Hydrodynamics and the quantum butterfly effect in black holes and large N quantum field theories

Scopelliti, V.

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Universiteit Leiden

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Issue Date: 2019-10-09

Curriculum Vitæ

I was born in Messina, Italy, on April 10, 1991. I grew up in Varapodio, a small village in Calabria, in the South of Italy, where I received my primary education. I attended high-school at the "Liceo Scientifico Nicola Pizi", with a scientific oriented program. In 2009 I moved to Rome to begin my studies at the Physics Department of "La Sapienza University of Rome". There, I was admitted to the honours program and I completed my BSc degree cum laude in 2012 with a thesis on "Peter-Weyl theorem and $SL(2, \mathbb{C})$ representations", supervised by Marco Bochicchio. Subsequently, I started the MSc program in theoretical physics at the same university, which, in 2014, I completed cum laude with a thesis on "Spin connection as Lorentz gauge field in Fairchild's action" (supervisor Giovanni Montani). During the MSc, I was part of the honours program and I undertook research projects in string theory under the supervision of Massimo Bianchi (Tor Vergata University). I have worked on these projects for the six subsequent months.

In September 2015, I started my PhD at Leiden University in the group of Koenraad Schalm on a project funded by the Netherlands Organisation for Scientific Research (NWO). I began studying the hydrodynamical transport properties of electrons in deformed graphene in collaboration with Adrew Lucas (Harvard University) and my supervisor. Intrigued by quantum chaos and the idea that it could affect hydrodynamic transport, I started to collaborate on this topic with Saso Grozdanov and Koenraad Schalm. Some of the results obtained during these years are presented in this thesis.

During my PhD I presented my research in seminars at the universities of Stanford, Harvard, Massachussets Institute of Technology (USA), at the conferences "Integrable and chaotic quantum dynamics" in Bled (SLO), "Physics at Veldhoven 2019" in Veldhoven (NL) and at a number of schools attended over these four years in France and The Netherlands. In the academic years 2015-2018, I served as a teaching assistant to the master courses "Effective Field theory" and "Quantum Field Theory".

I look forward to discover the new challenges and adventures that the (classical) butterfly effect will create in the coming years outside academia. I hope that, somehow, they will have something to do with hydrodynamics.

List of publications

- S. Grozdanov, K. Schalm and V. Scopelliti. *Many-body chaos and transport in large N (or weakly coupled) QFTs and close to the Quantum Critical Point.* In preparation . [Chapter 3]

- A. Romero-Bermúdez, K. Schalm and V. Scopelliti. *Regularization dependence of the OTOC. Which Lyapunov spectrum is the physical one?* JHEP **2019**, 107 (2019).

  [Chapter 5]

- S. Grozdanov, K. Schalm and V. Scopelliti. *Kinetic theory for classical and quantum many-body chaos.* Phys. Rev. E **99**, 012206, (2019). [Chapter 2]

- S. Grozdanov, K. Schalm and V. Scopelliti. *Black hole scrambling from hydrodynamics.* Phys. Rev. Lett. **120**, 231601 (2018).

  [Chapter 4]

Other publications by the author are:

- Y. Cheipesh, A. I. Pavlov, J. Tworzydlo, D. V. Efremov, V. Scopelliti, and N. V. Gnezdilov. *Planckian superconductor.* In preparation.

- V. Scopelliti, K. E. Schalm, A. Lucas. *Hydrodynamic charge and heat transport on inhomogeneous curved spaces.* Phys. Rev. B **96**, no.7, 075150, (2017).

- F. Cianfrani, G. Montani, V. Scopelliti. *Spin connections as Lorentz gauge field in Fairchild's action.* Mod. Phys. Lett. A **31**, 1650124, (2016).

Acknowledgements

The last four years have been a very enriching journey, both personally and professionally. And, as in all journeys, numerous people had an important role, from the ones I have spent time to have a drink or spend one day with, to the people I have had constantly around me. In the following, it is my pleasure to acknowledge some of the people who, academically, contributed to this thesis.

Firstly, I would like to thank Koenraad for his guidance, for the many hours spent discussing physics in his office and for stimulating me to follow ambitious intuitions. I will always remember the excitement I felt when ideas worked out, as well as the wonder of discovering totally unexpected results.

I would also like to thank Jan for the many thought-provoking conversations and for motivating the whole group to always keep the big picture of our research in mind.

Most of the work in this thesis was done in collaboration with Sašo: I feel lucky to have had the opportunity to work with him. I have learnt that "I don't understand what this means" can be the start of a full PhD program. I am very thankful for that.

I am grateful to Andy, for all the chats about physics, to Aurelio for his insights whenever I had a question, and to Nikolay, with whom I share the curiosity to find a way to experimentally check some of the ideas presented in this thesis.

I would like to thank all the people that have joined the group during these four years for creating a nice and stimulating atmosphere: Alex, Andrey, Bartek, Balazs, Christian, Emad, Floris, Jaakko, Josko, Ke, Miguel, Mohammad, Nick, Nikos, Petter, Philippe, Robert-Jan, Sasha, Simon, Tereza and Vladimir.

The Lorentz Institute is a great place to do, and to learn how to do research; I am thankful to everyone. I would also like to thank the secretaries, and Fran in particular, for all the help given during these years regarding administrative and practical problems.

A special thanks goes to Jorgos, with whom I have shared an office during the PhD.

Acknowledgements

There are many friends who contributed to make these years so vibrant. I am grateful to all of them, for the moments spent together and the ones to come.

Finally, I would like to thank my whole family for their constant and unconditioned support.