Skoltech
Skolkovo Institute of Science and Technology

# Jury Member Report – Doctor of Philosophy thesis.

**Name of Candidate:** Polovnikov Kirill

**PhD Program:** Physics

**Title of Thesis:** On connection between sparse graphs and hyperbolic geometry

**Supervisor:** Professor Mikhail Gelfand, Skoltech

Professor Sergey Nechaev, Interdisciplinary Scientific Center Poncelet

**Name of the Reviewer:**

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|---|---|
| I confirm the absence of any conflict of interest | **Signature:**  **Date: 13-08-2020** |

*The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.*

*If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.*

**Reviewer's Report**

The PhD Thesis of Kirill Polovnikov addresses several interdisciplinary issues related to the properties, organization and clustering in various mathematical, biological and cryptocurrency-network models, sharing a common structure of sparse graphs.

The Thesis contains an Introduction and a collection of 6 chapters, each being a copy of a separate publication.

Introduction lists relevant facts from the theory of random matrices, from the basic Wigner-Dyson theory to thorough discussion of spectral properties of sparse matrices, and can be considered as a nice brief introduction to the subject.

In Chapter 2, the spectral statistics of a toy model of random-length one-dimensional chains is shown to be related to the so-called "popcorn function" and Dedekind eta function. Buckling of two-dimensional

tissues in the process of their constrained growth is discussed in Chapter 3 with the help of the euconal equation and conformal mapping. In Chapter 4, the author addresses two-dimensional random walks evading an obstacle (either a semicircle or a triangle), investigates how the typical deviation of a trajectory from the obstacle scales with the trajectory length and demonstrates strong sensitivity of this deviation on the obstacle curvature. The last three Chapters (5-7) deal with self-organized communities in such different areas as molecular biology (chromatin folding) and cryptocurrency market. New methods for reconstruction of the graph structure are suggested.

The overall level of the Thesis research is high, the methods chosen are adequate, and the results were applied to uncover the structure of several real hierarchically-organized graphs.

As drawbacks I would like to mention (i) a bit artificial nature of the problem of one-dimensional chains of arbitrary length and (ii) absence of translation from the biological into physical language in Chapter 6.

Nevertheless I think the Thesis is of good quality and should be defended in a regular way.

**Provisional Recommendation**

☒ *I recommend that the candidate should defend the thesis by means of a formal thesis defense*

☐ *I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report*

☐ *The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense*