

# Research Achievements

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## 1. Hidden symmetry of higher-dimensional vacuum black hole spacetimes

Higher-dimensional Kerr-NUT-(A)dS spacetime which was discovered by Chen, Lü and Pope is known as a vacuum solution of Einstein's gravity theory describing rotating black holes in a higher-dimensional (A)dS spacetime. Among various kinds of symmetry in the vacuum black hole spacetimes, I have worked on Killing-Yano symmetry and have achieved many results as follows:

- I investigated curvature properties of the higher-dimensional Kerr-NUT-(A)dS spacetime and demonstrated that it is of type D in the algebraic classification of the Weyl curvature [1].
- I demonstrated that the Hamilton–Jacobi equations on those spacetimes which possess Killing-Yano symmetry can be solved by separation of variables. This means that geodesic motion of free particles is completely characterized by its first integrals [2].
- I wrote down the canonical form for metrics admitting Killing-Yano symmetry.
  - If nondegenerate, I have shown that the metrics are written in the form of higher-dimensional Carter's class [8]. Furthermore, we are able to show that if vacuum Einstein's vacuum equation is imposed, such spacetimes are uniquely determined by the metric found by Chen, Lü and Pope [3].
  - If degenerate, it is possible to show that the spacetimes possess fiber bundle structures where the Kerr-NUT-(A)dS spacetime is fibered over direct products of some Kähler manifolds [4,5].

## 2. Hidden symmetry of higher-dimensional charged black hole spacetimes

It is known that a generalisation of the Killing-Yano symmetry exists in charged black hole spacetimes of supergravity theories, which was pointed out by Kubizňák, Kunduri and Yasui. In order to understand the generalised Killing-Yano symmetry of charged black holes from a more unified view point, I have examined general properties of spacetimes admitting the generalised Killing-Yano symmetry. I have presented separability of geodesic equations [7] and the properties to several operators [6] on those spacetime backgrounds.

- We wrote down canonical forms for metrics admitting the generalised Killing-Yano symmetry. Although this is not the general form, a lot of known solutions fall into a particular class of our classification [10].
- We proposed one possible notion of deformed Sasakian manifolds with torsion. Using the generalised Killing-Yano symmetry, we construct an example of such manifolds. It was pointed out that the deformed Sasakian manifolds appear as a compactified internal space of higher-dimensional spacetime of supergravity [11].
- We investigated the generalised Killing–Yano symmetry of a particular class of Kaluza-Klein black holes in five dimensions. Furthermore, we constructed new Kaluza-Klein black holes of the 5-dimensional minimal supergravity [12].