Posudek práce
předložené na Matematicko-fyzikální fakultě
Univerzity Karlovy

☐ posudek vedoucího   ■ posudek oponenta
☐ bakalářské práce   ■ diplomové práce

Autor/ka: Bc. Aleš Flandera
Název práce: Geometry of isolated horizons
Studijní program a obor: FTF
Rok odevzdání: 2016

Jméno a tituly vedoucího/oponenta: Dr. Giovanni Acquaviva
Pracoviště: Ústav teoretické fyziky
Kontaktní e-mail: gioacqua@gmail.com

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 author reviews accurately the tools necessary for the pursuit of the goals. Although partial, the results are original and presented in a transparent way; moreover their usefulness is clearly highlighted, leaving space for further developments. The overall judgment on the thesis is very good.

Případné otázky při obhajobě a náměty do diskuze:

Práci
■ doporučuji
☐ nedoporučuji
uznat jako diplomovou/bakalářskou.

Navrhuji hodnocení stupněm:
☐ výborně ☐ velmi dobře ☐ dobře ☐ neprospěl/a

Místo, datum a podpis vedoucího/oponenta:

Milano, 23-08-2016

Review of the thesis
"Geometry of isolated horizons"

Candidate: Aleš Flandera

Supervisor: Mgr. Martin Scholtz, Ph.D.

Reviewer: Giovanni Acquaviva, Ph.D.

The diploma thesis in object has been presented by the candidate Aleš Flandera as fullfillment of the studies in the context of the Theoretical Physics programme of the Institute of Theoretical Physics.

As the title makes clear, the central subject of the thesis regards the notion of *isolated horizons*: such topic is of great importance in the description of distorted (or dirty) black holes, because the framework allows to take into account the back-reaction of accreting matter on the black hole metric instead of treating such matter as merely a "test mass". Moreover – unlike event horizons – isolated horizons do not suffer from teleological issues, which makes them more suitable for e.g. for numerical implementations of astrophysical scenarios involving black holes. These motivations are clearly stated in the introduction of the thesis, along with other considerations regarding the compelling connections between black holes, thermodynamics and quantum gravity. The importance of isolated horizons in this crucible is presented in a clear and satisfactory way and relevant references are provided.

The formalism adopted in the thesis is presented extensively in the first chapter and all the ingredients necessary to tackle the problem at hand are explained with sufficient detail and clarity. The main tool is represented by the Newman-Penrose (NP) formalism: such framework is applied to the description of the geometrical properties of non-expanding and isolated horizons in the subsequent chapters. The formalism involves sometimes very long systems of equations or cumbersome expressions: however, the quality of the presentation is not influenced negatively by this, as most of the details

are relegated into appropriate appendices.

As regards the specific goals of the thesis, the author makes clear that the work takes the moves from a quite recent paper (Krishnan, 2012), in which previous general results regarding isolated horizons have been translated into the NP formalism. The paper provides a way to construct a non-twisting NP null tetrad in a neighbourhood of isolated horizons, but no explicit form was given. The objective of the author is to extend such work by calculating explicitly such null tetrad onto and in the neighbourhood of the horizon of a Kerr-Newman metric, which represents a charged and spinning black hole. In order to do so, the author generalizes to the Kerr-Newman case the methods employed by others (Fletcher and Lun, 2003) in the Kerr scenario. As stressed before, the formalism involved in the pursuit of the goal is sometimes not manageable "by hand" due to its complexity: for this reason the author resorted to numerical computations with the aid of the software `Mathematica`. The code employed for the purpose of the thesis is listed in the appendix as well as provided in a CD-ROM attached. In section 4 the steps to achieve the goal and the main results are presented. It is made clear that, in order to build explicitly the sought tetrad off of the horizon, a perturbative expansion in the radial direction is needed: such procedure is the analogue of the Bondi expansion around null infinity, translated in this case in the NP formalism. The expansion of the NP quantities has been calculated here up to third order – which, given the computational cost of the procedure, seems to be enough to characterize the geometry in a neighbourhood of the horizon. It is moreover stated that a non-perturbative construction has been possible at least formally and that details about it will be provided in an upcoming publication. Although part of the results are thus not yet specified, those which are instead presented are worth of attention and will certainly be useful as a basis for future works.

In the concluding chapter of the thesis, the author provides a short outlook on possible future applications. For example, the results obtained could be useful for the study of Meissner effect, especially for the formulation of boundary conditions in the context of this formalism and their physical interpretation. Moreover, an interesting application regards the modelling of accretion disks surrounding black holes (the actual dirty black holes), which comprise not just electromagnetic fields but also other typical cosmological "fluids". In my opinion, the projection of the results in a future perspective complements in a good way the findings contained in the thesis.

Overall, the thesis is built in an organic way and all the tools necessary for the construction of the results are provided in a clean fashion. The motivations and the goals, as well as the problems encoutered during the pursuit of the results, are stated transparently. Even though the results presented are partial, the author specifies that further details will be provided in a peer-reviewed publication, which will make the work even more official in the scientific community. A minor critique regards only some inaccuracies in the English formulation of the thesis: however, in my opinion, this constitutes a secondary aspect of the work.