MATTHEW DUSCHENES

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SUMMARY

A PhD student at the University of Waterloo with Dr. Raymond Laflamme and Dr. Juan Carrasquilla, a graduate of the University of Michigan Applied Physics and Scientific Computing joint Master's programs, a graduate of the Perimeter Scholars International Master's program at the Perimeter Institute, and an Engineering Physics graduate of Queen's University. Research interests in both theoretical and computational condensed matter physics, including graph-theoretic, Monte Carlo, and machine learning approaches. Highly proficient in Python (JAX), C++, and Bash languages. A driven, ambitious, and passionate learner who is teachable, develops new techniques efficiently, and enjoys both team and independent work in a challenging environment.

EDUCATION

Physics PhD Program **Fall, 2021 - Summer, 2025**
University of Waterloo, Institute for Quantum Computing, Vector Institute, Perimeter Institute

- Research in theoretical and computational quantum information and many-body systems with Dr. Raymond Laflamme and Dr. Juan Carrasquilla. PhD student in residence at the Perimeter Institute and Vector Institute. Current research in efficient hamiltonian simulation, and optimization and learning theory for quantum control problems.
- *Relevant Courses:* Quantum Many-Body Physics Theory and Computation (96%), Quantum Information Processing (95%).
- *Publications, Conferences, and Symposia:*
  - Duschenes, M., Martin, D., Larocca, M., Holmes, Z. & Cerezo, M. "Connecting channel expressiveness to gradient magnitudes and noise induced barren plateaus" (2024). APS March Meeting, Session T51: Quantum Machine Learning Training and Beyond
  - Duschenes, M., Carrasquilla, J. & Laflamme, R. Characterization of overparametrization in the simulation of realistic quantum systems. *Physical Review A* **109**, 062607 (2024)
  - Duschenes, M., J., C. & R., L. "Overparameterization of Realistic Quantum Systems" (2023). APS March Meeting, Session Y70: Quantum System Learning

Applied Physics and Scientific Computing Master's Degree **Fall, 2018 - Summer, 2021**
University of Michigan, Michigan Institute for Computational Discovery & Engineering

- Research with Dr. Krishna Garikipati on development of numerical and graph-theoretic approaches for modelling high dimensional physical systems.
- Achieved PhD candidacy and voluntarily wrote and passed Physics qualifying exam in 2020 before transferring to Master's program in 2021 to pursue doctoral studies in theoretical physics at the University of Waterloo.
- *Relevant Courses:* Bayesian Inference, Scientific Computing, Monte Carlo methods, Electricity and Magnetism, Renormalization group, Linear Algebra, Numerical Methods.
- *Publications:*
  - Duschenes, M., Srivastava, S. & Garikipati, K. Numerical analysis of non-local calculus on finite weighted graphs. *Comput. Methods Appl. Mech. Eng.* **402**, 115513 (2022)
  - Zhang, X., Teichert, G. H., Wang, Z., Duschenes, M., Srivastava, S., Sunderarajan, A., Livingston, E. & Garikipati, K. mechanoChemML: A software library for machine learning in computational materials physics. *Computational Materials Science* **8**, 111493 (2022)

Perimeter Scholars International Master's Degree **Summer, 2017 - Spring, 2018**
Perimeter Institute

- Fully funded 2-year Masters of Science in a 1-year program.
- *Relevant Courses:* Quantum Measurement Theory, Quantum Field Theory I, II, and III, Condensed Matter I, II and III, Quantum Information, Machine Learning for Many-Body Physics, Perimeter Winter School 2017.
- *Master's thesis:* With Dr. Roger Melko, on the use of Monte Carlo and dimensional reduction machine learning to distinguish phases in Ising-like systems with local and non-local order.

Engineering Physics, Electrical Specialization Degree **Fall, 2013 - Spring, 2017**
Queen's University

- Graduated with Honours, with a 4.0 cumulative GPA, and several additional physics courses within the double-major program.
- *Relevant Courses:* Statistical Mechanics, Quantum Mechanics, Mathematical Methods.
- *Undergraduate thesis:* With Dr. Marc Dignam, defended on Metallic Waveguides with Biased Semi-conducting Superlattice for Terahertz source gain.

EXPERIENCE

Graduate Research Assistant **Fall, 2021 - Present**
Department of Physics, University of Waterloo

- Developed theoretical and numerical approaches to investigate correlations and noise-induced phenomena in quantum systems and to understand simulation and optimization methods.

Research Intern **Summer, 2023 - Present**
Los Alamos National Laboratory

- Selected as one of 20 from 600 graduate students for the Quantum Computing Summer School.
- Developed analytical tools using group theory to resolve open questions regarding quantum dynamics and to understand the effects of noise on parameterized quantum systems.

Teaching Assistant - Quantum Computing Implementations **Fall, 2024**
University of Waterloo

- Assisted with lectures, office hours, grading, and exams, with Dr. Raymond Laflamme.

Teaching Assistant - Electricity and Magnetism **Winter, 2023-2024**
University of Waterloo

- Assisted with lectures, office hours, grading, and exams, with Dr. Raymond Laflamme.

Teaching Assistant - International Summer School for Young Physicists Summer, 2022-2023
Perimeter Institute

- Taught lectures and mentored students on analytical and numerical approaches in physics.

Teaching Assistant - Machine Learning Certificate Program **Winter, 2022**
Vector Institute

- Developed course content, gave lectures and tutorials, and lead office hours sessions.

Graduate Research Assistant **Winter, 2019 - Summer, 2021**
Department of Mechanical Engineering, University of Michigan

- Developed graph theoretic methods and a mathematical formalism for representing dynamics.

Optical Engineering Assistant **Summer, 2016**
Christie Digital Systems

- Developed apparatuses and algorithms for balancing colour output in laser projection systems.

ACTIVITIES AND INTERESTS

Perimeter Outreach and Mentorship Programs **2021-Present**
Perimeter Institute for Theoretical Physics

- Chair of Graduate Student Seminar series, inviting speakers, and organizing workshops.
- Mentor of Perimeter master's students, and contributor to scientific outreach with the general public, scientists, and students; member of the women in physics working group; and student representative on the scientific communication and academic programming committees.

Journal and Conference Reviewer **2023-Present**
Various Organizations

- Journal referee for Physical Review Journals (PRE).
- Conference sub-reviewer for QCTIP and TQC quantum information conferences.

Varsity Cross Country and Track and Field Teams **2013 - 2017**
Queen's University

- Competed across North America in long distance running events, and coordinated workouts.

AWARDS

NSERC PGS-D Graduate Scholarship **2023 - 2025**
Natural Sciences and Engineering Research Council of Canada

President's Award, Marie Curie Award, Physics Department Fellowship **2023 - 2025**
University of Waterloo

Vector Research Grant **2022 - 2024**
Vector Institute

Perimeter PhD Student Residency **2021 - 2025**
Perimeter Institute

Applied Physics Graduate Fellowship **2018 - 2020**
Applied Physics Program, University of Michigan

Perimeter Scholar Scholarship **2017 - 2018**
Perimeter Institute and University of Waterloo

Principal's Scholarship, W.W. King Scholarship **2013 - 2014**
Faculty of Applied Science, Queen's University

REFERENCES

References available upon request.

Publications

[1] Duschenes, M. *Distinguishing phases and detecting local and non-local order using t-SNE and Monte Carlo methods*. Master's thesis, Perimeter Scholar's International Essays, Perimeter Institute, Waterloo, Ontario (2018).

[2] Kochunas, B., Garikipati, K., Duschenes, M. & Folk, T. The graph theoretic approach for nodal cross section parameterization (2020). arXiv:2010.09683 [physics.comp-ph].

[3] Duschenes, M. & Garikipati, K. Reduced order models from computed states of physical systems using non-local calculus on finite weighted graphs (2021). arXiv:2105.01740 [math.NA].

[4] Price, D., Folk, T., Duschenes, M., Garikipati, K. & Kochunas, B. Methodology for Sensitivity Analysis of Homogenized Cross-Sections to Instantaneous and Historical Lattice Conditions with Application to AP1000® PWR Lattice. *Energies* **14**, 3378 (2021).

[5] Zhang, X., Teichert, G. H., Wang, Z., Duschenes, M., Srivastava, S., Sunderarajan, A., Livingston, E. & Garikipati, K. mechanoChemML: A software library for machine learning in computational materials physics. *Computational Materials Science* **8**, 111493 (2022).

[6] Duschenes, M., Srivastava, S. & Garikipati, K. Numerical analysis of non-local calculus on finite weighted graphs. *Comput. Methods Appl. Mech. Eng.* **402**, 115513 (2022).

[7] Duschenes, M., Carrasquilla, J. & Laflamme, R. Characterization of overparametrization in the simulation of realistic quantum systems. *Physical Review A* **109**, 062607 (2024).

Seminars

[1] Duschenes, M. "Graph theoretic approaches for physical systems". In *UM Phys. Grad. Student Symp.* (2020).

[2] Duschenes, M. "Reduced order modelling on finite weighted graphs". In *MICDE Student Semin.* (2021).

[3] Duschenes, M. "Reduced order models using non-local calculus on unstructured weighted graphs". In *US Natl. Congr. Comput. Mech.* (2021).

[4] Duschenes, M. "Learning and Overparameterization of Constrained Variational Quantum Circuits". In *IAIFI Summer School and Workshop* (2022).

[5] Duschenes, M. "Overparameterization of Realistic Quantum Circuits". In *Perimeter Institute Quantum Matter Workshop* (2022).

[6] Duschenes, M. "Overparameterization of Realistic Quantum Systems". In *Perimeter Graduate Student Seminar Series* (2022). PIRSA:22110060 see, `https://pirsa.org`.

[7] Duschenes, M. "Overparameterization of Realistic Quantum Systems". In *Quantum Days Conference* (2023).

[8] Duschenes, M. "Overparameterization of Realistic Quantum Systems". In *Canadian Quantum Graduate Conference* (2023).

[9] Duschenes, M., J., C. & R., L. "Overparameterization of Realistic Quantum Systems" (2023). APS March Meeting, Session Y70: Quantum System Learning.

[10] Duschenes, M. "Overparameterization of Realistic Quantum Systems". In *IQC Graduate Quantum Conference* (2023).

[11] Duschenes, M. "Noisy Overparameterization of Quantum Systems". In *Vector Institute Quantum + Machine Learning Workshop* (2023).

[12] Duschenes, M. "Overparameterization of Realistic Quantum Systems". In *PI/MILA Quantum/AI Workshop* (2023).

[13] Duschenes, M., Martin, D., Larocca, M., Holmes, Z. & Cerezo, M. "Connecting channel expressiveness to gradient magnitudes and noise induced barren plateaus" (2024). APS March Meeting, Session T51: Quantum Machine Learning Training and Beyond.

[14] Duschenes, M. "Expressivity measures of quantum channels and their operational meaning". In *Perimeter Graduate Student Seminar Series* (2024). PIRSA:24040122 see, `https://pirsa.org`.

[15] Duschenes, M. Overparameterization and expressivity of realistic quantum systems (2024). Invited Talks - IBM Zurich (Christa Zoufal), Freie Universität Berlin (Jens Eisert Group), EPFL (Zoe Holmes Group).

[16] Duschenes, M. "Channel Expressivity Measures". In *IQC Graduate Student Conference* (2024).

[17] Duschenes, M. "Channel Expressivity Measures". In *Perimeter Graduate Student Conference* (2024). PIRSA:24090201 see, `https://pirsa.org`.

[18] Duschenes, M. "Expressivity measures of quantum channels and their operational meaning". In *CQIQC Conference X* (2024).