

Ruslan Shaydulin

E-mail: rsbaydu@g.clemson.edu

GitHub: <https://github.com/rsln-s>

Web: shaydul.in

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

Profile

An expert in quantum information 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 quantum and hybrid quantum-classical algorithms from theoretical analysis to error mitigation.

Work Experience

Vice President, Applied Research Lead – FLARE, JPMorgan Chase & Co.

Spring 2022 - Present

- Member of the Future Lab for Applied Research and Engineering

Maria Goeppert Mayer fellow – Argonne Scholar, Argonne National Laboratory

Fall 2020 - Spring 2022

- Working on quantum optimization and quantum machine learning with focus on DOE applications
- Recipient of prestigious and selective postdoctoral fellowship ([< 5 awarded annually](#))

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
-

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

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 *IEEE Transactions on Quantum Engineering*. DOI: [10.1109/TQE.2021.3140190](https://doi.org/10.1109/TQE.2021.3140190)

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 International Conference on Quantum Computing and Engineering (QCE)*, 2021. DOI: [10.1109/QCE52317.2021.00046](https://doi.org/10.1109/QCE52317.2021.00046)

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)

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)

* Co-first author

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

Abdulkadir Canatar, Evan Peters, Cengiz Pehlevan, Stefan M. Wild, **Ruslan Shaydulin**. Bandwidth Enables Generalization in Quantum Kernel Models.

In submission. Preprint: [2206.06686](https://arxiv.org/abs/2206.06686)

Pradeep Niroula, **Ruslan Shaydulin**, Romina Yalovetzky, Pierre Minssen, Dylan Herman, Shaohan Hu, Marco Pistoia. Constrained Quantum Optimization for Extractive Summarization on a Trapped-ion Quantum Computer.

In submission. Preprint: [2206.06290](https://arxiv.org/abs/2206.06290)

Alvin Gonzales, **Ruslan Shaydulin**, Zain Saleem, Martin Suchara. Quantum Error Mitigation by Pauli Check Sandwiching. *In submission*.

Preprint: [2206.00215](https://arxiv.org/abs/2206.00215)

Xiaoyuan Liu, **Ruslan Shaydulin**, Ilya Safro. Quantum Approximate Optimization Algorithm with Sparsified Phase Operator. *In submission*.

Preprint: [arXiv:2205.00118](https://arxiv.org/abs/2205.00118)

Ashish Kakkar, Jeffrey Larson, Alexey Galda, **Ruslan Shaydulin**. Characterizing Error Mitigation by Symmetry Verification in QAOA. *In submission*.

Preprint: [arXiv:2204.05852](https://arxiv.org/abs/2204.05852)

Ruslan Shaydulin*, Phillip C. Lotshaw*, Jeffrey Larson, James Ostrowski, Travis S. Humble. Parameter Transfer for Quantum Approximate Optimization of Weighted MaxCut. *In submission*.

Preprint: [arXiv:2201.11785](https://arxiv.org/abs/2201.11785)

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

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

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

Southeast Quantum Computing Workshop *University of Georgia*

May 20, 2022

Gave invited talk "Importance of Kernel Bandwidth in Quantum Machine Learning."

American Physical Society March Meeting '22 *Chicago, IL*

Mar 17, 2022

Gave talk "Importance of Kernel Bandwidth in Quantum Machine Learning."

Quantum Information Processing '22 *Pasadena, CA*

Mar 8, 2022

Presented poster "Importance of Kernel Bandwidth in Quantum Machine Learning."

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) Gave talk "QAOAKit: A Toolkit for Reproducible Study, Application, and Verification of the QAOA" | Nov 15, 2021 |
| IEEE Quantum Week 2021 Gave talks "Classical Symmetries and QAOA" and "Error Mitigation for Deep Quantum Optimization Circuits by Leveraging Problem Symmetries" | Oct 17-22, 2021 |
| QIC seminar <i>University of Delaware</i> Gave talk "Towards Practical Advantage in Quantum Optimization" | Sep 29, 2021 |
| SIAM Conference on Optimization (OP21) Gave a talk " Classical Symmetries and QAOA " | Jul 21, 2021 |
| Quantum Computing Tutorial <i>Argonne National Laboratory</i> Led a tutorial on Quantum Approximate Optimization Algorithm. | Jun 16, 2021 |
| HPC-AI colloquium <i>Intel</i> Gave talk "Towards Practical Advantage in Quantum Optimization" | Jun 8, 2021 |
| CM/QIS seminar <i>Virginia Tech</i> Gave talk "Classical Symmetries and QAOA" | Apr 19, 2021 |
| Chicago Quantum Exchange Member and Partner Workshop Gave talk "Quantum Optimization: the Next Five Years" | Apr 19, 2021 |
| Sixth International Conference for Young Quantum Information Scientists (YQIS 2021) Gave talk "Classical Symmetries and QAOA" | Apr 12, 2021 |
| LANS Seminar <i>Argonne National Laboratory</i> Gave talk "Classical Symmetries and QAOA" | Mar 24, 2021 |
| 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 <i>Clemson University</i> Presented poster "Relaxation-Based Coarsening for Multilevel Hypergraph Partitioning" | Nov 4, 2017 |
| 58th Scientific Conference <i>Moscow Institute of Physics and Technology</i> Gave talk "IPC (Inter-Process Communication) in OS X" | Nov 23-28, 2015 |

Leadership and Service

Requested Reviewer (peer review)

- IOP Quantum Science and Technology (2022)
- Springer Quantum Information Processing (2022)
- [Quantum](#) journal (2020, 2021)
- npj Quantum Information (2020)
- IEEE Transactions on Computers (2020)
- IEEE Transactions on Quantum Engineering (2020, 2021, 2022)
- IOP New Journal of Physics (2021)

- ACM Journal of Experimental Algorithmics (2021)

Program Committee Member

- IEEE International Conference on Quantum Computing and Engineering ([QCE21](#), QCE22)
- 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

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
- 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*
- Moscow Institute of Physics and Technology Abramov scholarship – Top 300 students in the university, based on high academic achievement, *recipients*