[Compiled May, 2024]

James Watson

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Summary

I am a quantum computing Research Fellow interested in finding tasks that quantum computers will excel at in the immediate future. My research has involved calculating & optimizing resource costs for quantum simulation algorithms for physics and chemistry; demonstrating the effectiveness of classical machine learning using quantum data; putting complexity theoretic bounds on the effectiveness of quantum algorithms; and applying tools from complexity theory to improve our understanding of physics. This broad experience makes me well-placed to tackle a range of quantum problems. I am interested in using classical computation and machine learning to speed up and improve quantum computing.

Academic Experience

Postdoctoral Research Fellow | University of Maryland, College Park | Sept 2021 - Current

- Selected examples of research:
    - Developed quantum algorithms for solving problems in nuclear physics & estimated resource costs.
    - Developing software package to reduce algorithm error in Product Formula-based simulations.
    - Machine learning applied to data from quantum data sources to efficiently predict properties.
    - Complexity-theoretic lower bounds on the efficiency of quantum algorithms for physics problems.
- Presented research at leading conferences in the field including QIP.
- Mentored graduate students, interfaced with stakeholders, etc.

PhD (Quantum Computing) | Supervisor: Toby Cubitt | University College London | Sept 2016 – Sept 2021

- Research in quantum computing and its relation to many-body physics.
- Guest lectured quantum algorithms courses: algorithms for linear systems and quantum simulation.
- Teaching Assistant for undergraduate mathematics & physics courses.
- Organized multiple student conferences and seminar groups.

Education

MMath (Part III Mathematics) | University of Cambridge | Sept 2015 – Sept 2016

- Awarded Distinction (highest possible grade).
- Thesis: The Tensor Renormalization Group for Condensed Matter Physics.
- Courses: quantum field theory, string theory, general relativity, statistical field theory, black holes, quantum information, quantum computation.

Bachelors (Physics) | University of Cambridge | Sept 2012 – Sept 2015

- Awarded 1st Class degree (highest possible grade).
- Ranked in top 10 in program of +200.
- Courses: linear algebra, differential equations., calculus, probability, quantum mechanics, electrodynamics, electromagnetism, thermodynamics, mechanics, Python, C++, numerical methods, General Relativity, Math Methods.

Professional Work

Summer Associate | Goldman Sachs | June 2015 – Aug 2015

- Built custom models for estimating oil shipping prices based on publicly available data.
- Provided hedging analysis for clients in commodities trading using statistical analysis techniques.
- Monte Carlo pricing of complex over-the-counter options using GS proprietary language, Slang.

Summer Intern | Daiwa Capital Markets | July 2014

- Spent time with trading desks and rotation through fixed income, equities, DCM and quant analysis.

Awards & Honors

- EPRSC Research Fellowship, 2017-2021.
- Top 10 ranking in my undergraduate class at Cambridge.
- Cambridge University Churchill Scholarship for Academic Excellence, 2013, 2014, & 2015.
- Top 5 Candidate National Physics Olympiad UK, AS-Level, 2011.

Additional Skills

- Languages: Python, MATLAB, and Mathematica.
- Tools: Numpy, Pandas, Scikit-learn, XGBoost, Scipy, Git + Github/Gitlab, Jupyter Notebook.
- Other: Excel, Word, Outlook, PowerPoint, and LaTeX.

Other Professional Activities

- Program Committee Member: QIP 2023, YQIS 2024
- Conference Reviewer: QIP, TQC, STOC, QSIM, STACS, CCC, ICALP.
- Journal Reviewer: Nature Communications, Quantum, SIAM, Foundations of Physics, CIMP.
- Outreach for schools and women in STEM initiatives.

Research Papers

Published

- *The Complexity of Translationally Invariant Problems beyond Ground State Energies.* J. D. Watson, J. Bausch, and S. Gharibian, 40th International Symposium on Theoretical Aspects of Computer Science (STACS 2023), 254, (2023). doi:10.4230/LIPIcs.STACS.2023.54
- *Uncomputably Complex Renormalisation Group Flows.* J. D. Watson, E. Onorati, & T. S. Cubitt, Nature Communications, 13(1). (2022). doi:10.1038/s41467-022-35179-4
- *Computational complexity of the ground state energy density problem*. J. D. Watson, & T. S. Cubitt, Proceedings of the 54th Annual ACM SIGACT Symposium on Theory of Computing. (2022). doi:10.1145/3519935.3520052
- **Uncomputability of phase diagrams.* J. Bausch, T. S. Cubitt, & J. D. Watson, Nature Communications, 12(1), (2021). doi:10.1038/s41467-020-20504-6

Preprints

- *Polynomial-Time Classical Simulation of Noisy IQP Circuits after Constant Depth.* J. Rajakumar, J. D. Watson, Y.-K. Liu. arXiv:2403.14607 [Under Review: FOCS]
- *Quantum Algorithms for Simulating Nuclear Effective Field Theories*. J. D. Watson, J. Bringewatt, A. F. Shaw, A. Childs, Z. Davoud, A. Gorshkov. arXiv:2312.05344 [Under Review: PRX]
- **Provably Efficient Learning of Phases of Matter via Dissipative Evolutions*. E. Onorati, C. Rouze, D. Stilck Franca, and J. D Watson. arXiv:2311.07506 [Under Review: Annales Henri Poincaré]

- **Efficient learning of ground and thermal states within phases of matter*. E. Onorati, C. Rouze, D. Stilck Franca, and J. D Watson. arXiv:2301.12946 [**Accepted:** Nature Communications]
- *The Complexity of Approximating Critical Points of Quantum Phase Transitions.* J. D. Watson and J. Bausch. arXiv:2105.13350 [Under Review: PRX]
- *Detailed Analysis of Circuit-to-Hamiltonian Mappings*. J. D. Watson. arXiv:1910.01481

Soon to be Released (Manuscripts available on request)
- *Nearly Optimal Computation of Time-Evolved Expectation Values using Trotterization with Richardson Extrapolation*. J. D. Watson and J. Watkins.
- *Improved quantum supremacy using Gibbs sampling from O(1)-local Hamiltonians.* J. D. Watson and J. Rajakumar.

*Denotes papers ordered alphabetically where I am primary contributor.
**Denotes papers ordered alphabetically where I am joint primary contributor.

Supervising and Mentoring Experience

Joel Rajakumar – PhD student, University of Maryland

Andrew Zheng –Undergraduate Research Projects, University of Maryland.

David Kong – Undergraduate Research Projetcs, University of Maryland.

Selected Conference Talks

- **QIP 2024** (Taipei, Taiwan) "Efficient Learning of Phases of Matter"
- **TQC 2023** (Averio, Portugal) "Efficient learning of ground and thermal states within phases of matter"
- **ECT* 2023** "Nuclear and particle physics on a quantum computer: Where do we stand now?" (Trento, Italy) "Quantum Algorithms for Simulating Nuclear Physics"
- **VTQ-QIS Workshop 2023** (Arlington, Virginia) "Efficient learning of ground and thermal states within phases of matter"
- **Young Innovators Conference 2022** (IQC, Waterloo), "Complexity and Computability in Physics"
- **STOC 2022** (Rome, Italy) "The Computational Complexity of the Ground State Energy Density Problem"
- **ML and Quantum for Nuclear Physics 2022** (Seattle, US), "Quantum Algorithms for Simulating Nuclear Physics"
- **QIP 2022 Plenary Talk** (Caltech, US) "Complexity in the Thermodynamic Limit: The Ground State Energy Density Problem"
- **Workshop on Combinatorial Reconfiguration, ICALP 2021** (Virtual) "The Complexity of Translationally Invariant Problems beyond Ground State**"**
- **QIP 2020** (Shenzhen, China): "The Uncomputability of Phase Diagrams".
- **Quantum Simulation and Computation, 2019** (ICMAT, Madrid): "The Uncomputability of Phase Diagrams".
- **Quantum Roundabout 2018** (Nottingham, UK): "Computational Complexity of the Ground State Energy Density Problem" – **Runner up prize for best talk**.