Posudek práce

předložené na Matematicko-fyzikální fakultě
Univerzity Karlovy

❑ posudek vedoucího ☒ posudek oponenta
☒ bakalářské práce ❑ diplomové práce

Autor: Jurčík Róbert
Název práce: Centre of the Kerr and Appell space-times
Studijní program a obor: Obecná fyzika
Rok odevzdání: 2021

Jméno a tituly oponenta: Martin Žofka
Pracoviště: ÚTF MFF UK
Kontaktní e-mail: martin.zofka@matfyz.cuni.cz

Odborná úroveň práce:
❑ vynikající ☒ velmi dobrá ❑ průměrná ❑ podprůměrná ❑ nevyhovující

Věcné chyby:
☒ téměř žádné ❑ vzhledem k rozsahu přiměřený počet ❑ méně podstatné četné ❑ závažné

Výsledky:
❑ originální ☒ původní i převzaté ❑ netriviální kompilace ❑ citované z literatury ❑ opsané

Rozsah práce:
❑ veliký ❑ standardní ☒ dostatečný ❑ nedostatečný

Grafická, jazyková a formální úroveň:
❑ vynikající ☒ velmi dobrá ❑ průměrná ❑ podprůměrná ❑ nevyhovující

Tiskové chyby:
❑ téměř žádné ☒ vzhledem k rozsahu a tématu přiměřený počet ❑ četné

Celková úroveň práce:
❑ vynikající ☒ velmi dobrá ❑ průměrná ❑ podprůměrná ❑ nevyhovující

Slovní vyjádření, komentáře a připomínky oponenta:
The thesis investigates the innermost parts of the Kerr and Appell spacetimes, specifically, the region encircled by the ring curvature singularity. The question it asks is about the intrinsic and extrinsic form of the region. The thesis contains a nice, intuitive summary of intrinsic and extrinsic curvatures of 2D surfaces. Generally, the Appell case is only used for comparisons and the bulk of work focuses on the Kerr spacetime, which is certainly far more important for GR. The author confirmed that the intrinsic curvature of the surface defined by r=0 vanishes and it is thus flat. The thesis further explores various curvature invariants along the surface and also suggests using extrinsic curvature embeddings of the studied surface which is interesting. However, it seems to the reviewer that were we to reproduce both intrinsic *and* extrinsic curvatures through an embedding in a vacuum spacetime then it would lead to the original spacetime, at least locally. The thesis concludes by refuting a claim in literature concerning the interpretation of the central region of the Kerr spacetime.

P. 7, relation (2.1): This should be $d\theta(s)/ds$.
P. 9, relation (2.6): The author uses R for both the radius of an oscillation circle and the scalar curvature based on the Riemann tensor. Perhaps it would be advisable to mention that R is also referred to as the Ricci scalar.
P. 15, regarding the Appell case embedding problem: to ensure the induced metric due to the embedding coincides with the intrinsic metric on a compact surface, we generally need a Euclidean space of 3*2+11=17 dimensions.
P. 17, divergence of curvature implied by Figures 3.1 and 3.2: In fact, the plots suggest we might take a limit along the blue wedge towards the origin of coordinates and avoid the divergence. Indeed, setting M=a (as assumed) and a=r, the curvature vanishes—this is due to the fact that we end up with Minkowski as $M=a=r\to 0$. In reality, one must take a fixed value of a and then take the limit $r\to 0$ to see the divergence. This is because these plots describe a whole family of extremal Kerr spacetimes, not a single solution. The same applies to Figure 3.3.
P. 18, regarding the interpretation of the extrinsic curvature of the central disc, relation (3.27): Perhaps we could take the dicone not with its vortices sticking out and most of the cones cut out but rather cut out the two vortices and their neighborhoods instead. That would give us an infinite hourglass shape and a vanishing extrinsic curvature at the outer rim located at infinity.
P. 24, the authors of *Gravitation* should be in the order Misner, Thorne, Wheeler—hence MTW.

Případné otázky při obhajobě a náměty do diskuze:
What does the author mean on p. 2 by possibly being "…able to extract some information from the inside of a black hole in the future…?"
Could it be perhaps simpler to study a different surface encircled by the ring singularity?
So, can we expect some future work on the external embeddings?

Práci
☒ doporučuji
❑ nedoporučuji
uznat jako bakalářskou.

Navrhuji hodnocení stupněm:
☒ výborně ❑ velmi dobře ❑ dobře ❑ neprospěl/a

Místo, datum a podpis oponenta: Praha, 21.8.2021

Martin Kolář