

# Posudek práce

předložené na Matematicko-fyzikální fakultě  
Univerzity Karlovy

- posudek vedoucího  
 bakalářské práce
- posudek oponenta  
 diplomové práce

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Název práce: Thermodynamics and black holes. Entropy and information.

Studijní program a obor: Fyzika, obecná fyzika

Rok odevzdání: 2018

Jméno a tituly vedoucího/opponenta: Giovanni Acquaviva, Ph.D.

Pracoviště: Ústav teoretické fyziky

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## 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 topic specified in the title is developed throughout the thesis in the following way: in the first chapter, the candidate presents an overview of classical and semi-classical results that are commonly known as the “four laws of black hole thermodynamics,, ; the second chapter is instead aimed to clarify the notions of entropy and information and their role in the context of black hole thermodynamics, an important issue that nowadays is still matter of research.

At first, the candidate proposes a detailed review of the four laws, whose completeness is hampered only by the fact that he doesn't have yet a quantum-field-theoretic education; however, in lack of this ingredient (helpful, for instance, for defining a black hole temperature), he resorted to a semi-classical version of the original black hole radiance result, accessible through purely quantum mechanical arguments. The candidate has been able to gather the relevant information from different sources and repropose a synthetic version of the proofs due to Hawking, Bekenstein, Bardeen and Carter, showing confidence in dealing with non-trivial tensorial expressions. The only comment here regards his style in the presentation of the mathematical parts, which tends to be sometimes confusing.

The second chapter is initially intended as a complement for the first one, with the aim of relating formally the horizon area to the notion of entropy. This reason motivated the candidate to study more in detail how different definitions of entropy arised historically, and then present how thermodynamic and black hole entropy might be related, both contributing to the “generalized second law,, given by Bekenstein. With such information at hand, the candidate briefly presents related issues such as the information loss paradox and the entropy bounds, without going into too much details. This last part of the second chapter, in my view, represents a declaration of interest in the open problems that are still discussed in the field nowadays; in this perspective, the candidate added also a final section regarding “possible developments,, that he would like to address in the future.

Overall, the candidate has been able to carry out the formal calculations in an independent way and shows very good understanding of the topics that are at his reach as a Bachelor student. The style of writing is very good and the stream of reasonings is carried on in a clear way. Besides this, he showed curiosity for new subjects and tools (e.g. density matrix formalism) and he is certainly motivated to understand more deeply the ramifications of the topic. While the structure of the thesis was mostly suggested by the advisor Ana Alonso-Serrano and me, the candidate managed to reformulate and connect the different parts by his own. Most of the help that came from us regarded the stylistic aspect.

### **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:

V Praze dne