AMARNATH CHAKRABORTY

Ph.D. Physics · University of Missouri–Columbia

GitHub | LinkedIn | Google Scholar | Website

amarnathchakraborty95@gmail.com | achakraborty@mail.missouri.edu

Bio

My work was driven by a simple frustration: the quantum materials problems I find most compelling—how electrons conspire to produce superconductivity, topological order, or Mott insulating behavior in real systems—are precisely the ones that exhaust every classical computational tool before the physics becomes clear. That frustration is what pulled me toward quantum computing, not as a field in itself, but towards the one credible path where classical and quantum methods in a hybrid environment can simulate the systems I actually care about. Along the way I have built algorithms, broken them on real hardware, and learned to think about noise, circuit depth, and compilation overhead as physical constraints rather than engineering nuisances—and somewhere in that process, quantum algorithms stopped being just a tool and became a research direction I want to pursue in their own right. My quantum internship with IBM and my current work at Chinar Quantum AI have been where that shift became concrete: Hamiltonian simulation, quantum-enhanced sampling, and early fault-tolerant frameworks are no longer things I read about—they are problems I am actively building toward. My four peer-reviewed publications keep me anchored in rigorous materials theory; everything since has been about learning to ask quantum algorithmic questions with the same depth.

Education

Ph.D. in Physics *2019–2025*
Supervisors: Prof. Giovanni Vignale & Dr. Guang Bian
University of Missouri–Columbia
Coursework: Quantum Mechanics 1 & 2, Solid-State Physics, Quantum Computation (IBM-QIC).

M.S. in Physics *2016–2018*
University of Hyderabad
Coursework: Advanced Condensed Matter Physics, Mathematical Phsyics I & II, Numerical Methods.

Professional Highlights

- Four peer-reviewed publications (*Phys. Rev. B* ×3, *Nat. Commun.*); five conference presentations including APS March Meeting (2021–2025) and IBM Quantum Developer Conference 2025.
- Demonstrated SKQD outperforms VQE in accuracy and runtime on 20-qubit Fermi–Hubbard instances on IBM hardware; reduced two-qubit gate count by ∼25% via approximate quantum compilation (AQC); applied ZNE with global and local gate folding calibrated from device data.
- Currently prototyping QMCMC (spectral-gap amplification, sinc^2-bandpass oracle, twirling) and QRC pipelines for optimisation and temporal learning at Chinar Quantum AI.
- Qiskit Advocate; Quantum Excellence badge (Advanced, QGSS 2025); maintained Python/Julia tight-binding libraries with Git/CI for cross-group reuse.

Technical Skills

Programming & Software	Python, Julia, Fortran, MATLAB; Qiskit, PennyLane	**Quantum Algorithms**	VQE, HI VQE, SKQD, Trotterization, ZNE, AQC, QMCMC, QRC, Gate Twirling; learning QSVT, LCU
HPC & Dev Tools	HPhi (exact diagonalization), MPI/OpenMP, Git, CI pipelines	**Materials Modeling**	Tight-binding, Kubo formalism, DFT (VASP), Green's function methods
Mathematical Methods	Linear algebra, spectral methods, perturbation theory	**Conceptual Areas**	Early fault-tolerant algorithms, topological phases, correlated electrons

Research Interests

- Near-term and early-FT Hamiltonian simulation: QFD/SKQD methods and extension toward QSVT/LCU-based approaches as hardware matures.
- Quantum-enhanced MCMC for combinatorial optimization, and twirling protocols for near-term hardware compatibility.
- Quantum reservoir computing as a hardware-efficient paradigm for temporal learning and dynamical system emulation.
- Strongly correlated lattice models (Hubbard, frustrated magnets, moiré flat bands) as classically hard, physically motivated benchmarks for quantum simulation algorithms.

Research Experience

Quantum Research Intern, Chinar Quantum AI — *2025–Present*

- **QMCMC for Optimization:** Implementing quantum-walk-based sampling protocols that converge faster than classical MCMC via spectral-gap amplification, with twirling to make the channel hardware-compatible. Benchmarking against simulated annealing and QAOA.
- **Quantum Reservoir Computing:** Using Trotterized Hamiltonian evolution as the fixed reservoir layer—the same many-body dynamics that simulate correlated physics serve as a classically hard feature map, with only a classical readout trained for time-series prediction and dynamical system emulation.

Doctoral Research, University of Missouri–Columbia — *2019–2025*

- **Ph.D. Research in 2D Quantum Materials (2019–25):** Investigated how symmetry, topology, and external fields collectively control the electronic and optical behaviour of two-dimensional materials—from symmetry-protected Dirac and Weyl fermions in nonsymmorphic semimetals and Bismuthene, to field-driven metal-insulator transitions in bilayer graphene, to the exotic flat-band and geometric phases that emerge in twisted bilayer graphene. The broader goal across all of this was understanding which features of these systems are robust, which are tuneable, and which make them candidates for next-generation quantum devices.
- **Hamiltonian Simulation, IBM × Mizzou QIC (2025):** Implemented 20-qubit Fermi–Hubbard simulation on IBM heavy-hex hardware. SKQD converged faster with no barren-plateau issues vs. VQE; approximate Trotter compilation cut two-qubit gates by $\sim$25%; ZNE improved energy and correlator fidelity. Mentor: Dr. Pontus Laurell.

Key Publications

PRB 2025 Insulator-Metal Transition & Magnetic Crossover in Bilayer Graphene. *Phys. Rev. B* 111, 125130

Nat Commun 2024 Observation of 2D Weyl Fermions in Bismuthene. *Nat. Commun.* 15, 6001

PRB 2023 Giant Faraday Rotation in Nonsymmorphic Dirac Semimetals. *Phys. Rev. B* 107, 245120

PRB 2021 Photon Absorption in 2D Nonsymmorphic Dirac Semimetals. *Phys. Rev. B* 105, 085101

Master's Research, University of Hyderabad — *2016–2018*

Calculated polaron self-energies and decoherence factors in polar quantum dots via LLP Holstein methods—relevant to solid-state qubit noise characterization.
Supervisor: Prof. Ashok Chatterjee

Research Projects & Academic Engagements

- **Qiskit Global Summer School**, IBM Q (2025) — quantum compilation, error mitigation, VQE; Quantum Excellence badge (Advanced).
- **Quantum Simulation Summer School**, UMD/NSF RQS (2025) — near-term simulation, resource estimation, early fault-tolerant algorithm design.
- **Visiting Research Scholar**, I-FIM, NUS (2024) — orbital susceptibility and metal–insulator transitions in bilayer graphene under crossed fields.
- **Project Assistant**, JNCASR (2019), Supervisor: Prof. N. S. Vidhyadhiraja — TMDCA and Lanczos (HPhi) for phase diagrams of disordered Hubbard models.
- **Summer Intern**, IIT Kharagpur (2017), Supervisor: Prof. S. S. Mandal — Weyl Hamiltonian via Boltzmann transport; conductivity anomaly analysis.

Conferences

- **IBM Quantum Developer Conference 2025** — *SKQD Approach for the Fermi–Hubbard Model to Investigate High-T_c Superconductivity.*
- **EP2DS-26 / MSS-22**, 2025 — *Trigonal Warping-Enabled Low-Field Insulator-Metal Transition in Bilayer Graphene.*
- **APS March Meeting** 2021–2025 — presentations on nonsymmorphic Dirac semimetals (2021, 2022–23) and bilayer graphene (2025).
- **ICTS Summer School on Entropy, Information, and Order in Soft Matter**, 2018.
- **National Science Conference on Condensed Matter Physics**, University of Hyderabad, 2017.

Fellowships and Awards

- **Qiskit Advocate** — accepted for contributions to quantum simulation; Quantum Excellence badge (Advanced), QGSS 2025.
- **Physics Leaders Award** — outstanding research presentation, Graduate Studies category, University of Missouri.
- **INSPIRE Scholarship** (2013–2018) — DST, Government of India; awarded for academic excellence in pure science.
- **NET-JRF** (2018) — National Eligibility Test for Junior Research Fellowship, All India Rank 145.
- Top 1% nationwide in the National Graduate Physics Examination (India).

Outreach and Interests

- Teaching quantum computing (Qiskit, Hamiltonian simulation, topological qubit design) to physics students at UMC (2025). And training new recruits at CQAI on Quantum Hamiltonian Simulations.
- Built a Python library for Berry curvature simulation in TBG under magnetic fields (GitHub: TBG-Bands & Response).
- Active reader of quantum algorithms literature: Preskill's notes, Nielsen & Chuang, Lin & Tong (QSVT).