

Posudek práce

předložené na Matematicko-fyzikální fakultě
Univerzity Karlovy

- | | |
|--|--|
| <input type="checkbox"/> posudek vedoucího | <input checked="" type="checkbox"/> posudek oponenta |
| <input type="checkbox"/> bakalářské práce | <input checked="" type="checkbox"/> diplomové práce |

Autor/ka: David Miškovský

Název práce: Mathematical methods and exact spacetimes in quadratic gravity

Studijní program a obor: Fyzika – Teoretická fyzika

Rok odevzdání: 2021

Jméno a tituly vedoucího/opponenta: Mgr. Alena Pravdová, Ph.D.

Pracoviště: Matematický ústav AV ČR

Kontaktní e-mail: pravdova@math.cas.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 goal of this diploma thesis is to derive vacuum field equations of quadratic gravity in the Newman-Penrose formalism and present its applications on simple examples.

In Introduction, the author gives a brief historical overview of general relativity.

In Chapter 1, the least action formulation of Einstein's general relativity and its generalization including quadratic terms in curvature, quadratic gravity, is summarized. The quadratic gravity field equations are then rearranged by separating the Ricci tensor part and the Ricci tensor free part.

In Chapter 2, the standard Newman-Penrose (NP) formalism is rederived, including the Ricci and Bianchi identities. The geometrical interpretation of NP quantities is recalled.

In Chapter 3, as an application of the NP formalism to general relativity, the Schwarzschild solution is rederived as the only vacuum spherically symmetric spacetime. In quadratic gravity, the field equations and Bach tensor components projected onto the NP frame are computed.

In Chapter 4, the NP formalism is applied to the Robinson-Trautman and the Kundt classes of spacetimes. In general relativity, the NP formalism with the Robinson-Trautman spherically symmetric metric ansatz is used to rederive the Schwarzschild solution again. In quadratic gravity, the NP formalism with the Robinson-Trautman spherically symmetric metric ansatz is employed to find the NP projections of the field equations. These equations can be simplified using the conformal-to-Kundt form of the spherically symmetric metric for which NP quantities are calculated and the quadratic gravity field equations are given, which are in agreement with previously obtained results. The simple pp-wave solutions are then studied in general relativity and quadratic gravity.

The work has a clear structure and an appropriate length. I have noticed a small number of grammar errors (often errors in the use of articles). I have the following objections

- page 31 - eqs. (3.41)-(3-47) - since the NP projections of the Bach tensor part B^2 are not expressed using the NP quantities, the NP projections of the quadratic gravity field equations are not complete;
- page 24, eq. (2.105) - the contravariant index of m should be ν and $e^{(b)}$ should have a covariant index μ ;
- page 44 - the symbol H is used for two different functions, I would prefer to use different symbols;
- the choice of the language is sometimes too informal for a scientific text, e.g. "Does not make sense, right?" on page 4.

I find the idea of extending the NP formalism to quadratic gravity interesting and useful. It involves a considerable amount of computations and the author has undertaken the task appropriately. Thus I am happy to recommend his work to be accepted and acknowledged as a diploma thesis.

Případné otázky při obhajobě a náměty do diskuze:

I would like to ask the following questions:

- Are computations made mainly by hand or using a computer algebra software (e.g., Mathematica)?
- For spherically symmetric spacetimes, it is possible to express the Ricci tensor in terms of Ricci rotation coefficients and components of the Weyl tensor, e.g., (4.52)-(4.54). How general is such behaviour beyond the class of spherically symmetric spacetimes?
- Would it be possible to present at least one complete NP quadratic gravity field equation (with B^z components expressed using NP quantities)?

Práci

doporučuji

nedoporučuji

uznat jako diplomovou/bakalářskou.

Navrhuji hodnocení stupněm:

výborně velmi dobře dobře neprospěl/a

Místo, datum a podpis vedoucího/oponenta:

Prague, August 31, 2021