Research results

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Squashed Kaluza-Klein black holes with a 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 compactified 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. By considering a twisted extra dimension, I easily obtained a new exact Kaluza-Klein black hole solution in the five-dimensional Einstein-Maxwell theory (squashed Kaluza-Klein black holes) [13]. I applied this squashing method to some known asymptotically flat black hole solutions and obtained new rotating black holes, BPS multi-black holes and slowly rotating black holes in the dilaton gravity [2,4,7,10,11].

Rotating multi-black holes with non-trivial asymptotic structures

There exist five-dimensional black hole solutions with the different horizon topologies, i.e., an S^3 and a lens space $L(n;1)=S^3/Z_n$ (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 on the Eguchi-Hanson space in the five-dimensional Einstein-Maxwell system with a Chern-Simons term and a positive cosmological constant [8]. In the two-black holes case, these solutions 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 the lens space S^3/Z_2 in the space with the non-trivial asymptotic structure. On the other hand, the two-centered Klemm-Sabra solutions 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 in the space with the trivial asymptotic structure. Then I compared my solutions with the two-centered Klemm-Sabra solutions. As a result, I 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 [8].

I also constructed five-dimensional supersymmetric black ring solutions which asymptote to non-trivial spacetimes [6,9,12].

Further I generalized the squashed Kerr-Gödel black hole to rotating multi-black holes with the Gödel parameter [5]. Each black hole can have an inner and an outer ergoregions. I explicitly presented the various shapes of these ergoregions in the case of two black holes with the phenomena of merging ergoregions.