{Z}_n$ in addition to S^3. We also obtained multi-black holes on the Gibbons-Hawking space with a positive cosmological constant. We extended these solutions to have angular momenta in the five-dimensional Einstein-Maxwell system with a Chern-Simons term.

Coalescence of Black Holes There exist five-dimensional black hole solutions with the different horizon topologies, i.e., the S^3 horizons and the lens space $L(n;1) = S^3/\mathbb{Z}_n$ horizons. These differences of the horizon topologies are related to the asymptotic structures of the spacetime. To discuss these differences, we constructed new charged rotating multi-black hole solutions on the Eguchi-Hanson space in the five-dimensional Einstein-Maxwell system with a Chern-Simons term and a positive cosmological constant. In the two-black holes case, these solutions described the coalescence of two rotating black holes with the horizon topologies of S^3 into a single rotating black hole with the horizon topology of the lens space $S^3/\mathbb{Z}_2$. We compared our solutions with the two-centered Klemm-Sabra solutions which describe the coalescence of two rotating black holes with the horizon topologies of S^3 into a single rotating black hole with the horizon topology of S^3. We saw that the horizon areas of the final black hole after the coalescence depended on the angular momenta. It was clarified that the difference of the dependence between two cases was related to the asymptotic structures of the higher dimensional spacetime.