

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

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- 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](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 conversation and reading)