Posudek práce

předložené na Matematicko-fyzikální fakultě
Univerzity Karlovy v Praze

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

Autor/~~ka~~: MiroslavTomášik
Název práce: Rovnice geodetiky v prostoročasech s helikální symetrií
Studijní program a obor: Fyzika, Obecná fyzika
Rok odevzdání: 2012

Jméno a tituly ~~vedoucího~~/oponenta: Martin Žofka
Pracoviště: ÚTF MFF UK
Kontaktní e-mail: zofka@mbox.troja.mff.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 vedoucího/oponenta:
The thesis is in English, which is a highly useful exercise for the author. It introduces the concept of helical symmetry in an illuminating way. It compares its results to the Newtonian case. The author learned Mathematica, C++, numerical methods, geodesics, etc. Author's original work includes: Christoffel symbols of the perturbed metric at a general position, numerical solution of the geodesic equation, calculation of Lyapunov exponents, survey of the causal structure of the spacetime.

- The present work is a compilation of several topics and, sometimes, it feels a little random. It seems to be a good starting point for a diploma thesis.
- The thesis dwells perhaps too long on numerical methods and, particularly, their software implementation. The form of an attachment would be more appropriate to keep the main text more concise and easier to read.
- Sometimes the assumptions are not stated clearly and the reader may be a bit confused. There are some typos. The use of a spellchecker would have been useful.
- Page 14, below (2.14): Particle B should not rotate in the opposite direction, alpha should be positive.
- The Newtonian case only features a test particle and the solution is not self-consistent. There is no back reaction of the test particle on the source of the field. As emphasized on top of page 17, this is not the Kepler problem. This is related to the issue of the form of orbits. Why not take the exact solution with two circular orbits?
- The numerical results (plots) only tell us we either cannot look at highly eccentric orbits or that we should use a higher-order Runge-Kutta method and not RK of the order 4.
- Page 22, above (3.3): There are certainly many vacuum solutions to Einstein equations which are not flat. E.g., gravitational waves.
- The same page: The perturbation condition should read h_{/mu/nu} << 1.
- Pages 34, 44: Test particles do not emit gravitational waves. Particle A does, however.
- Page 56: A nice check on the consistency of calculations!

Případné otázky při obhajobě a náměty do diskuze:

- Why should the Newtonian trajectory for k<1 be a closed ellipse? It is not even an ellipse unless a<<b. Is it because the author uses this fact plus M_{Sun} << M_{Earth}? What coordinate system is used here (one would expect an open curve in the co-rotating frame—a precessing ellipse)? Could the system decay if we prescribe the trajectory of A using thus an external force which comes from outside of the system? The system is not conservative then.
- Page 32: Normalization of the 4-velocity of particle B? Is it only up to the lowest order?
- Page 69 and the following figures: Did the null geodesics hit particle A directly? It seems it could have been at a different point on its orbit.
- For how many orbits did the author integrate the geodesic equations to obtain the Lyapunov exponents? There is no further discussion of the stability of the solutions. The stability of the Newtonian solution is mentioned only very briefly and it is not based on the Lyapunov exponents (difficult to compare).
- What is the physical cause of the limited range of admissible b's?
- Page 45: Does the 'center of mass' really have to be at the origin of coordinates? There are gravitational waves emitted and absorbed which act as an external force. This is also related to the Newtonian limit—is it really the case here, too? How can we compare the two cases when the Newtonian solution is not self-consistent (it only has one source- and one test particle)? If we required self-consistency, we would also get one more equation to satisfy, similarly to the GR case.
- Figures 5.10 through 5.13: Explanation missing in the captions. Does the spacetime include particle B? Studies the causal structure of the spacetime. Very brief. Nothing special? The more interesting region is actually close to the source particles.
- Full Einstein equations—solution? Any hints? Suggestions? Did the author actually try?
- Possible or even planned future work? Perhaps going one order higher?

Práci
☒ doporučuji
❑ nedoporučuji
uznat jako ~~diplomovou~~/bakalářskou.

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

Místo, datum a podpis ~~vedoucího~~/oponenta: Praha, 5.9.2012