UNIVERSITÉ DU LUXEMBOURG

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Report on the thesis "Complexity, Holography and Geometry"
PhD candidate: Dimitrios Patramanis
Supervisor: Paweł Caputa
Affiliation: University of Warsaw

This is a cumulative thesis reporting the PhD research undertaken by Dimitrios Patramanis under the supervision of Paweł Caputa at the Institute for Theoretical Physics, University of Warsaw.

It is focused on the study of Krylov complexity, a measure of the complexity of quantum evolution introduced in a celebrated paper by Parker et al. published as ??Phys. Rev. X 9, 041017 (2019).

The thesis includes various sections, including a colorful acknowledgment and an informal introduction. The core of the thesis involves 4 chapters, in which a friendly summary is followed by a research publication. The thesis closes with a conclusion and bibliography. There are no appendices. The structure is natural and reasonable.

As an evaluator, I would have appreciated a one-page description of the structure of the thesis, indicating a) that the thesis is cumulative, and b) explicitly listing the publications that result from the thesis and the corresponding references. This is rather standard practice, although I agree that information can be obtained by browsing the thesis.

The thesis focuses on a topic on which I have done some research and that I have reviewed in the manuscript:

Pratik Nandy, Apollonas S. Matsoukas-Roubeas, Pablo Martínez-Azcona, Anatoly Dymarsky, Adolfo del Campo, "Quantum Dynamics in Krylov Space: Methods and Applications", arXiv:2405.09628, published as Physics Reports 1125, 1 (2025).

In addition, the thesis of my PhD student Nicoletta Carabba on the topic was published in Springer Thesis, as "Quantum Speed Limits to Operator Growth" (2024).

The literature has exploded and two other reviews have quickly followed, including one by the PhD supervisor Paweł Caputa (arXiv:2503.10753) and the other being arXiv:2507.06286. This shows the unusual level of activity on the research PhD topic.

I believe it is unusual to find a PhD thesis that has had a comparable impact in the community.

One of the research papers [P Caputa, JM Magan, D Patramanis, Geometry of Krylov complexity, Phys. Rev. Research 4, 013041 (2022)] has quickly become a key reference in the field, attracting over 200 citations. This reference was decisive in motivating my own research on the topic. It stands out for its pedagogical style and deep insights regarding the role of symmetry of the generators of the evolution on the dynamics of the Krylov complexity. It introduces a complexity algebra as well as a connection with the well-studied generalized coherent states.

The following chapter is based on a solo contribution by the PhD candidate, clearly demonstrating his maturity and independence as a researcher. The findings presented here were published in Progress of Theoretical and Experimental Physics 2022 (6), 063A01 (2022) and have also attracted significant attention (50 citations at the time of writing).

The subsequent chapter further shows the ability of the PhD candidate to establish his own collaborations and has been reported as D Patramanis, W Sybesma, SciPost Physics Core 7 (2), 037 (2024).
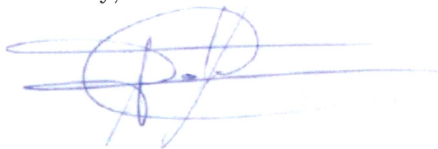
The last chapter of the core of the thesis is based on the second publication with the PhD advisor and is associated with the publication Pawel Caputa, Javier M. Magan, Dimitrios Patramanis, and Erik Tonni, Krylov complexity of modular Hamiltonian evolution, Phys. Rev. D 109, 086004 (2024).

From the quality of research, publication record, and writing skills, I have no doubt that Dimitrios Patramanis has acquired and experience and maturity as a researcher that largely qualify him for the degree of Doctor of Philosophy in Physics.

This is a cumulative thesis in which four chapters involve published manuscripts. However, the research is first-class and has had a major impact. The impact of the research by the Ph.D. candidate is consistent with that of many postdoctoral researchers. From the point of view of research excellence, the thesis is a worthy distinction.

Please do not hesitate to contact me if you require further information.

Sincerely,

Prof. Dr. Adolfo del Campo, Luxembourg