Abhijeet Alase

Personal Data

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Research interests

My research spans several areas at the intersection of condensed matter physics and quantum information science. I specialize in the physics of topological systems and their applications to quantum technologies, particularly in the realm of topological quantum computation and quantum sensing. I have made significant contributions to broader areas within quantum information science, including quantum algorithms and implications of PT-symmetric quantum mechanics.

Keywords: topological insulators and superconductors, bulk-boundary correspondence, Majorana qubits, quantum algorithms, quantum sensing, PT-symmetric quantum mechanics.

Employment history

08/2025 - present	**Concordia University**, Canada Assistant Professor
08/2022 - 05/2025	**University of Sydney**, Australia Postdoctoral Research Fellow
	University of Calgary, Canada
09/2020 - 07/2022	Killam Postdoctoral Fellow
03/2019 - 08/2020	Postdoctoral associate
01/2022 - 04/2022	Sessional Instructor (part-time)

Education

09/2013 - 02/2019	**Dartmouth College**, USA Ph.D. in Physics (March 2nd, 2019) Supervisor: Prof. Lorenza Viola Dissertation: Boundary physics and bulk-boundary correspondence in topological phases of matter
08/2009 - 05/2013	**Indian Institute of Technology, Bombay**, India B. Tech. with Honors in Engineering Physics (August 2013) CGPA: 9.32/10 (Department rank 4)

Honors and awards

- **Killam 2020 Postdoctoral Fellowship (116,000 CAD)**. Awarded annually to one out of over 500 postdoctoral scholars from the University of Calgary across all faculties.
- **Prize for outstanding Ph.D. research (500 USD)** by Springer in 2019.
- **The Physics and Astronomy Graduate Research Award 2018 (500 USD)** from Dartmouth College for outstanding research accomplishments as a graduate student and the commitment to continued work in physics, astronomy, or related sciences.
- Awarded gold medal in **Indian National Physics Olympiad** and attended Physics Nurture Camp 2009 on the basis of performance in the same. Awarded to 35 top performing candidates out of 30,000 participants in Indian National Physics Olympiad.
- Secured all India rank 845 in **Indian Institute of Technology Joint Entrance Examination 2009 (IIT-JEE)** among over one million applicants.
- Awarded **National Talent Search Scholarship** by Government of India in 2007.

Publications

Books

- A. Alase, "Boundary physics and bulk-boundary correspondence in topological phases of matter" (Springer Nature, Cham, 2019).

Research articles

1. M. C. Goffage, A. Alase, M. C. Cassidy, and S. N. Coppersmith, "Leakage at zero temperature from changes in chemical potential in Majorana qubits", arXiv preprint arXiv:2504.17485.
2. X. C. Kolesnikow, T. B. Smith, F. Thomsen, A. Alase and A. C. Doherty, "Protected phase gate for the 0-π qubit using its internal modes", arXiv preprint arXiv:2503.14634.
3. A. Alase, "Quantum signal processing without angle finding", arXiv preprint arXiv:2501.07002.
4. A. Alase and S. Karuvade, "Resolvent-based quantum phase estimation: Towards estimation of parametrized eigenvalues", arXiv preprint arXiv:2410.04837.
5. A. Alase, K. D. Stubbs, B. C. Sanders, and D. L. Feder, "Erasure conversion in Majorana qubits via local quasiparticle detection", Phys. Rev. Research **6**, 043294 (2024).
6. A. Alase, E. Cobanera, G. Ortiz, and L. Viola, "Wiener-Hopf factorization approach to a bulk-boundary correspondence and stability conditions for topological zero-energy modes", Ann. Phys. **458**, 169457 (2023).
7. A. Alase, O. Doty, and D. L. Feder, "Matrix permanent and determinant from a spin system", Phys. Rev. A **108**, 012207 (2023).
8. A. Alase, S. Karuvade and C. M. Scandolo, "Reply to the Comment on 'The operational foundations of PT-symmetric and quasi-Hermitian quantum theory' ", J. Phys. A: Math. Theor. **56**, 208001 (2023).
9. S. Sarkar, C. Mukhopadhyay, A. Alase and A. Bayat, "Free-fermionic topological quantum sensors", Phys. Rev. Lett. **129**, 090503 (2022).
10. A. Alase, R. Nerem, M. Bagherimehrab, P. Høyer and B. C. Sanders, "Tight bound for estimating expectation values from a system of linear equations", Phys. Rev. Research **4**, 023237 (2022).
11. A. Alase, S. Karuvade and C. M. Scandolo, "The operational foundations of PT-symmetric and quasi-Hermitian quantum theory", J. Phys. A: Math. Theor. **55**, 244003 (2022).
12. A. Alase and D. L. Feder, "Generating and detecting topological phases with higher Chern number", Phys. Rev. A **103**, 053305 (2021).
13. S. Karuvade, A. Alase and B. C. Sanders, "Observing a changing Hilbert space inner product", Phys. Rev. Research **4**, 013016 (2022).
14. Q.-R. Xu, V. P. Flynn, A. Alase, E. Cobanera, L. Viola and G. Ortiz, "Squaring the fermion: The threefold way and the fate of zero modes", Phys. Rev. B **102**, 125127 (2020). Selected as **Editor's suggestion**.
15. E. Cobanera, A. Alase, G. Ortiz, and L. Viola, "Generalization of Bloch's theorem for arbitrary boundary conditions: Interfaces and topological surface band structure", Phys. Rev. B **98**, 245423 (2018) .
16. A. Alase, E. Cobanera, G. Ortiz, and L. Viola, "Generalization of Bloch's theorem for arbitrary boundary conditions: Theory", Phys. Rev. B. **96**, 195133 (2017). Selected as **Editor's suggestion**. Featured as a **Synopsis** in *Physics*.
17. E. Cobanera, A. Alase, G. Ortiz, and L. Viola, "Exact solution of corner-modified banded block-Toeplitz eigensystems", J. Phys. A: Math. Theor. **50**, 195204 (2017). **Highlights collection**.
18. A. Alase, E. Cobanera, G. Ortiz, and L. Viola, "Exact solution of quadratic fermionic Hamiltonians for arbitrary boundary conditions", Phys. Rev. Lett. **117**, 076804 (2016).

Conferences

Conference organization

- Member of the **program and organizing committee** for the **Coogee Workshop on quantum information theory** held in Sydney in April 2024.
- **Chair** for a virtual session on unconventional superconductivity at the **APS March Meeting 2024** held in March 2024.
- **Chair** for a session in the **Topological Order on the Pacific Ocean 2023 workshop** held in Sydney in November 2023.
- Member of the **Local Organizing Committee for the Sixth International Conference on Quantum Error Correction (QEC23)** held in Sydney in Oct-Nov 2023.

Conference talks

- "Wiener-Hopf factorization approach to bulk-boundary correspondence", Australian Institute of Physics (AIP) Congress, Australia (November 2024).
- (Virtual) "Wiener–Hopf factorization approach to a bulk-boundary correspondence and stability conditions for topological zero-energy modes", American Physical Society March Meeting, USA (March 2024).
- **Invited talk** "Tackling quasiparticle poisoning in Majorana qubits via quasiparticle detection", ANZCOP-AIP Summer Meeting, Australia (2023).
- "Tunable fermionic quantum error correction", American Physical Society March meeting, USA (March 2023).
- (Virtual) "Active correction of fermionic parity-preserving errors in an individual Majorana qubit", American Physical Society March Meeting, USA (March 2022).
- (Virtual) "Generating and detecting topological phases with higher Chern number", 52nd Annual Meeting of the APS Division of Atomic, Molecular and Optical Physics, USA (June 2021).
- (Virtual) "Generating and detecting topological phases with higher Chern number", American Physical Society March Meeting, USA (March 2021).
- (Virtual) "Observing a changing Hilbert space inner product", Quantum Frontiers in Technology and Applications, India (December 2020).
- (Virtual) "Detection of topological order in ultracold atoms", Quantum 2020, USA (October 2020).
- "Uncovering Majorana modes through a boundary matrix approach", American Physical Society March Meeting, USA (March 2016).

Poster presentations

- "Quantum signal processing without angle finding", EQUS workshop, Australia (December 2024).
- "Quantum signal processing without angle finding", Quantum techniques in machine learning (QTML), Australia (October 2024).
- "Converting errors into erasures for Majorana qubits", EQUS workshop, Australia (November 2023).
- "Converting errors into erasures for Majorana qubits", 6th International Conference on Quantum Error Correction, Australia (October 2023).
- "Generating and detecting topological phases with higher Chern number", Quantum Australia (February 2023).
- "Generating and detecting topological phases with higher Chern number", EQUS workshop, Australia (December 2022).
- "Characterizing and engineering Majorana excitations via generalized Bloch theorem", Gordon Godfrey Workshop, University of New South Wales, Australia (November 2022).

- (Virtual) "Lower Bound and Optimal Quantum Algorithm for Expectation Values from a System of Linear Equations", 16th Conference on the Theory of Quantum Computation, Communication and Cryptography (TQC) 2021, Latvia (July 2021).
- (Virtual) "Conditions for Efficient Quantum Computation of Expectation Values from a System of Linear Equations", Conference on Quantum Information Processing (QIP) 2021, Germany (February 2021).
- (Virtual) "Conditions for Efficient Quantum Computation of Expectation Values from a System of Linear Equations", Quantum Days, Canada (January 2021)
- (Virtual) "PT-symmetric model for quantum computation", 16th Conference on the Theory of Quantum Computation, Communication and Cryptography (TQC), Latvia (June 2020).
- "A model for quasi-Hermitian quantum computing", poster presentation in Quantum Alberta Workshop, Canada (July 2019).
- "Investigation of topological edge states using generalized Bloch theorem", poster presentation in Gordon Research Conference on correlated electron systems, USA (June 2018).
- "Characterizing and engineering Majorana excitations via generalized Bloch theorem", poster presentation in the conference", Majorana states in condensed matter: Towards topological quantum computation", Spain (May 2017).
- "Generalized entanglement as a unifying framework for fermionic entanglement", APS Fall meeting, New England section, USA (November 2015).

Colloquia and Seminars

Colloquia

- "Topological systems for quantum technologies", Concordia University, Canada (2024).
- Fault-tolerant quantum computation using Majorana-based qubits, University of New South Wales, Sydney (February 2023).
- (Joint colloquium, virtual) "Observing a changing Hilbert space inner product", Indian Institute of Technology Madras, India (January 2022).
- (Virtual) "Bulk-boundary correspondence in topological phases of matter", University of Calgary, Canada (April 2021).
- (Joint colloquium, virtual) "PT Symmetry as a time-dependent inner product on Hilbert space", Centre for Quantum Technologies, Singapore (August 2020).

Seminars

- "Quantum signal processing without angle finding", Macquarie University, Australia (February 2025).
- "Topological systems for quantum technologies", presented during August-September 2024 at several research institutes in India including Indian Institute for Science, Education and Research Pune (IISER Pune), Tata Institute for fundamental research (TIFR), Indian Institute of Technology Bombay (IITB), Indian Institute of Technology Madras (IITM), Institute formathematical sciences (IMSc), and International center for theoretical science (ICTS).
- "Majorana-based fault-tolerant quantum computation", EQUS seminar, The University of Queensland, Australia (March 2024).
- "Exponential suppression of Pauli errors in Majorana qubits via quasiparticle detection", The University of Melbourne, Australia (September 2023).
- (Virtual) "Operational foundations of PT-symmetric quantum theory", The Institute of Mathematical Sciences, India (August 2022).
- (Virtual) "Operational foundations of PT-symmetric quantum theory", The University of York, UK (May 2022).
- (Virtual) "Matrix factorization approach to bulk-boundary correspondence and stability of zero modes", Dartmouth College, USA (May 2021).

- (Virtual) "Optimal quantum algorithm for expectation values from a system of linear equations" Los Alamos National Laboratory, USA (April 2021).
- "Investigation of topological edge states using Generalized Bloch theorem", University of Alberta, Edmonton, Canada (December 2019).
- "Investigation of topological edge states using Generalized Bloch theorem", University of Calgary, Canada (September 2018).
- "Investigation of topological edge states using Generalized Bloch theorem", University of Sherbrooke, Canada (May 2018).
- "Investigation of topological edge states using Generalized Bloch theorem", University of Massachusetts Boston, USA (April 2018).
- "Investigation of topological edge states using Generalized Bloch theorem", Dartmouth College, USA (March 2018).

Research internships and undergraduate research projects

08/2012 - 05/2013	**Remodeling Grover's algorithm using generalized search operator** Supervisor: Prof. Avatar Tulsi Indian Institute of Technology, Bombay.
05/2012 - 07/2012	**Implementing controlled gates on NMR qubits using geometric phase** Supervisor: Prof. David G. Cory Institute for Quantum Computing, Waterloo, Canada.
05/2011 - 06/2011, 12/2011	**Classical capacity of a qubit channel under thermal bath** Supervisor: Prof. Sibasish Ghosh The Institute of Mathematical Sciences, India.

Supervision and teaching

Supervision

- Supervisor of one PhD student (Ulrich Chiapi-Ngamako) and one Masters student (Asaad Hanna) at Concordia University.
- Primary supervisor for two honours students (Judd Katz and Rhys MacKintosh) at the University of Sydney. Both students received Sydney Quantum Academy honours scholarship. Rhys MacKintosh received the University medal.
- Secondary supervisor for one PhD student (Xanda Kolesnikow) at the University of Sydney.
- Primary supervisor for three undergraduate students (Luke Murray, Raymond Trinh and Akito Koike) and joint supervisor for two undergraduate students (Angel Poi and Owen Marschner) for Special Studies Project at the University of Sydney.
- Mentor for one PhD student (Marcus Goffage) at the University of New South Wales.
- Mentor for one Masters student (Riley Nerem) at the University of Calgary, who is now pursuing PhD at the University of California, San Diego.

Teaching

- **Course instructor:** Electricity and magnetism for engineering students (University of Calgary, Winter 2022).
- **Guest lecturer:** Relativistic quantum mechanics (3 lectures), Introduction to quantum computation (1 lecture), Microscopic theory of solids (1 lecture), Quantum information science (1 lecture), Introduction to condensed matter physics (3 lectures)
- **Teaching assistant:** Classical mechanics, Intermediate quantum mechanics, Advanced statistical mechanics, Microscopic theory of solids, Quantum information science, Introduction to condensed matter physics (2 terms), Introduction to quantum computation (2 terms)
- **Lab instructor and grader:** Introductory physics I, Introductory Physics II

Professional societies and service

- Organizer and moderator for EQUS panel on "Inclusive practices in research and teaching" (2024).
- Panelist for Sydney Quantum Academy event on "Life as a postdoc" (2024).
- External assessor on the **selection committee for the Sydney Quantum Academy PhD scholarships** round 9 (2023).
- Member of the **EQUS Mentoring and Career Development Committee** (March 2023 - present).
- President (2021-22) and Vice-President Internal (2020-21) of the **Postdoctoral Fellows Association of the University of Calgary (PDAC)**, which is the postdoc union at the University of Calgary.
- Appointed member of the **General Faculties Council (2020-21)** at the University of Calgary.
- Member of the **Postdoctoral Representatives Committee (2020-21)** at the University of Calgary
- Member of the **Joint Committee** between the board of governors of the University of Calgary and the Postdoctoral Fellows Association of the University of Calgary.
- Reviewer since September 2017 for **Mathematical Reviews** published by American Mathematical Society.
- Member of the **American Physical Society**.
- Organizer of the **Quantum computing journal club** at the University of Calgary.
- Organizer of the **Condensed matter journal club** at Dartmouth College.

Outreach

- Organizer of science day demonstrations at Dartmouth college (Feb 2015, Feb 2016).
- Organizer of science day demonstrations at IIT Bombay (Feb 2010).

Computer skills

Qiskit, Quil, Python, Matlab, Mathematica and C++

Languages

English (fluent), Hindi (fluent), Marathi (fluent)