Research plans

Verification of higher-dimensional spacetime models by Kaluza-Klein black hole spacetimes

Five-dimensional squashed Kaluza-Klein black hole spacetimes behave as fully five-dimensional black holes in the vicinity of the horizon, while they asymptote to four-dimensional flat spacetimes with a twisted S^1 as a compactified extra dimension. Then we can regard squashed Kaluza-Klein black hole spacetimes as realistic higher-dimensional spacetime models.

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 classical tests of general relativity (light deflection, gravitational redshift of light, and perihelion precession), innermost stable circular orbits, and black hole shadows. I assume that the five-dimensional squashed Kaluza-Klein black hole solution describes the geometry around the compact object, then I discuss 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.

Generalization of five-dimensional Kaluza-Klein black hole spacetimes

I want to generalize a family of five-dimensional squashed Kaluza-Klein black hole spacetimes [1, 2, 4, 8, 9, 10, 12]. For example, I have constructed extremal charged black hole spacetimes in odd dimensions [14]. When the size of a compact extra dimension becomes constant, I have investigated five-dimensional rotating Kaluza-Klein vacuum multi-black hole spacetimes [15]. I have generalized such spacetimes to charged rotating Kaluza-Klein multi-black hole spacetimes in the five-dimensional Einstein-Maxwell theory [16].

I generalize five-dimensional multi-black holes on four-dimensional Ricci-flat base spaces as a first step. I construct extremal charged Kaluza-Klein multi-black holes on the Kerr-Taub-bolt space in the five-dimensional Einstein-Maxwell theory [19]. The spacetime is effectively four dimensions at infinity. Inspecting the regularity, I expect that, when the topology of each black hole is not the S^3 but the lens space, the five-dimensional spacetime is regular on and outside the black hole horizons. Using a positive cosmological constant, I also construct an exact solution, which describes the coalescence of multi-black holes on the Kerr-Taub-bolt space, and discuss the topology change of horizon.

Further I construct multi-black strings in a five-dimensional Kaluza-Klein universe [20]. I discuss the analyticity of horizons, the Gregory-Laflamme instability, motions of test particles, and the difference between this spacetime and other dynamical black hole spacetimes.