Skoltech
Skolkovo Institute of Science and Technology

Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Andrey Kardashin

PhD Program: Computational and Data Science and Engineering

Title of Thesis: On applications of variational quantum circuits

Supervisor: Professor Jacob Biamonte

Name of the Reviewer: Ivan Oseledets

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Date: 17-04-2023**

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 thesis of A. Kardashin is devoted to practical quantum computations, including physical setups.

The variational quantum eigensolver is implemented on an optical setup for two qubits. Also, the thesis studies variational quantum eigensolver for the model with Dzyaloshinskii-Moriya type interactions, where the ground state is highly entangled. Also, binary classification in quantum setting is considered. The results are published in top journals.

The structure of the thesis is as follows. Chapter 1 gives a theoretical background. Chapter 2 describes the concept of variational quantum computing: we have a function f(theta) such that it can be fastly evaluated on a quantum computer.

Chapter 3 gives the variational quantum computing formulation of different problems and shows that such problems indeed can be solved on a quantum computer.

Chapter 4 is focused on binary classification tasks.

Comments.

1. It is often not clear from the discussion what are the results belonging to the author and what are the existing ones. If think, the presentation has to be modified accordingly. Structuring the presentation not only in the form of freeform discussion but statements like 'We propose'… It will help the reader
2. In Chapter 4, the classifier is trained to distinguish certain channels. Can we use classical ML models for the same tasks, such as transformers for sequence modeling? What is the advantage of quantum here
3. Is there any understanding how the performance will improve with larger n? What can we say about expressive power of VQ models in such case?
4. p.68: why 0.999 is chosen? Seems to be rather arbitrary.

Overall, the thesis is a solid work, written as a well-structured monograph on the topic. I really liked reading it. I might have some concerns about the practicality of the methods until larger quantum machines are tested, but this is for sure one of the most promising and straightforward direction in quantum computing. The dissertation makes a solid contribution to the field.

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