Skoltech
Skolkovo Institute of Science and Technology

Thesis Changes Log

Name of Candidate: Oksana Borzenkova

PhD Program: Computational and data science and engineering

Title of Thesis: Linear optical realization of variational quantum algorithms

Supervisor: Prof. Jacob Biamonte

Co-supervisor: Dr. Stanislav Straupe

The thesis document includes the following changes in answer to the external review process.

1. **From Dr. Yong-Su Kim:**

   a. **Please discuss limitations of VQE when the Hilbert space increases. Also briefly introduce how one can obtain excited state energy with VQE.**
   I expand the subsection "Limitations of VQA" menthiong there several limitations as the Hilbert space expands. (Specifically, the size of the Hilbert space grows exponentially with the number of qubits, complicating state preparation for larger systems and increasing sensitivity to noise in current quantum devices. Additionally, the depth and complexity of quantum circuits required for preparing variational states lead to longer execution times and a greater risk of errors, while the optimization algorithms may struggle to converge to the global minimum due to the more complex landscape of potential solutions. Moreover, the need for classical computation for parameter optimization raises significant resource demands as the number of parameters escalates. To obtain excited state energies and enhance VQE's efficacy, researchers can use approaches such as quantum subspace expansion, which involves working within a smaller subspace or leveraging overlaps with the ground state, as well as designing modified ansatz architectures specifically aimed at excited states. Post-processing techniques, like the excited-state quantum eigensolver or quantum state tomography, can also be employed to identify excited states after finding the ground state energy. Together, these strategies facilitate the exploration of a broader range of quantum systems despite the inherent challenges associated with increasing Hilbert spaces).

   b. **I think it would be beneficial to compare two experiments, one on the optical table with bulk optics and the other on a chip, in terms of benefits and challenges.**
   This information was incorporated at the beginning of Section 3.

2. **From Prof. Vladimir Palyulin:**

   a. **The new results and plots from the presentation deserve to be introduced to the manuscript**
   Added.

   b. **I still believe that the for V and H used in different contexts different fonts have to be used (it is the matter of correct theoretical style)**
   Upon reviewing the document, it was observed that the Hamiltonian and visibility are represented using mathematical fonts, while polarizations are expressed in text fonts. Furthermore, the document consistently provides explanations when introducing the Hamiltonian or visibility notations.

c. **Page 54 Shwinger->Schwinger.**
Corrected.

3. **From Prof. Sergey Alyatkin:**

a. **I would like to see further minor corrections of the thesis to compare existing on-demand single photon platforms with demonstrated in this work. I think it would be beneficial to address the questions from other Jury members raised during the defence procedure (for example, advantages of 6 photon scheme and single photon on-demand for generation of multiple photons).**
Concise discussions pertaining to the merits and limitations of each scheme have been incorporated at the conclusion of the respective subsections.

4. **From Dr. Konstantin Katamadze: The following text revision should be done:**

a. **Highlight the scientific novelty of the results**
I incorporated the emphasized terms within the abstract and the conclusion.

b. **Add technical details to the part, related to the multi photon source (6-fold coincidence rate and others)**
The previous iteration of the text, upon review, confirmed this assertion.

c. **It should be highlighted that results related to the quantum dot source have been done by candidate's colleagues, so, they are not a part of candidate's original results.**
Done.

d. **There are still some confusion between polarization and dual-rail encoding (|L> and |R> vector relates to circular polarization) on page 45**
Although this designation is prevalent in the literature, it has been substituted with "i" and "-i" for the purposes of this work.

e. **It is still not clear, how has the gate fidelity values, presented after Eq. (4.6) been measured. Is it candidate's result, or it was measured by colleagues?**
It was measured by my colleagues and the detailed information is presented in the paper ***Skryabin, N. N., Kondratyev, I. V., Dyakonov, I. V., Borzenkova, O. V., Kulik, S. P., & Straupe, S. S. (2023). Two-qubit quantum photonic processor manufactured by femtosecond laser writing. Applied Physics Letters, 122(12).*** *(as referred in the text)*

f. **There is no caption in Table 4.1.**
As I understand it, this refers to table 5.1. A caption has been added to it.

g. **It looks like not all the figures are mentioned in the text.**
It has been checked and refs added.

h. **For the source presented in Sec. 5.1. it is not clear, what is the difference between different channels.**
I am uncertain about the specific distinction being discussed. Additionally, I have ascertained the reasons that various emitters generate distinct frequencies for single-photon events.

i. **Fig. 5.5. According to the text, the crystal should be denoted as PPKTP instead of BiBO**
Corrected.

j. **For all the presented multiphoton sources it is necessary to compare the obtained results, and used technical solutions with results, presented in literature.**
Added to corresponding subsections.