Xuchen Cao

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Education

University of Illinois Urbana Champaign *Sep 2019–May 2026*

Ph.D. in Physics (Advisor: Thomas Faulkner) *Degree Expected May 2026*

M.S. in Physics *May 2021*

University of Science and Technology of China *Sep 2015–Jun 2019*

B.S. in Physics *Jun 2019*

Research Experience

Chaos for Random Modular Hamiltonians *Mar 2023–Sep 2023*

- Calculated spectral form factors of random modular Hamiltonians obtained from partial traces of random pure states with replica trick, and related them to objects in combinatorial mathematics known as non-crossing annular permutations
- Analytical expression for the ramp obtained in agreement with numerical results

One Sided Blackholes in DSSYK Model *Mar 2024–Oct 2025*

- Constructed one-sided blackholes with end-of-the-world branes in the double scaled SYK (DSSYK) model
- Identified the bulk Hilbert space and the algebra of boundary observables
- Proved the impossibility of full bulk reconstruction in this case, identified the boundary algebra as a type II_1 von Neumann factor
- Proposed a new strategy to diagonalize DSSYK Hamiltonians in the presence of matter
- Discussed the semiclassical JT gravity limit of our construction
- Demonstrated the existence of a 'no man's island' in the semiclassical limit
- Identified the structure of divergence of trumpet amplitudes in the DSSYK model

Crossed Product and Python's Lunch *Dec 2024–Nov 2025*

- Defined the algebra of observables within the python's lunch region bounded by multiple extremal surfaces in long wormholes
- Implemented split property and crossed product construction for von Neumann algebras to obtain a type II_∞ algebra in python's lunch
- Calculated entropies for these algebras and showed that they agree with generalized entropies
- Discussed the application of operator-valued weights and their usage in defining algebras with desired properties

Haagerup Reduction in Quantum Field Theory *Aug 2025–Now*

- Constructing concrete examples of Haagerup reduction for type III_1 algebras in quantum field theory
- Comparing our construction to the algebra in de Sitter space
- Looking for further applications of the reduction method in physics

Topological Insulator with Rotation Symmetries *Sep 2021–Sep 2022*

- Studied topological field theories coupling lattice curvatures and electromagnetic fields in topological insulators with rotation symmetry
- Identified fractional charges and polarizations localized respectively on surface disclinations and bulk disclination lines
- Obtained numerical results in lattice models in agreement with analytical ones

Two-Body Currents and Magnetic Dipole Moments in Nuclei *Mar 2021–Nov 2023*

- Analyzed the contribution of two-body currents from chiral effective theories to the magnetic dipole moments of heavy nuclei
- Incorporated this contribution in the valence-space in-medium similarity renormalization group (VS-IMSRG) method
- Improved the agreement of numerical results with experimental data

Publications

Xuchen Cao, Thomas Faulkner, Zhencheng Wang. "Gravitational Algebras with Two Areas" *arXiv:2512.04435* [hep-th] https://arxiv.org/abs/2512.04435 *2025*

Xuchen Cao, Ping Gao. "Single-Sided Black Hole in Double-Scaled SYK Model and No Man's Island." *arXiv:2511.01978* [hep-th] https://arxiv.org/abs/2511.01978 *2025*

Xuchen Cao, Thomas Faulkner. "Ramp from Replica Trick." *JHEP* **01** (2025) 104, https://doi.org/10.1007/JHEP01(2025)104. *2024*

T. Miyagi, **X. Cao**, R. Seutin, S. Bacca, R.F. Garcia Ruiz, K. Hebeler, J.D. Holt, A. Schwenk. "Impact of Two-Body Currents on Magnetic Dipole Moments of Nuclei." *Physical Review Letters* **132** (2024) 23, 232503, https://doi.org/10.1103/PhysRevLett.132.232503. *2023*

Julian May-Mann, Mark R. Hirsbrunner, **Xuchen Cao**, Taylor L. Hughes. "Topological field theories of three-dimensional rotation symmetric insulators: Coupling curvature and electromagnetism." *Phys. Rev. B* **107** (2023) 205149, https://doi.org/10.1103/PhysRevB.107.205149. *2022*

Other Skills

Programming Languages: Python, Mathematica
Languages Spoken: Chinese (native), English (fluent), Japanese (daily conservation and reading)