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May 12, 2022

Report on Doctoral Thesis of Eliška Polášková

This is a report on Doctoral Thesis of Eliška Polášková titled *Properties and interpretation of black hole spacetimes*, written under a supervision of Prof. Pavel Krtouš at Charles University, submitted in Prague 2022.

The main objective of this Thesis is to review and push forward our understanding of black hole spacetimes in higher dimensions. The particular focus is on the so called Kerr-NUT-AdS class – a unique family of (vacuum with cosmological constant) spacetimes with the remarkable hidden symmetry of the Principal Killing–Yano (PKY) tensor. In higher dimensions, black holes can rotate in several independent directions, as well as may admit several NUT parameters. The corresponding Kerr-NUT-AdS metric thus contains a number of free parameters that can associated with the mass of the black hole, NUT parameters, rotation parameters, and the cosmological constant. Interestingly, when written in coordinates adapted to the PKY tensor, the precise physical meaning of these parameters is very hard to identify, as is the task of considering some physically interesting subcases, such as the equal spinning limit, limit of vanishing rotation, and so on. These highly non-trivial limits are *singular* and involve rescaling of both: parameters and coordinates.

The main result of the Thesis is to perform one such limit to obtain an '*equal-spinning spacetime*', where several angular momenta in different directions are equal to each other. This is accompanied by the discussion as to what happens with the PKY tensor (and generated from it other symmetries) under this limit, and a particular example demonstrating that this limit leads to an enhancement of (explicit) symmetries of the spacetime.

The Thesis is based on one published paper in Physical Review D, and a conference proceeding.[1] With extended introduction, the Thesis is self-contained and presents all technical details about the equal spinning limit (some of which go beyond of what was discussed in the paper). The Thesis is written in good quality English, I have found almost no typos.

[1] During her Ph.D., the candidate has published yet another paper on a different topic, the results of which are not presented in this Thesis.

I have several questions for potential discussion.

1. The equal-spinning limit is studied in the case of vanishing NUT parameters. However, in such a case, the limit can be straightforwardly taken starting from the Myers-Perry coordinates and/or their (A)dS generalization. If needed, the corresponding canonical (PKY adapted) form should then be obtainable by the (possibly degenerate?) Jacobi transformation. Has this been considered? Do the two procedures yield the same result?

2. It seems that one of the results of the Thesis was to show that after the equal spinning limit is taken, the explicit symmetries are enhanced – an explicit example in 6d is provided. However, this fact seems to be well know, e.g., gr-qc/0405125, gr-qc/0407030, and many other, where the extra symmetries are explicitly constructed. Would these results coincide upon doing the Jacobi transformation to the PKY coordinates?

3. Please explain again why after the limit, one cannot talk about the "true Kähler submanifolds". In particular, what is meant by the statement in the Thesis that "the separation into these is not integrable"?

4. There seem to be two parameters a and $\tilde{a}$ in the metric (4.8). Is this still before the equal spinning limit? If not, what is the physical meaning of these two parameters?

To summarize, although the Thesis is not very extensive, I think its overall *quality is good* and I am happy to recommend it to *be recognized* as Doctoral Thesis.
Kind regards,

David Kubizňák