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Research results

Five-dimensional black holes with a twisted compact extra dimension

Higher-dimensional black holes gather much attention not only as key points of unified theory but also in various fields of theoretical physics. A Kaluza-Klein type spacetime with compact extra dimensions is one of realistic higher-dimensional spacetime models which would describe our effectively four-dimensional universe. Then constructions of Kaluza-Klein black hole solutions and observational verifications of such black holes are interesting problems. In higher-dimensional spacetimes, even if we impose asymptotic flatness to the four-dimensional part of the spacetime, there are various possibilities of fiber bundle structures of the extra dimensions as the fiber over the four-dimensional base spacetime.

By considering a twisted compact extra dimension, I easily constructed a new exact Kaluza-Klein black hole solution in the five-dimensional Einstein-Maxwell theory [18]. This black hole has squashed S^3 horizons and behaves as a four-dimensional black hole in the region far away from the horizon. I applied this squashing method to some known asymptotically flat black hole solutions and constructed new rotating Kaluza-Klein black holes, BPS multi-black holes, and Kaluza-Klein black holes in dilaton gravity [7,9,12,15,16].

Coalescence of rotating multi-black holes

There exist five-dimensional black hole solutions with different horizon topologies, i.e., an S^3 and a lens space S^3/Z_n (n: natural numbers) horizons. The variety of the horizon topologies are related to the asymptotic structures of the spacetime. To discuss these properties, I constructed new charged rotating multi-black hole solutions in the five-dimensional Einstein-Maxwell-Chern-Simons system with a positive cosmological constant [13]. These solutions describe the coalescence of 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/Z_n in the space with the non-trivial asymptotic structure. Then I compared my solutions with the Klemm-Sabra solutions, which describe the coalescence of rotating black holes in the space with the trivial asymptotic structure. As a result, I saw that the horizon areas of the final black hole after the coalescence depend on the angular momenta. It was clarified that the difference of the dependence between two cases is related to the asymptotic structures of the higher-dimensional spacetime.

I also constructed rotating Kaluza-Klein multi-black holes with the Gödel parameter [10]. Each black hole can have an inner and an outer ergoregions. I explicitly presented the various shapes of ergoregions with the phenomena of mergers. Further I constructed BPS multi-black holes and supersymmetric black rings with non-trivial asymptotic structures in the five-dimensional Einstein-Maxwell-Chern-Simons system [11,14,17].