

# Ruslan Shaydulin

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

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## 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.

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## 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 Braviy, 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)

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## 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*

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## 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)

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)

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## Contributed Talks and Posters

<b>IEEE Quantum Week 2021</b> Gave talks "Classical Symmetries and QAOA" and "Error Mitigation for Deep Quantum Optimization Circuits by Leveraging Problem Symmetries"	<b>Oct 17-22, 2021</b>
<b>QIC seminar</b> <i>University of Delaware</i> Gave talk "Towards Practical Advantage in Quantum Optimization"	<b>Sep 29, 2021</b>
<b>SIAM Conference on Optimization (OP21)</b> Gave a talk " <a href="#">Classical Symmetries and QAOA</a> "	<b>Jul 21, 2021</b>
<b>Quantum Computing Tutorial</b> <i>Argonne National Laboratory</i> Led a tutorial on Quantum Approximate Optimization Algorithm.	<b>Jun 16, 2021</b>
<b>HPC-AI colloquium</b> <i>Intel</i> Gave talk "Towards Practical Advantage in Quantum Optimization"	<b>Jun 8, 2021</b>
<b>CM/QIS seminar</b> <i>Virginia Tech</i> Gave talk "Classical Symmetries and QAOA"	<b>Apr 19, 2021</b>
<b>Chicago Quantum Exchange Member and Partner Workshop</b> Gave talk "Quantum Optimization: the Next Five Years"	<b>Apr 19, 2021</b>
<b>Sixth International Conference for Young Quantum Information Scientists (YQIS 2021)</b> Gave talk "Classical Symmetries and QAOA"	<b>Apr 12, 2021</b>
<b>LANS Seminar</b> <i>Argonne National Laboratory</i> Gave talk "Classical Symmetries and QAOA"	<b>Mar 24, 2021</b>
<b>APS March Meeting</b> Gave talk "Classical Symmetries and QAOA"	<b>Mar 17, 2021</b>
<b>INFORMS Annual Meeting</b> Gave talk "Classical Symmetries and the Quantum Approximate Optimization Algorithm"	<b>Nov 13, 2020</b>
<b>Quantum Computing Seminar</b> <i>IBM Research</i> Gave talk "Practical Optimization on Near-term Quantum Computers"	<b>Sep 24, 2020</b>
<b>Quantum Computing Tutorial</b> <i>Argonne National Laboratory</i> Led <a href="#">a tutorial on Quantum Approximate Optimization Algorithm</a> .	<b>Jun 15, 2020</b>
<b>SIAM Conference on Parallel Processing for Scientific Computing (PP20)</b> <i>Seattle, WA</i> Gave talk "Multilevel Hybrid Quantum-Classical Algorithms on Graphs"	<b>Feb 13, 2020</b>

<b>Information Science and Technology Institute Seminar</b> <i>Los Alamos National Laboratory</i> Gave talk "Practical Optimization on Near-term Quantum Computers"	<b>Nov 26, 2019</b>
<b>Supercomputing '19</b> <i>Denver, CO</i> Gave talk "Hybrid Quantum-Classical Algorithms for Graph Problems: Forging a Path to Near-Term Applications" at the <a href="#">Clemson booth</a> and at the <a href="#">SC Theater</a>	<b>Nov 17-22, 2019</b>
<b>Mathematics and Computer Science Seminar</b> <i>Argonne National Laboratory</i> Gave talk "Practical Optimization on Near-term Quantum Computers"	<b>Nov 15, 2019</b>
<b>Quantum Computing Seminar</b> <i>Oak Ridge National Laboratory</i> Gave talk "Practical Optimization on Near-term Quantum Computers"	<b>Nov 4, 2019</b>
<b>International Green and Sustainable Computing Conference (IGSC 2019)</b> <i>Alexandria, VA</i> Presented poster "Reinforcement Learning for Quantum Approximate Optimization"	<b>Oct 22, 2019</b>
<b>Chicago Quantum Exchange Meeting</b> <i>University of Chicago</i> Presented poster "Practical Quantum Approximate Optimization"	<b>June 12, 2019</b>
<b>SIAM Conference on Computational Science and Engineering (CSE19)</b> <i>Spokane, WA</i> Presented poster " <a href="#">Quantum Local Search for Graph Community Detection</a> "	<b>Feb 25-28, 2019</b>
<b>Quantum Computing Tutorial</b> <i>Argonne National Laboratory</i> Gave talk " <a href="#">QAOA Algorithm Introduction</a> "	<b>Dec 10-11, 2018</b>
<b>Supercomputing '18</b> <i>Dallas, TX</i> Gave talk "Community Detection Across Emerging Quantum Architectures" at Clemson booth	<b>Nov 11-16, 2018</b>
<b>Quantum Computing Workshop</b> <i>Argonne National Laboratory</i> Presented preliminary results on " <a href="#">Machine Learning on Near-Term Quantum Computers</a> "	<b>Jul 25-27, 2018</b>
<b>32nd Clemson Mini-Conference on Discrete Mathematics and Algorithms</b> <i>Clemson University</i> Presented poster "Relaxation-Based Coarsening for Multilevel Hypergraph Partitioning"	<b>Nov 4, 2017</b>
<b>58th Scientific Conference</b> <i>Moscow Institute of Physics and Technology</i> Gave talk "IPC (Inter-Process Communication) in OS X"	<b>Nov 23-28, 2015</b>

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## 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

## 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.

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## 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.

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## 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

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## 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*