Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Nikita Stroev

PhD Program: Physics

Title of Thesis: Modelling of exciton-polariton condensates for unconventional computing

Supervisor: Professor Natalia Berloff

Name of the Reviewer: Pavlos Lagoudakis

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Date: 24-11-2021**

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

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art
- The relevance of the obtained results to applications (if applicable)
- The quality of publications

The summary of issues to be addressed before/during the thesis defense

Mr Stroev's on the "MODELLING OF EXCITON-POLARITON CONDENSATES FOR UNCONVENTIONAL COMPUTING" describes the correspondence between computational problems of high complexity and the physical system states. In the strong coupling regime, it was shown that one can realize k-local Hamiltonians with $k > 2$ with the nontrivial phase configurations and presented the methodology of encoding/decoding of an arbitrary computational task into the optical/photonic hardware. Mr Stroev analysed the most generic machine-learning approach including potential architecture mapping. Using the nonlinear spin clusters, Mr Stroev approximated the predetermined architecture with minor accumulated error, pushing the limits of the available computation.

The thesis consists of 6 chapters comprising a description of the state-of-the-art and background physics of the physical system (Ch.1&2). Chapter 3 is devoted to the methods applied on polariton condensates for the realization of different tasks. The basic block describes the mechanism behind XY Hamiltonian's realization of the system obeying the Gross-Pitaevskii description, and its generalization in the tensor sum's minimization. Furthermore application of machine-learning tasks into the XY Hamiltonian is explored with a focus on reservoir computing. Chapter 4 is aiming at utilizing the established connections (encoding-decoding procedure) between different computing tasks including the fundamental building block in the SAT problem. The chapter concludes with the calculation of the general mistake accumulated in the transferred deep learning architectures. Chapter 5 describes the conclusions and outlook of the work. Chapter 6 is an appendix of methodologies and perspectives of the work on constructing hard optimization instances.

In my opinion, the work is worthy of a PhD. The results obtained by Mr Stroev represent an extensive body of original studies in a competitive and technologically-important field. The work has been published in several respected journals.

There are, naturally, some points that could be pursued in an oral exam if only to give an indication of the depth of understanding the candidate has of some of the more complex aspects of the problems studied during the thesis. I would anticipate that these would focus in particular some of more technical aspects of the various methods, the motivation for undertaking these investigations within the context of the wider field, the possible applications involved, and the intellectual contribution of the candidate in the parts of the work presented in the thesis and the problems that he was given by his supervisor.

Provisional Recommendation

X *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*