Ken Matsuno

Research plans

Higher-dimensional black holes with a twisted extra dimension

I would like to extend previous analysis in five dimensions to that in odd dimensions higher than five. Since odd-dimensional spheres S^{2n+3} (n: natural numbers) have structures similar to an S^3, constructions of higher-dimensional black hole solutions with a twisted S^1 as an extra dimension are also similar to those in five dimensions. As a first step, I have constructed extremal charged solutions where the mass of the black hole is equal to its charge [5]. There exists a null hypersurface where an expansion for an outgoing null geodesic congruence vanishes, then these spacetimes look like black holes. I have shown that the metrics admit C^0 extension across the horizon, but some components of Riemann curvature diverge there if the dimension is higher than five. The singularity is relatively mild so that an observer along a free-fall geodesic can traverse the horizon. When the size of a compact extra dimension becomes constant, I construct rotating Kaluza-Klein multi-black holes as a five-dimensional vacuum solution [4]. I expect that each black hole has an analytic horizon whose topology is a lens space. I also construct Kaluza-Klein multi-black holes on the Taub-Bolt space [3]. Then I extend above discussion about analyticity of horizons of Kaluza-Klein multi-black holes in five dimensions to that in higher dimensions [2]. Further I construct extremal charged black hole solutions in five-dimensional dynamical Kaluza-Klein universes [1].

Verification of extra dimension by squashed Kaluza-Klein black holes

A five-dimensional squashed Kaluza-Klein black hole spacetime admits stable circular orbits similar to the four-dimensional black hole spacetimes. I focus on the geodetic precession effect, the classical tests (light deflection, time delay, and perihelion precession), innermost stable circular orbits, and black hole shadows. As a first step, I have considered the parallel transportation of a spin vector along a circular geodesic in the squashed Kaluza-Klein black hole spacetime and derived the geodetic precession angle with the higher-dimensional correction [8]. Then I discuss remained physical phenomena with higher-dimensional corrections. If precise experiments of these phenomena agree with the expected values of general relativity, it requires a rigorous upper limit of the size of the extra dimension, or it excludes the squashed Kaluza-Klein metric for describing the geometry around astronomical objects.

Hawking radiation as tunneling from higher-dimensional black holes

Hawking radiation is one of the interesting phenomena where both of general relativity and quantum theory play a role. I have discussed Hawking radiation from a five-dimensional squashed Kaluza-Klein black hole on the basis of the tunneling mechanism [6]. I have used the two-dimensional effective metric, which is obtained by the dimensional reduction near the horizon, as the background metric. I have obtained not only the desired Hawking temperature of the squashed Kaluza-Klein black hole but also the effect of the backreaction associated with the radiation in a very simple manner. Then I consider Hawking radiation from squashed Kaluza-Klein black holes with quantum corrections. Further I discuss Hawking radiation as tunneling from various higher-dimensional black holes. If higher-dimensional black holes are created in future accelerator experiments, I expect that my present work could make a contribution to the verifications of Hawking radiation and extra dimensions in asymptotically Kaluza-Klein spacetimes.