Abhinav Deshpande

Research Scientist IBM

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Education

- 2015 Ph.D in Physics, University of Maryland, College Park, USA
- 2021 Dissertation title: "The complexity of simulating quantum physics: dynamics and equilibrium" Advisor: Prof. Alexey V. Gorshkov Co-advisor: Prof. Bill Fefferman
- 2010 Integrated B.Sc-M.Sc in Physics, Indian Institute of Technology (IIT) Kanpur, Kanpur, India
 2015 M.Sc project advisor: Prof. Saikat Ghosh

Experience

2023 - Research Scientist, IBM Quantum, San Jose

ongoing

- 2021 IQIM Postdoctoral Scholar, Research Associate in Theoretical Physics, California Institute of 2023 Technology, Pasadena
- 2015 **Research Assistant**, *Department of Physics, University of Maryland*, College Park 2021 Affiliations:

 $\odot\,$ Joint Center for Quantum Information and Computer Science (QuICS) $\odot\,$ Joint Quantum Institute (JQI)

- Jul 2020 Independent contractor, Xanadu Quantum Technologies, Toronto
- Dec 2020 Working on improving the evidence for hardness of a restricted version of Gaussian boson sampling
- Jun Aug **Visitor**, Institute for Quantum Information and Matter, California Institute of Technology, 2019 Pasadena

Worked with Prof. Fernando Brandão and Prof. Manuel Endres on cross-entropy benchmarking in Rydberg atoms

- May Jul Visiting Scientist, Max Planck Institute for Quantum Optics, Munich
 - 2014 Worked in the group of Prof. Ignacio Cirac with Prof. Anne E. B. Nielsen on fractional quantum Hall states

May - Jul Summer Intern, Technische Universität (TU) Dortmund, Dortmund

2013 Worked with Dr. Dieter Suter on experimental NMR quantum computing

Research Interests

Applications of quantum information to many-body physics, Complexity theory, Classical simulation of quantum systems, Quantum dynamics

Awards and Achievements

- 2022 Chicago Quantum Creators Prize
- 2017 NSF travel grant of \$500 to attend Quantum Information Processing (QIP) 2017
- 2015 Dean's Fellowship, Graduate School, University of Maryland Awarded to outstanding incoming graduate students (amount: \$5000)
- 2015 General Proficiency Medal, IIT Kanpur Awarded for best academic performance in the physics department

- 2013 Working Internships in Science and Engineering, German Academic Exchange Service (DAAD) Awarded \$2800 to fund a summer internship at TU Dortmund
- 2010 Academic Excellence Award, IIT Kanpur
 - 2013 Awarded for being among the top 7% out of 820 students across all disciplines (won three consecutive years)
 - 2010 Rank 54, Joint Entrance Examination Out of approximately 472,000 nation-wide applicants to the Indian Institutes of Technology
 - 2010 Gold medal, Indian Association of Physics Teachers Awarded to the top 35 out of 30,000 in the Indian National Physics Olympiad
- 2010 Fellow, *Kishore Vaigyanik Protsahan Yojana*, Department of Science and Technology, Government 2015 of India
 - Awarded \$8000 under a scheme to "attract exceptionally highly motivated students for pursuing basic science courses and research careers in science."
 - 2008 National Talent Search Scholarship, Government of India Awarded to 1000 high-school students across India based on an examination and interview (amount: \$200)

Long-term programs/workshops

- 2022 Quantum Many-Body Dynamics and Noisy Intermediate-Scale Quantum Systems, Kavli Institute for Theoretical Physics (KITP)
- 2022 Towards Classically Intractable Quantum Simulations of Physics and Chemistry, KITP
- 2021 Quantum Complexity: Theory and Application, Dagstuhl

Service

2022 – Editor at Quantum journal

ongoing

- 2017 Reviewed/sub-reviewed for:
- ongoing **Conferences:** Conference on the Theory of Quantum Computation, Communication and Cryptography (TQC) 2023, Quantum Information Processing (QIP) 2023, TQC 2022, Quantum Computing Theory in Practice (QCTIP) 2022, QIP 2022, Innovations in Theoretical Computer Science (ITCS) 2022, Computational Complexity Conference (CCC) 2021, TQC 2021, QIP 2021, TQC 2020, QIP 2018

Journals: Annals of Physics, Foundations of Physics, Nature Communications, Nature Physics, NPJ Quantum Information, Physical Review A, Physical Review B, Physical Review Letters, PRX Quantum, Quantum, Quantum Information & Computation, Quantum Information Processing, SciPost, Science Advances, Science Bulletin

- **Others:** NSF PFI, NSF SBTR/STTR
- 2022 Served on programme committee of NSF Workshop on Quantum Advantage and Next Steps, UChicago
- Aug 2017 Co-organized (with Dr. Jeremy Young) the JQI-QuICS-CMTC seminar at the University of Jan 2019 Maryland

Patents/Patent Applications

M. C. Tran, A. Deshpande, A. Y. Guo, A. Lucas, A. V. Gorshkov, *Optimal state transfer and entanglement generation in power-law interacting systems*, U.S. Provisional Patent Application 63/262085, filed Oct 4, 2021.

A. Lucas, M. C. Tran, A. Ehrenberg, A. Y. Guo, A. Deshpande, A. V. Gorshkov, Z.-X. Gong, C.-F. Chen, Y. Hong,

Quantum State Transfer, U.S. Patent Application 17574301, filed Jan 12, 2022.

Publications

- 21. B. Ware, A. Deshpande, D. Hangleiter, P. Niroula, B. Fefferman, A. V. Gorshkov, M. J. Gullans, "A sharp phase transition in linear cross-entropy benchmarking", arXiv:2305.04954
- 20. S. Ghosh, A. Deshpande, D. Hangleiter, A. V. Gorshkov, B. Fefferman, "Sharp complexity phase transitions generated by entanglement", arXiv:2212.10582
- 19. J. T. Iosue, A. Ehrenberg, D. Hangleiter, A. Deshpande, A. V. Gorshkov, "Page curves and typical entanglement in linear optics", arXiv:2209.06838
- U. Chabaud, A. Deshpande, and S. Mehraban, "Quantum-inspired permanent identities", Quantum 6, 877 (2022); arXiv:2208.00327
- A. Ehrenberg, A. Deshpande, C. L. Baldwin, D. A. Abanin, and A. V. Gorshkov, "Simulation Complexity of Many-Body Localized Systems", arXiv:2205.12967 Accepted in QIP 2023.
- M. Van Regemortel, O. Shtanko, L. P. Garcia-Pintos, A. Deshpande, H. Dehghani, A. V. Gorshkov, and M. Hafezi, "Monitoring-induced Entanglement Entropy and Sampling Complexity", Physical Review Research 4, L032021 (2022); arXiv:2201.12672
- A. Deshpande, P. Niroula, O. Shtanko, A. V. Gorshkov, B. Fefferman, and M. J. Gullans, "Tight bounds on the convergence of noisy random circuits to the uniform distribution", PRX Quantum 3, 040329 (2022); arXiv:2112.00716 Accepted in QIP 2022.
- A. Deshpande*, A. Mehta*, T. Vincent, N. Quesada, M. Hinsche, M. Ioannou, L. Madsen, J. Lavoie, H. Qi, J. Eisert, D. Hangleiter, B. Fefferman, and I. Dhand, "Quantum computational advantage via high-dimensional Gaussian Boson Sampling", Science Advances 8, eabi7894 (2022); arXiv:2102.12474
- M. C. Tran, A. Y. Guo, A. Deshpande, A. Lucas, and A. V. Gorshkov, "Optimal state transfer and entanglement generation in power-law interacting systems", Physical Review X 11, 031016 (2021); arXiv:2010.02930 Accepted in QIP 2021.
- A. Deshpande, A. V. Gorshkov, and B. Fefferman, "The importance of the spectral gap in estimating ground-state energies", PRX Quantum 3, 040327 (2022); arXiv:2007.11582 Accepted in ITCS 2022, QIP 2021, Q-Turn 2020.
- A. Y. Guo, A. Deshpande, S.-K. Chu, Z. Eldredge, P. Bienias, D. Devulapalli, Y. Su, A. M. Childs, and A. V. Gorshkov, "Implementing a fast unbounded quantum fanout gate using power-law interactions", Physical Review Research 4, L042016; arXiv:2007.00662 Accepted in TQC 2021.
- O. Shtanko, A. Deshpande, P. S. Julienne, and A. V. Gorshkov, "Complexity of Fermionic Dissipative Interactions and Applications to Quantum Computing", PRX Quantum 2, 030350 (2021); arXiv:2005.10840
 - * These authors contributed equally.

- M. C. Tran, C.-F. Chen, A. Ehrenberg, A. Y. Guo, A. Deshpande, Y. Hong, Z.-X. Gong, A. V. Gorshkov, and A. Lucas, "Hierarchy of linear light cones with long-range interactions", Physical Review X 10, 031009 (2020); arXiv:2001.11509
- Z. Eldredge, L. Zhou, A. Bapat, J. R. Garrison, A. Deshpande, F. T. Chong, and A. V. Gorshkov, "Entanglement bounds on the performance of quantum computing architectures", Physical Review Research 2, 033316 (2020); arXiv:1908.04802
- G. Pagano, A. Bapat, P. Becker, K. S. Collins, A. De, P. W. Hess, H. B. Kaplan, A. Kyprianidis, W. L. Tan, C. Baldwin, L. T. Brady, A. Deshpande, F. Liu, S. Jordan, A. V. Gorshkov, and C. Monroe,

"Quantum approximate optimization of the long-range lsing model with a trapped-ion quantum simulator", Proceedings of the National Academy of Sciences, 202006373 (2020); arXiv:1906.02700

- N. Maskara*, A. Deshpande*, A. Ehrenberg, M. C. Tran, B. Fefferman, and A. V. Gorshkov, "Complexity phase diagram for interacting and long-range bosonic Hamiltonians", Physical Review Letters 129, 150604 (2022); arXiv:1906.04178
- V. V. Orre, E. A. Goldschmidt, A. Deshpande, A. V. Gorshkov, V. Tamma, M. Hafezi, and S. Mittal, "Interference of temporally distinguishable photons using frequency-resolved detection", Physical Review Letters 123, 123603 (2019); arXiv:1904.03222
- A. Bapat, Z. Eldredge, J. R. Garrison, A. Deshpande, F. T. Chong, and A. V. Gorshkov, "Unitary entanglement construction in hierarchical networks", Physical Review A 98, 062328 (2018); arXiv:1808.07876
- A. Deshpande, B. Fefferman, M. C. Tran, M. Foss-Feig, and A. V. Gorshkov, "Dynamical phase transitions in sampling complexity", Physical Review Letters 121, 030501 (2018); arXiv:1703.05332
- A. Deshpande and A. E. B. Nielsen, "Lattice Laughlin states on the torus from conformal field theory", Journal of Statistical Mechanics: Theory and Experiment 2016 (1), 013102; arXiv:1507.04335
- S. M. Roy, A. Deshpande, and N. Sakharwade, "Remote tomography and entanglement swapping via von Neumann-Arthurs-Kelly interaction", Physical Review A 89, 052107; arXiv:1308.2852

See also: Google Scholar, arXiv, ORCID

Talks

- Gaussian Boson Sampling and Random Matrix Theory
 Shenzhen Conference on Random Matrix Theory and Applications
- The complexity of simulating quantum dynamics
 - O Quantum Creators Prize Symposium 2022, Chicago
- $_{\odot}$ Noisy random circuits: properties and applications in quantum computing
 - \circ Quantum Information Processing (QIP) 2022
 - \odot NSF Workshop on Quantum Advantage and Next Steps

- Am I living in the post-quantum-advantage era?
 - o Noisy intermediate scale quantum advantage journal club, University of Maryland
 - UCL–Bristol visit day at AWS/IQIM Caltech
 - Summer School on Quantum Computing and Its Applications (QCA'22) at Jaypee Institute of Information Technology
- The importance of the spectral gap in estimating ground-state energies
 - $\,\circ\,$ Quantum information theory seminar at University College London
 - JQI-QuICS-CMTC seminar
 - o Q-Turn workshop
 - Quantum Information Processing 2021
 - APS March Meeting 2021
 - Innovations in Theoretical Computer Science (ITCS) 2022
- Quantum Computing: Where we are headed
 - Keynote talk at Manipal Institute of Technology
- Gaussian Boson Sampling and its complexity
 - $\odot\,$ Quantum information seminar at UT Austin
 - O Dagstuhl workshop on Quantum Complexity: Theory and Application
- Sampling-complexity phase diagrams
 - o IQI seminar, California Institute of Technology, 2019
- Complexity phase transition in interacting and long-range bosonic Hamiltonians
 APS March Meeting, 2019
- Sampling from ground states of local Hamiltonians
 Workshop on Challenges in Quantum Computation, Simons Institute, 2018
- Complexity of sampling as an order parameter
 JQI-QuICS-CMTC seminar, 2017

Outreach

- 2022 Volunteered at a workshop on graduate school applications organized by Gender Minorities and Women in Physics, Math and Astronomy (GWiPMA) at Caltech
- 2022 Volunteer at QIP 2022
- 2019 Volunteer at TQC 2019 + NISQ conference and workshop
- 2018 Volunteer at the USA Science and Engineering Festival for the JQI and the American Physical Society (APS)
- 2017 Volunteer at QIP 2017
- Oct 2016 Part of the Mental Health Task Force, a team formed to raise awareness about mental health in Feb 2018 the physics community at UMD
 - 2016 Volunteer at Maryland Day for the JQI
 - 2015 Volunteered with Graduate Resources Advancing Diversity with Maryland Astronomy and Physics (GRAD-MAP) to assist with a bootcamp on Python for undergraduate students
 - 2015 Member of core grading committee, International Physics Olympiad 2015, Mumbai
 - 2012 Member of core grading committee, Asian Physics Olympiad 2012, New Delhi

Mentoring

2022 Served as mentor in the Caltech Accountability Partners Program, a program to advise undergraduate students through the graduate admissions process, in collaboration with Future Ignited, a program to diversify STEM

- Jun Aug Co-supervised (with Prof. Alexey V. Gorshkov) Nishad Maskara, a Caltech undergraduate, through
 the SURF program. Co-authored a paper "Complexity phase diagram for interacting and long-range
 bosonic Hamiltonians"
 - 2012 Served as an Academic Mentor in the Counselling Service of IIT Kanpur, tutoring students on 2013 academic probation

Press

- 2021 "New Approach to Information Transfer Reaches Quantum Speed Limit", press release
- 2020 "A Speed Test for Ripples in a Quantum System", Physics
- 2020 "New Quantum Information Speed Limits Depend on the Task at Hand", press release
- 2019 "Stretched photons recover lost interference", press release
- 2018 "Complexity test offers new perspective on small quantum computers", press release