Research plans

Higher-dimensional Kaluza-Klein black hole solutions with a twisted compact extra dimension

I want to generalize a family of five-dimensional squashed Kaluza-Klein black hole solutions [1, 2, 4, 8, 9, 10, 12]. I have constructed extremal charged solutions in odd dimensions [14]. There exists a null hypersurface then these spacetimes look like black holes. 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 have investigated five-dimensional rotating Kaluza-Klein vacuum multi-black hole solutions [15]. I have generalized such solutions to charged rotating Kaluza-Klein multi-black hole solutions in the five-dimensional pure Einstein-Maxwell theory [16]. Quantization conditions between the mass, the angular momentum, and charges appear from the regularity condition of horizon. The Kaluza-Klein spacetime structure with a compact extra dimension plays a crucial role in constructions of exact charged rotating black hole solutions in the five-dimensional pure Einstein-Maxwell theory.

I construct five-dimensional extremal charged Kaluza-Klein multi-black holes on the Kerr-Taub-bolt space [17]. I also construct extremal charged black hole solutions in five-dimensional dynamical Kaluza-Klein universes [18]. Further I extend the discussion about analyticity of horizons of Kaluza-Klein multi-black holes in five dimensions to that in higher dimensions [19].

Verification of higher-dimensional spacetimes by squashed Kaluza-Klein black hole solutions

Five-dimensional squashed Kaluza-Klein black hole solutions 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 these squashed Kaluza-Klein black hole solutions as models of realistic higher-dimensional 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 [11], 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.