Research Plan (Ken Matsuno)

Inner Structures of Squashed Kaluza-Klein Black Holes We have studied charged static squashed Kaluza-Klein black hole solutions which asymptote to the locally flat spacetime, i.e., a twisted constant S^1 fiber bundle over the four-dimensional Minkowski spacetime, at the infinity. These solutions are specified by the three parameters, namely, the mass, the electric charge and the size of the extra dimension.

Recently, we have obtained two types of Kaluza-Klein black hole solutions related to the shapes of the curvature singularities. When the electric charge is smaller than the critical charge specified by the size of the S^1 fiber at the spatial infinity, there is a point singularity where the spatial cross section of the spacetime shrinks to a point. On the other hand, when the electric charge is larger than the critical charge, there exist a stretched singularity where the the spatial cross section of the spacetime is stretched infinitely along the S^1 fiber.

We expect that the difference of these two types of singularities has an effect on the global spacetime geometry. We consider the motions of a test particle in these Kaluza-Klein black hole spacetime and discuss the relation between the behaviors of a test particle and two types of curvature singularities.

Measurement of Extra Dimension by Kaluza-Klein Black Holes In the brane world scenarios, one of the interesting problems is a verification of the size of extra dimensions from the various physical phenomena in higher-dimensional spacetimes. In such phenomena, we focus on the Gravity Probe B experiment and the perihelion precession of the Mercury as the first step.

Here, the Gravity Probe B satellite moves along a stable circular orbit around the Earth and collects data about two gravitational effects, the geodetic effect and the frame dragging effect. We focus on the geodetic effect which is the leading effect and estimated by the four-dimensional vacuum static Schwarzschild black hole. We expect that the geodetic effect is suffered from a correction by the existence of extra dimensions.

Thus we apply an five-dimensional vacuum static squashed Kaluza-Klein black hole solution with a compact extra dimension to the outer region of the Earth. We estimate the size of this compact extra dimension by the higher-dimensional correction to the geodetic precession angle with the Gravity Probe B experiment. Even if, the result of the Gravity Probe B measurement gives the predicted value with an expected accuracy, the accuracy of an observation gives an upper limit of the size of an extra dimension. We compare this correction with that to the perihelion precession of the Mercury by applying an five-dimensional vacuum static squashed Kaluza-Klein black hole solution to the outer region of the Sun.

Rotating Squashed Multi-Black Holes with Godel Parameter Recently, we have constructed new charged rotating multi-object solutions in the five-dimensional Einstein-Maxwell system with a Chern-Simons term and a positive cosmological constant. We expect that these solutions describe the coalescence of the rotating black holes in the squashed Godel universe which asymptotes to the locally flat spacetime at the infinity. We compare our solutions with the multi-centered Klemm-Sabra solutions which describe the coalescence of charged rotating multi-black holes in the flat spacetime. We discuss the relation between the behavior of the horizon areas and the asymptotic structures of the spacetime.