Research results

Five-dimensional squashed Kaluza-Klein black hole spacetimes

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 spacetimes and observational verifications of such black holes are interesting problems.

Considering a twisted compact extra dimension, I constructed a new exact Kaluza-Klein black hole spacetime in the five-dimensional Einstein-Maxwell theory [1]. The black hole has squashed S^3 horizons and behaves as a four-dimensional black hole in the region far away from the horizon. Then we can regard squashed Kaluza-Klein black hole spacetimes as realistic higher-dimensional spacetime models.

I applied this squashing method to some known asymptotically flat black hole spacetimes and constructed new charged rotating black holes, BPS multi-black holes, and black holes in dilaton gravity [2, 4, 8, 10, 12, 14, 15, 16]. I also constructed an extremal charged black hole in a five-dimensional Kaluza-Klein universe [17]. I considered the parallel transportation of a spin vector along a circular geodesic in a squashed Kaluza-Klein black hole spacetime and derived the geodetic precession angle with the higher-dimensional correction [11]. I discussed Hawking radiation from a five-dimensional squashed Kaluza-Klein black hole on the basis of the tunneling mechanism [13]. I also discussed a simple method to prove non-smoothness of a higher-dimensional multi-black hole horizon [18].

Coalescence of five-dimensional rotating multi-black holes

There exist five-dimensional black hole spacetimes with different horizon topologies, i.e., the S^3 and the lens space S^3/Z_n horizons. The variety of the horizon topologies are related to the asymptotic structures of the spacetime. I constructed charged rotating multi-black hole spacetimes in the five-dimensional Einstein-Maxwell-Chern-Simons theory with a positive cosmological constant [6]. These spacetimes describe the coalescence of rotating black holes in the space with the non-trivial asymptotic structure. Then I compared my spacetimes with the spacetimes 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 spacetimes.

I constructed rotating Kaluza-Klein multi-black holes with the Gödel parameter [9]. Each black hole can have an inner and an outer ergoregions. I also constructed BPS multi-black holes and supersymmetric black rings with non-trivial asymptotic structures in the five-dimensional Einstein-Maxwell-Chern-Simons theory [3, 5, 7].