

# Eric Anschuetz — Curriculum Vitae

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## Experience

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### Research.....

- **California Institute of Technology** **Pasadena, CA**  
*Sherman Fairchild Postdoctoral Scholar* 2023–  
Investigated a variety of problems in quantum algorithms, including (but not limited to):
  - The trainability of variational quantum algorithms
    - Surveying links between variational quantum algorithms not exhibiting barren plateaus in their loss landscapes and the ability for classical algorithms to efficiently simulate them; first demonstration of the classical simulability of quantum convolutional neural networks when they are efficiently trainable. (arXiv 2023)
  - The expressive power of quantum machine learning models using techniques from quantum foundations
    - Using quantum contextuality to show arbitrarily large, unconditional expressivity separations between a class of quantum recurrent models and a broad class of classical neural sequence models; also showing the first lower bound on the classical complexity of simulation of certain subgroups of the Clifford hierarchy. (arXiv 2024)
  - Product state approximations for quantum spin glass ground states
    - Demonstrating exact asymptotic value achieved by lowest-energy product states; also bounding the asymptotic value of the true ground state. (arXiv 2024)
  
- **Massachusetts Institute of Technology** **Cambridge, MA**  
*PhD student, Aram Harrow and Mikhail D. Lukin groups* 2017–2023  
Investigated a variety of problems in quantum algorithms, including (but not limited to):
  - The trainability of variational quantum algorithms
    - Using techniques from random matrix theory, Morse theory, and statistical query learning to show shallow, local variational quantum circuits are difficult to train. (Nat. Comm. 2022)
    - Using techniques from Morse theory and large deviations theory to show shallow, nonlocal variational quantum circuits are difficult to train. (ICLR 2022)
  - The expressive power of quantum machine learning models using techniques from quantum foundations
    - Using quantum contextuality and the constant rank theorem to show an unconditional expressivity separation between a class of quantum recurrent models and a broad class of classical neural sequence models; also showing the first lower bound on the classical complexity of GKP state simulation. (PRX Quantum 2022)
    - Using quantum contextuality to show an expressivity separation between a quantum generative model and certain classes of Bayesian networks. (PRX 2022)
  - Algorithms for near-term quantum computers
    - Constructing a loss suitable for near-term quantum computers for  $\ell_0$  norm regularized regression. (PRD 2022)
    - Using coresets to improve throughput in variational quantum algorithms. (Electronics 2021)
    - Constructing GAN-like architectures where a large classical model is aided by a small quantum computer. (PRA 2019)

- **Zapata Computing** **Cambridge, MA**  
*Internship* *Summer 2018, 2019*  
 Investigated the use of near-term quantum computers for variational quantum algorithms. Investigated the performance of the QAOA on a combinatorial optimization formulation of factoring (QTOP 2019), as well as designed a method for using eigenstate thermalization to train quantum Boltzmann machines. (arXiv 2019, results presented at an invited talk at the Quantum Machine Learning and Data Analytics Workshop 2019)
- **Harvard University** **Cambridge, MA**  
*Undergraduate research assistant, Mikhail D. Lukin group* *2015–2017*  
 Helped construct the “Atom Array” Rydberg atom experiment, investigating the use of controllable optical tweezers for deterministic trapping of ultracold atoms. Wrote and implemented the initial optical tweezer control algorithm in C++, interfacing with a software-defined radio. (Science 2016)

## Teaching.....

- **Massachusetts Institute of Technology** **Cambridge, MA**  
*Teaching assistant, 8.371[J] (Quantum Information Science)* *2023*  
 Aided in problem set creation and grading. Assisted students on assignments and in understanding the material in weekly office hours.
- **Massachusetts Institute of Technology** **Cambridge, MA**  
*High School Summer Program (HSSP) lecture* *2019*  
 Presented lecture on ongoing research in quantum algorithms.
- **Massachusetts Institute of Technology** **Cambridge, MA**  
*Teaching assistant, 8.311 (Electromagnetic Theory)* *2019*  
 Led weekly recitations and prepared associated online lecture notes. Assisted students on assignments and in understanding the material in weekly office hours.
- **Massachusetts Institute of Technology** **Cambridge, MA**  
*Master’s student mentor* *2019*  
 Mentored master’s student in research project developing methods for quantum compilation (Master’s thesis, results published in ACM Trans. Quantum Comput. 2021).

## Reviewing.....

Served as a reviewer for:

- *FOCS*
- *ICLR*
- *ICML*
- *Nature Communications*
- *NeurIPS*
- *npj Quantum Information*
- *Machine Learning: Science and Technology*
- *New Journal of Physics*
- *Physical Review A*
- *Physical Review B*
- *Physical Review Letters*

- *Physical Review Research*
- *Physical Review X*
- *PRX Quantum*
- *QCTiP*
- *QIP*
- *QTML* (program committee)
- *Quantum*
- *Quantum Machine Intelligence*
- *Quantum Science and Technology*
- *TQC*

## Publications

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E. R. Anschuetz, D. Gamarnik, and B. T. Kiani, Bounds on the ground state energy of quantum  $p$ -spin hamiltonians (2024), arXiv:2404.07231 [quant-ph] .

M. A. Perlin, R. Shaydulín, B. P. Hall, P. Minssen, C. Li, K. Dubey, R. Rines, E. R. Anschuetz, M. Pistoia, and P. Gokhale, Q-CHOP: Quantum constrained Hamiltonian optimization (2024), arXiv:2403.05653 [quant-ph] .

E. R. Anschuetz and X. Gao, Arbitrary polynomial separations in trainable quantum machine learning (2024), arXiv:2402.08606 [quant-ph] .

M. Cerezo, M. Larocca, D. García-Martín, N. L. Diaz, P. Braccia, E. Fontana, M. S. Rudolph, P. Bermejo, A. Ijaz, S. Thanasilp, E. R. Anschuetz, and Z. Holmes, Does provable absence of barren plateaus imply classical simulability? Or, why we need to rethink variational quantum computing (2023), arXiv:2312.09121 [quant-ph] .

E. R. Anschuetz, *The Trainability and Expressivity of Quantum Machine Learning Models*, Ph.D. thesis, Massachusetts Institute of Technology, Cambridge, MA, USA (2023).

E. R. Anschuetz, D. Gamarnik, and B. Kiani, Combinatorial NLTS from the overlap gap property (2023a), arXiv:2304.00643 [quant-ph] .

P. Gokhale, E. R. Anschuetz, C. Campbell, F. T. Chong, E. D. Dahl, P. Frederick, E. B. Jones, B. Hall, S. Issa, P. Goiporia, S. Lee, P. Noell, V. Omole, D. Owusu-Antwi, M. A. Perlin, R. Rines, M. Saffman, K. N. Smith, and T. Tomesh, SupercheQ: Quantum advantage for distributed databases (2022), arXiv:2212.03850 [quant-ph] .

E. R. Anschuetz, A. Bauer, B. T. Kiani, and S. Lloyd, Efficient classical algorithms for simulating symmetric quantum systems, *Quantum* **7**, 1189 (2023b).

J. Vizslai, T. Tomesh, P. Gokhale, E. Anschuetz, and F. T. Chong, Training quantum Boltzmann machines with coresets, in *2022 IEEE International Conference on Quantum Computing and Engineering (QCE)* (2022) pp. 292–298.

E. R. Anschuetz, H.-Y. Hu, J.-L. Huang, and X. Gao, Interpretable quantum advantage in neural sequence learning, *PRX Quantum* **4**, 020338 (2023c).

E. R. Anschuetz, L. Funcke, P. T. Komiske, S. Kryhin, and J. Thaler, Degeneracy engineering for classical and quantum annealing: A case study of sparse linear regression in collider physics, *Phys. Rev. D* **106**, 056008 (2022).

E. R. Anschuetz and B. T. Kiani, Quantum variational algorithms are swamped with traps, *Nat. Commun.* **13**, 7760 (2022).

M. S. Rudolph, S. Sim, A. Raza, M. Stechly, J. R. McClean, E. R. Anschuetz, L. Serrano, and A. Perdomo-Ortiz, *ORQVIZ: Visualizing High-Dimensional Landscapes in Variational Quantum Algorithms*, Tech. Rep. (Zapata Computing Inc., 2021).

E. R. Anschuetz, Critical points in quantum generative models, in *International Conference on Learning Representations*, edited by K. Hofmann, A. Rush, Y. Liu, C. Finn, Y. Choi, and M. Deisenroth (OpenReview, 2022).

X. Gao, E. R. Anschuetz, S.-T. Wang, J. I. Cirac, and M. D. Lukin, Enhancing generative models via quantum correlations, *Phys. Rev. X* **12**, 021037 (2022).

T. Tomesh, P. Gokhale, E. R. Anschuetz, and F. T. Chong, Coreset clustering on small quantum computers, *Electronics* **10**, 1690 (2021).

J. X. Lin, E. R. Anschuetz, and A. W. Harrow, Using spectral graph theory to map qubits onto connectivity-limited devices, *ACM Trans. Quantum Comput.* **2**, 1 (2021).

E. R. Anschuetz and C. Zanoci, Near-term quantum-classical associative adversarial networks, *Phys. Rev. A* **100**, 052327 (2019).

E. R. Anschuetz and Y. Cao, Realizing quantum Boltzmann machines through eigenstate thermalization (2019), arXiv:1903.01359 [quant-ph] .

E. Anschuetz, J. Olson, A. Aspuru-Guzik, and Y. Cao, Variational Quantum Factoring, in *Quantum Technology and Optimization Problems*, edited by S. Feld and C. Linnhoff-Popien (Springer International Publishing, Cham, 2019) pp. 74–85.

M. Endres, H. Bernien, A. Keesling, H. Levine, E. R. Anschuetz, A. Krajenbrink, C. Senko, V. Vuletic, M. Greiner, and M. D. Lukin, Atom-by-atom assembly of defect-free one-dimensional cold atom arrays, *Science* **354**, 1024 (2016)

## Talks

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- *Arbitrary Polynomial Separations in Trainable Quantum Machine Learning* , invited talk, Los Alamos National Laboratory (2024)
- *Quantum Theory and Algorithms*, invited talk, Planning Workshop on Quantum Computing (2024)
- *Rethinking Quantum Neural Networks*, invited talk, CSUN (2024)

- *Interpretable Expressivity Separations in Trainable Quantum Machine Learning*, invited talk, IQIM Seminar, Caltech (2024)
- *Enhancing Generative Models via Quantum Correlations*, invited talk, Tensor Network Reading Group, Mila (2023)
- *A discussion on QML*, panel, CIFAR Quantum Information Science Program Meeting (2023)
- *Efficient Classical Algorithms for Simulating Symmetric Quantum Systems*, invited talk, Centre for Quantum Technologies (2023)
- *The Expressive Power of Restricted Quantum Machine Learning Architectures*, invited talk, QHack (2023)
- *Contextuality for Quantum Advantage*, invited tutorial, Harvard University (2022)
- *Interpretable Quantum Advantage in Neural Sequence Learning*, invited talk, Masaryk University (2022)
- *Critical Points in Hamiltonian Agnostic Variational Quantum Algorithms*, invited talk, Quantum Research Seminars Toronto (2021)
- *Critical Points in Hamiltonian Agnostic Variational Quantum Algorithms*, invited talk, Centre for Quantum Technologies (2021)
- *Critical Points in Hamiltonian Agnostic Variational Quantum Algorithms*, invited talk, Quantum Algorithms and Applications seminar, Microsoft (2021)
- *Quantum Advantage in Basis-Enhanced Neural Sequence Models*, Quantum Techniques in Machine Learning (2021)
- *Near-Term Quantum-Classical Associative Adversarial Networks*, Quantum Techniques in Machine Learning (2020)
- *Improved Training of Quantum Boltzmann Machines*, American Physical Society March Meeting (2019)

## Awards and Honors

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- Sherman Fairchild Prize Postdoctoral Fellowship, California Institute of Technology (2023)
- Graduate Research Fellow, National Science Foundation (2017)
- Dean of Science Fellow, Massachusetts Institute of Technology (2017)
- Harvard College Scholar, Harvard University (2015)

## Education

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- **Massachusetts Institute of Technology** **Cambridge, MA**  
*Physics*  
 PhD in progress, co-advised by Aram Harrow and Mikhail Lukin, 5.00/5.00 GPA  
 2017–2023
- **Harvard University** **Cambridge, MA**  
*Physics*  
 AM, 3.89/4.00 GPA, 3.95/4.00 major GPA  
 2015–2017
- **Harvard University** **Cambridge, MA**  
*Physics and mathematics joint concentration, computer science secondary*  
 AB, 3.92/4.00 GPA, *magna cum laude* with Highest Honors in physics  
 2013–2017