

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

Sergey Bravyi, **Ruslan Shaydulin**, Shaohan Hu, Dmitri Maslov. Clifford Circuit Optimization with Templates and Symbolic Pauli Gates. *Quantum* 5, 580, 2021. DOI: [10.22331/q-2021-11-16-580](https://doi.org/10.22331/q-2021-11-16-580)

Ruslan Shaydulin, Stuart Hadfield, Tad Hogg, Ilya Safro. Classical symmetries and the Quantum Approximate Optimization Algorithm. *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. DOI: [10.1109/QCS54837.2021.00011](https://doi.org/10.1109/QCS54837.2021.00011)

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 and White Papers

Ruslan Shaydulin, Martin Suchara and Jeffrey Larson. Standardized low-level noise characterization to differentiate DOE quantum testbeds. *Quantum Computing Testbeds Stakeholder Workshop White Paper*, 2021

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

Ruslan Shaydulin, Stefan Wild. Importance of Kernel Bandwidth in Quantum Machine Learning. *In submission*.

Preprint: [arXiv:2111.05451](https://arxiv.org/abs/2111.05451)

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

DOE Quantum Computing Testbeds Stakeholder Workshop

Dec 2, 2021

Gave talk "Standardized Low-Level Noise Characterization to Differentiate DOE Quantum Testbeds"

Supercomputing '21 (International Workshop on Quantum Computing Software)

Nov 15, 2021

Gave talk "QAOAKit: A Toolkit for Reproducible Study, Application, and Verification of the QAOA"

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 Gave talk "Classical Symmetries and QAOA"	Mar 17, 2021
INFORMS Annual Meeting Gave talk "Classical Symmetries and the Quantum Approximate Optimization Algorithm"	Nov 13, 2020
Quantum Computing Seminar <i>IBM Research</i> Gave talk "Practical Optimization on Near-term Quantum Computers"	Sep 24, 2020
Quantum Computing Tutorial <i>Argonne National Laboratory</i> Led a tutorial on Quantum Approximate Optimization Algorithm .	Jun 15, 2020
SIAM Conference on Parallel Processing for Scientific Computing (PP20) <i>Seattle, WA</i> Gave talk "Multilevel Hybrid Quantum-Classical Algorithms on Graphs"	Feb 13, 2020
Information Science and Technology Institute Seminar <i>Los Alamos National Laboratory</i> Gave talk "Practical Optimization on Near-term Quantum Computers"	Nov 26, 2019
Supercomputing '19 <i>Denver, CO</i> 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	Nov 17-22, 2019
Mathematics and Computer Science Seminar <i>Argonne National Laboratory</i> Gave talk "Practical Optimization on Near-term Quantum Computers"	Nov 15, 2019
Quantum Computing Seminar <i>Oak Ridge National Laboratory</i> Gave talk "Practical Optimization on Near-term Quantum Computers"	Nov 4, 2019
International Green and Sustainable Computing Conference (IGSC 2019) <i>Alexandria, VA</i> Presented poster "Reinforcement Learning for Quantum Approximate Optimization"	Oct 22, 2019
Chicago Quantum Exchange Meeting <i>University of Chicago</i> Presented poster "Practical Quantum Approximate Optimization"	June 12, 2019
SIAM Conference on Computational Science and Engineering (CSE19) <i>Spokane, WA</i> Presented poster " Quantum Local Search for Graph Community Detection "	Feb 25-28, 2019
Quantum Computing Tutorial <i>Argonne National Laboratory</i> Gave talk " QAOA Algorithm Introduction "	Dec 10-11, 2018
Supercomputing '18 <i>Dallas, TX</i> Gave talk "Community Detection Across Emerging Quantum Architectures" at Clemson booth	Nov 11-16, 2018
Quantum Computing Workshop <i>Argonne National Laboratory</i> Presented preliminary results on " Machine Learning on Near-Term Quantum Computers "	Jul 25-27, 2018

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**Oct 25, 2021**

Led and co-organized a tutorial "Combinatorial Optimization on Quantum Computers" and a workshop "The Future of Quantum Optimization"

IEEE Quantum Week 2021**Oct 19, 2021**

Session chair

Afro-Academic, Cultural, Technological and Scientific Olympics (ACT-SO)**2021-22**

Mentored a high-school student

SIAM Conference on Optimization (OP21)**Jul 20-23, 2021**Co-organized a minisymposium "[Quantum Discrete Optimization](#)"**Chicago Quantum Exchange****Apr 16, 2021**Co-organized a workshop "[Quantum Feature Maps for the NISQ Era](#)"**IEEE Quantum Week****Oct 15, 2020**Led and co-organized a minitutorial "[Combinatorial Optimization on Quantum Computers](#)"**SIAM Conference on Parallel Processing for Scientific Computing (PP20)** *Seattle, WA***Feb 12-15, 2020**Led and co-organized a minitutorial "[Combinatorial Optimization on Quantum Computers](#)"**SIAM Conference on Parallel Processing for Scientific Computing (PP20)** *Seattle, WA***Feb 12-15, 2020**

Co-organized a minisymposium "Recent Advances and Trends in Hybrid Quantum-Classical Algorithms"

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

Student volunteer, run tutorials, technical program session and Birds-of-Feather

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~~Quantum Computing Tutorial~~ Argonne National Laboratory

May 14, 2019

Led and co-organized a [hands-on tutorial for Qiskit, a framework for quantum computing](#)

Mathematics Teacher, Summer School Kostroma, Russia

Summer 2014

School administrator, organized extracurricular activities.

Teaching

Network Science CPSC 8480 Clemson University

Fall 2018, 2019

Teaching Assistant responsible for grading and answering students' questions during office hours

Design and Analysis of Algorithms CPSC 8400 Clemson University

Spring 2019

Teaching Assistant responsible for grading and answering students' questions during office hours

Algorithms and Data Structures CPSC 2120 Clemson University

Spring 2019

Teaching Assistant responsible for running the lab section, grading and answering students' questions during office hours

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

Python, C

Prior experience: C++, MATLAB, Objective-C, Swift, Bash, 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, *recipients*