

Ruslan Shaydulin

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Google Scholar: <https://scholar.google.com/citations?user=PxOuGGcAAAAJ>

Profile

PhD researcher in computer science. My research focuses on applying quantum computers to problems in optimization and machine learning. I have extensive experience in all aspects of designing and implementing hybrid quantum-classical algorithms from theoretical analysis to error mitigation, with particular interest in practical aspects of applying variational and decomposition-based approaches.

Work Experience

Maria Goeppert Mayer fellow – Argonne Scholar, Argonne National Laboratory **Fall 2020 - Present**

- Working on quantum optimization and quantum machine learning with focus on DOE applications

Research Intern, IBM Research – Quantum **Summer 2020**

- Developed and implemented a novel approach for Clifford circuit optimization in collaboration with Sergey Bravyi, Dmitri Maslov and Shaohan Hu ([arXiv:2105.02291](https://arxiv.org/abs/2105.02291))
- Selected as one of four interns to be [highlighted in a promotional video](#) on the basis of performance

Intern, Quantum Artificial Intelligence Lab (QuAIL) **Spring 2020**

NASA Ames Research Center (KBR)

- Developed novel analysis connecting the symmetries in problem instance structure to the performance of Quantum Approximate Optimization Algorithm in collaboration with Stuart Hadfield and Tad Hogg ([arXiv:2012.04713](https://arxiv.org/abs/2012.04713))
- Performed extensive numerical simulations using HPC resources

Research Aide, Argonne National Laboratory **Summer 2018, 2019**

- Developed quantum-accelerated frameworks for network community detection and graph partitioning under the supervision of Yuri Alexeev
 - Co-authored 6 papers on quantum optimization and machine learning (5 first author)
 - Contributed to multiple proposals
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Education

Clemson University, SC **Summer 2020**

PhD in Computer Science, advisor: Ilya Safro

Master of Science in Computer Science en route to PhD **Fall 2019**

Research in algorithms, high performance computing, big data analysis and quantum computing

Relevant coursework: Design & Analysis of Algorithms, Data Mining, Distributed & Cluster Computing, Parallel Architecture, Network Science

Moscow Institute of Physics and Technology **Summer 2016**

Department of Control and Applied Math,

Bachelor of Science in Applied Mathematics and Physics

Minor: Computer Science and Data Analysis

Peer-reviewed Publications

Ruslan Shaydulin, Stuart Hadfield, Tad Hogg, Ilya Safro. Classical symmetries and QAOA. *Quantum Inf Process* 20, 359 (2021). DOI: [10.1007/s11128-021-03298-4](https://doi.org/10.1007/s11128-021-03298-4)

Ruslan Shaydulin, Kunal Marwaha, Jonathan Wurtz, Phillip C. Lotshaw. QAOAKit: A Toolkit for Reproducible Study, Application, and Verification of the QAOA. In *Proceedings of the 2nd International Workshop on Quantum Computing Software (in conjunction with Supercomputing '21)*, 2021. Preprint [arXiv:2110.05555](https://arxiv.org/abs/2110.05555)

Ruslan Shaydulin, Alexey Galda. Error Mitigation for Deep Quantum Optimization Circuits by Leveraging Problem Symmetries. *2021 IEEE Intl. Conf. on Quantum Computing and Engineering (to appear)*, 2021. Preprint: [arXiv:2106.04410](https://arxiv.org/abs/2106.04410)

Ruslan Shaydulin, Stefan M. Wild. Exploiting Symmetry Reduces the Cost of Training QAOA. *IEEE Transactions on Quantum Engineering*, 2021 DOI: [10.1109/TQE.2021.3066275](https://doi.org/10.1109/TQE.2021.3066275)

Zirou Qiu, Ruslan Shaydulin, Xiaoyuan Liu, Yuri Alexeev, Christopher S. Henry, Ilya Safro. ELRUNA: Elimination Rule-based Network Alignment. *ACM Journal of Experimental Algorithmics*, 2021. DOI: [10.1145/3450703](https://doi.org/10.1145/3450703)

Hayato Ushijima-Mwesigwa, Ruslan Shaydulin, Christian F. A. Negre, Susan Mniszewski, Yuri Alexeev, Ilya Safro. Multilevel Combinatorial Optimization Across Quantum Architectures. *ACM Transactions on Quantum Computing*, 2020. DOI: [10.1145/3425607](https://doi.org/10.1145/3425607)

Justin Sybrandt, Ruslan Shaydulin, Ilya Safro. Hypergraph Partitioning With Embeddings. In *IEEE Transactions on Knowledge and Data Engineering*, 2020. DOI: [10.1109/TKDE.2020.3017120](https://doi.org/10.1109/TKDE.2020.3017120)

Zain Saleem, Kaiwen Gui, Ruslan Shaydulin, Martin Suchara. Comparing Constrained and Unconstrained Quantum Approximate Optimization Algorithms. In *Proceedings of the 2nd International Workshop on Quantum Resource Estimation (QRE 2020)* (co-located with *International Symposium on Computer Architecture (ISCA)* 2020).

Ruslan Shaydulin, Caleb Thomas, Paige Rodeghero. Making Quantum Computing Open: Lessons from Open-Source Projects. In *Proceedings of First International Workshop on Quantum Software Engineering (Q-SE 2020)* (co-located with *ICSEW* 2020). DOI: [10.1145/3387940.3391471](https://doi.org/10.1145/3387940.3391471)

Sami Khairy, Ruslan Shaydulin, Lukasz Cincio, Yuri Alexeev, Prasanna Balaprakash. Learning to Optimize Variational Quantum Circuits to Solve Combinatorial Problems. In *Proceedings of Thirty-Fourth AAAI Conference on Artificial Intelligence (AAAI-20)*, 2020. **Acceptance rate: 20.6%**
DOI: [10.1609/aaai.v34i03.5616](https://doi.org/10.1609/aaai.v34i03.5616)

Sami Khairy, Ruslan Shaydulin, Lukasz Cincio, Yuri Alexeev, Prasanna Balaprakash. Reinforcement-Learning-Based Variational Quantum Circuits Optimization for Combinatorial Problems. In *Proceedings of the Machine Learning and the Physical Sciences workshop at Conference on Neural Information Processing Systems (NeurIPS 2019)*, 2019. ([link](#))
Preprint: [arXiv:1911.04574](https://arxiv.org/abs/1911.04574)

Ruslan Shaydulin, Yuri Alexeev. Evaluating Quantum Approximate Optimization Algorithm: A Case Study. In *Proceedings of the 2nd International Workshop on Quantum Computing for Sustainable Computing (QCSC 2019) (in conjunction with 10th International Green and Sustainable Computing Conference (IGSC 2019))*, 2019
DOI: [10.1109/IGSC48788.2019.8957201](https://doi.org/10.1109/IGSC48788.2019.8957201)

Sami Khairy, Ruslan Shaydulin, Lukasz Cincio, Yuri Alexeev, Prasanna Balaprakash. Reinforcement Learning for Quantum Approximate Optimization. *Research Poster, Supercomputing '19*, 2019 ([available in Proceedings](#))

Ruslan Shaydulin, Ilya Safro, and Jeffrey Larson. Multistart Methods for Quantum Approximate Optimization. In *Proceedings of 2019 IEEE High Performance Extreme Computing Conference (HPEC)*, 2019
Best Student Paper (of ~50 student papers). DOI: [10.1109/HPEC.2019.8916288](https://doi.org/10.1109/HPEC.2019.8916288)

Ruslan Shaydulin, Hayato Ushijima-Mwesigwa, Christian F.A. Negre, Ilya Safro, Susan M Mniszewski, and Yuri Alexeev. A Hybrid Approach for Solving Optimization Problems on Small Quantum Computers. *Computer*, 52(6):18-26, 2019.
Cover Feature. DOI: [10.1109/MC.2019.2908942](https://doi.org/10.1109/MC.2019.2908942)

Ruslan Shaydulin, Hayato Ushijima-Mwesigwa, Ilya Safro, Susan Mniszewski, and Yuri Alexeev. Network Community Detection on Small Quantum Computers. *Advanced Quantum Technologies*, 2(9):1900029, 2019.
DOI: [10.1002/qute.201900029](https://doi.org/10.1002/qute.201900029)

Ruslan Shaydulin, Hayato Ushijima-Mwesigwa, Ilya Safro, Susan Mniszewski, and Yuri Alexeev. Community Detection Across Emerging Quantum Architectures. In *Proceedings of the 3rd International Workshop on Post Moore's Era Supercomputing (in conjunction with Supercomputing '18)*, 12-14, 2018. Preprint [arXiv:1810.07765](https://arxiv.org/abs/1810.07765)

Ruslan Shaydulin and Ilya Safro. Aggregative Coarsening for Multilevel Hypergraph Partitioning. In *Proceedings of 17th International Symposium on Experimental Algorithms (SEA 2018)*, 103:2:1-2:15, 2018.
DOI: [10.4230/LIPIcs.SEA.2018.2](https://doi.org/10.4230/LIPIcs.SEA.2018.2)

Ruslan Shaydulin, Jie Chen, and Ilya Safro. Relaxation-Based Coarsening for Multilevel Hypergraph Partitioning. *Multiscale Modeling & Simulation*, 17(1):482-506, 2019. DOI: [10.1137/17M1152735](https://doi.org/10.1137/17M1152735)

Invited Articles

Yuri Alexeev, Jeffrey Larson, Sven Leyffer, and Ruslan Shaydulin. Solving Combinatorial Optimization Problems on Quantum Computers. In *SIAM News Vol. 53 #6 July/August 2020*

Online Preprints and In-Submission Works

Sergey Bravyi, Ruslan Shaydulin, Shaohan Hu, Dmitri Maslov. Clifford Circuit Optimization with Templates and Symbolic Pauli Gates. *In submission*. Preprint: [arXiv:2105.02291](https://arxiv.org/abs/2105.02291)

Xiaoyuan Liu, Anthony Angone, Ruslan Shaydulin, Ilya Safro, Yuri Alexeev, Lukasz Cincio. Layer VQE: A Variational Approach for Combinatorial Optimization on Noisy Quantum Computers. *In submission*.
Preprint: [arXiv:2102.05566](https://arxiv.org/abs/2102.05566)

Ruslan Shaydulin, Justin Sybrandt. To Agile, or not to Agile: A Comparison of Software Development Methodologies. Preprint: [arXiv:1704.07469](https://arxiv.org/abs/1704.07469)

Contributed Talks and Posters**IEEE Quantum Week 2021****Oct 17-22, 2021**

Gave talks "Classical Symmetries and QAOA" and "Error Mitigation for Deep Quantum Optimization Circuits by Leveraging Problem Symmetries"

QIC seminar *University of Delaware***Sep 29, 2021**

Gave talk "Towards Practical Advantage in Quantum Optimization"

SIAM Conference on Optimization (OP21)**Jul 21, 2021**

Gave a talk "[Classical Symmetries and QAOA](#)"

Quantum Computing Tutorial *Argonne National Laboratory***Jun 16, 2021**

Led a tutorial on Quantum Approximate Optimization Algorithm.

HPC-AI colloquium *Intel***Jun 8, 2021**

Gave talk "Towards Practical Advantage in Quantum Optimization"

CM/QIS seminar *Virginia Tech***Apr 19, 2021**

Gave talk "Classical Symmetries and QAOA"

Chicago Quantum Exchange Member and Partner Workshop**Apr 19, 2021**

Gave talk "Quantum Optimization: the Next Five Years"

Sixth International Conference for Young Quantum Information Scientists (YQIS 2021)**Apr 12, 2021**

Gave talk "Classical Symmetries and QAOA"

LANS Seminar *Argonne National Laboratory***Mar 24, 2021**

Gave talk "Classical Symmetries and QAOA"

APS March Meeting**Mar 17, 2021**

Gave talk "Classical Symmetries and QAOA"

INFORMS Annual Meeting**Nov 13, 2020**

Gave talk "Classical Symmetries and the Quantum Approximate Optimization Algorithm"

Quantum Computing Seminar *IBM Research***Sep 24, 2020**

Gave talk "Practical Optimization on Near-term Quantum Computers"

Quantum Computing Tutorial *Argonne National Laboratory***Jun 15, 2020**

Led [a tutorial on Quantum Approximate Optimization Algorithm](#).

SIAM Conference on Parallel Processing for Scientific Computing (PP20) *Seattle, WA***Feb 13, 2020**

Gave talk "Multilevel Hybrid Quantum-Classical Algorithms on Graphs"

Information Science and Technology Institute Seminar *Los Alamos National Laboratory***Nov 26, 2019**

Gave talk "Practical Optimization on Near-term Quantum Computers"

Supercomputing '19 *Denver, CO***Nov 17-22, 2019**

Gave talk "Hybrid Quantum-Classical Algorithms for Graph Problems: Forging a Path to Near-Term Applications" at the [Clemson booth](#) and at the [SC Theater](#)

Mathematics and Computer Science Seminar *Argonne National Laboratory***Nov 15, 2019**

Gave talk "Practical Optimization on Near-term Quantum Computers"

Quantum Computing Seminar *Oak Ridge National Laboratory***Nov 4, 2019**

Gave talk "Practical Optimization on Near-term Quantum Computers"

International Green and Sustainable Computing Conference (IGSC 2019) *Alexandria, VA***Oct 22, 2019**

Presented poster "Reinforcement Learning for Quantum Approximate Optimization"

Chicago Quantum Exchange Meeting *University of Chicago***June 12, 2019**

Presented poster "Practical Quantum Approximate Optimization"

SIAM Conference on Computational Science and Engineering (CSE19) *Spokane, WA***Feb 25-28, 2019**

Presented poster "[Quantum Local Search for Graph Community Detection](#)"

Quantum Computing Tutorial *Argonne National Laboratory***Dec 10-11, 2018**

Gave talk "[QAOA Algorithm Introduction](#)"

Supercomputing '18 *Dallas, TX***Nov 11-16, 2018**

Gave talk "Community Detection Across Emerging Quantum Architectures" at Clemson booth

Quantum Computing Workshop *Argonne National Laboratory***Jul 25-27, 2018**

Presented preliminary results on "[Machine Learning on Near-Term Quantum Computers](#)"

32nd Clemson Mini-Conference on Discrete Mathematics and Algorithms *Clemson University***Nov 4, 2017**

Presented poster "Relaxation-Based Coarsening for Multilevel Hypergraph Partitioning"

58th Scientific Conference *Moscow Institute of Physics and Technology***Nov 23-28, 2015**

Gave talk "IPC (Inter-Process Communication) in OS X"

Leadership and Service

Requested Reviewer (peer review)

- [Quantum](#) journal
- npj Quantum Information
- IEEE Transactions on Computers
- IEEE Transactions on Quantum Engineering
- IOP New Journal of Physics
- ACM Journal of Experimental Algorithmics

Program Committee Member

- IEEE International Conference on Quantum Computing and Engineering ([QCE21](#))
- The Third International Workshop on Quantum Resource Estimation ([QRE 2021](#))

INFORMS Annual Meeting Led and co-organized a tutorial "Combinatorial Optimization on Quantum Computers" and a workshop "The Future of Quantum Optimization"	Oct 25, 2021
IEEE Quantum Week 2021 Session chair	Oct 19, 2021
Afro-Academic, Cultural, Technological and Scientific Olympics (ACT-SO) Mentored a high-school student	Oct 19, 2021
SIAM Conference on Optimization (OP21) Co-organized a minisymposium " Quantum Discrete Optimization "	Jul 20-23, 2021
Chicago Quantum Exchange Co-organized a workshop " Quantum Feature Maps for the NISQ Era "	Apr 16, 2021
IEEE Quantum Week Led and co-organized a minitutorial " Combinatorial Optimization on Quantum Computers "	Oct 15, 2020
SIAM Conference on Parallel Processing for Scientific Computing (PP20) <i>Seattle, WA</i> Led and co-organized a minitutorial " Combinatorial Optimization on Quantum Computers "	Feb 12-15, 2020
SIAM Conference on Parallel Processing for Scientific Computing (PP20) <i>Seattle, WA</i> Co-organized a minisymposium "Recent Advances and Trends in Hybrid Quantum-Classical Algorithms"	Feb 12-15, 2020
Supercomputing '19 <i>Denver, CO</i> Student volunteer, run tutorials, technical program session and Birds-of-Feather	Nov 17-22, 2019
Quantum Computing Tutorial <i>Argonne National Laboratory</i> Led and co-organized a hands-on tutorial for Qiskit, a framework for quantum computing	May 14, 2019
Mathematics Teacher, Summer School <i>Kostroma, Russia</i> School administrator, organized extracurricular activities.	Summer 2014

Teaching

Network Science CPSC 8480 <i>Clemson University</i> Teaching Assistant responsible for grading and answering students' questions during office hours	Fall 2018, 2019
Design and Analysis of Algorithms CPSC 8400 <i>Clemson University</i> Teaching Assistant responsible for grading and answering students' questions during office hours	Spring 2019
Algorithms and Data Structures CPSC 2120 <i>Clemson University</i> Teaching Assistant responsible for running the lab section, grading and answering students' questions during office hours	Spring 2019

Mathematics Teacher, Summer School *Kostroma, Russia*

Summer 2014

Created and taught a course on basics of graph theory, combinatorics and number theory to middle and high school students.

Languages and Technologies

C , Python

Prior experience: C++, MATLAB, Objective-C, Swift, Bash, IBM Qiskit

Limited prior experience: R, SQL, yacc, bison, AWS, Google Cloud Engine

Technologies and tools: UNIX/Linux, MPI, OpenMP

Honors and Awards

- Outstanding Young Engineer Award for the year 2021, awarded by IEEE Chicago Section
- International Green and Sustainable Computing Conference (IGSC 2019) student travel award, *recipient*
- Best Student Paper at IEEE HPEC 2019 (of ~50 student papers), *recipient*
- IBM Teach-the-Qiskit-Teacher training program, *selected to represent Argonne National Laboratory*
- Upsilon Pi Epsilon CS Honor Society, *member*
- Supercomputing '19 Student Volunteer Travel award, *recipient*
- SIAM CSE '19 Broader Engagement Travel award, *recipient*
- Clemson CCIT Supercomputing '17, '18 and '19 travel award, *recipient*
- Clemson Graduate Travel Grant, Spring '19, *recipient*
- Moscow Institute of Physics and Technology Abramov scholarship – Top 300 students in the university, based on high academic achievement, *recipient*