Shawn Xingshan Cui

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Employment/Education

Associate Professor	**Department of Mathematics, Purdue University**
	Department of Physics and Astronomy, Purdue University
	2023 – current
Assistant Professor	**Department of Mathematics, Purdue University**
	Department of Physics and Astronomy, Purdue University
	2019 – 2023
Assistant Professor	**Department of Mathematics, Virginia Tech**
	2018 – 2019
Postdoctoral Fellow	**Stanford University**
Supervisor: Patrick Hayden	*2016 – 2018*
Research Intern	**Microsoft Quantum Research – QuArC**
Supervisor: Alex Bocharov	*2015.6 – 2015.9*
Ph.D. in Mathematics	**University of California Santa Barbara**
Supervisor: Zhenghan Wang	*2011–2016*
Thesis: Higher Categories and Topological Quantum Field Theories	
Master Program	**Sun Yat-Sen University**
	2010–2011
B.Sc. in Mathematics	**Sun Yat-Sen University**
	2007–2010

Research Interests

topological quantum field theory, higher category theory, low dimensional topology, Hopf algebras, quantum invariants, topological quantum computation, quantum information.

Awards/Grants

o 2023, Seed of Success Acorn Award.

o 2023-2026, PI, "*Non-semisimple quantum invariants of three and four manifolds*". NSF DMS-2304990.

o 2023-2024, Co-PI, "*Exploiting Topological Phases of Matter*". College of Science Quantum Seed Grant, Purdue University.

o 2023, Co-PI, Conference on "*Topological Quantum Computing*". NSF DMS-2327208.

o 2023-2028, Co-PI, Center for Quantum Technologies, NSF IUCRC.

o 2020-2024, PI, "*Topological quantum computing beyond anyons*". NSF CCF-2006667.

o 2020-2025, Co-PI, DOE Quantum Science Center led by Oak Ridge National Laboratory.

○ 2020-2025, Co-PI, "*Toward Mathematical Intelligence and Certifiable Automated Reasoning: Theoretical Understanding and Experimental Realization*". ARO Multidisciplinary University Research Initiative grant.

○ 2019-2020, Purdue Research Foundation International Travel Grant (unused due to Covid-19).

○ 2015-2016, Graduate Division Dissertation Fellowship, UC Santa Barbara.

○ 2011-2012, Department of Mathematics Raymond L. Wilder Award, UC Santa Barbara.

○ 2011-2013, Microsoft Graduate Fellowship, UC Santa Barbara.

Publications/Preprints (reverse chronological order)

[31]   B. Yan, P. Chen, and S. X. Cui. "Generalized Kitaev spin liquid model and emergent twist defect". Annals of Physics (2024), p. 169682.

[30]   P. Chen, B. Yan, and S. X. Cui. "Quantum circuits for toric code and X-cube fracton model". Quantum 8 (Mar. 2024), p. 1276. DOI: 10.22331/q-2024-03-13-1276.

[29]   S. X. Cui, C. Galindo, and D. Romero. "Abelian Group Quantum Error Correction in Kitaev's Model" (2024). arXiv: 2404.08552.

[28]   A. L. Kaufmann and S. X. Cui. "Universal topological quantum computing via double-braiding in SU (2) Witten-Chern-Simons theory" (2023). arXiv: 2312.16747.

[27]   J. Chaidez, J. Cotler, and S. X. Cui. "Combed Trisection Diagrams and Non-Semisimple 4-Manifold Invariants" (2023). arXiv: 2309.08461.

[26]   J. Chaidez, J. Cotler, and S. X. Cui. "4-Manifold invariants from Hopf algebras". Algebraic & Geometric Topology 22.8 (2023), pp. 3747–3807.

[25]   M. Ilyas, S. Cui, and M. Perkowski. "Ternary Logic Design in Topological Quantum Computing". Journal of Physics A: Mathematical and Theoretical 55.30 (2022), p. 305302.

[24]   C. Griffin and S. X. Cui. "Constructing approximately diagonal quantum gates". International Journal of Quantum Information (2022), p. 2250025.

[23]   S. X. Cui, P. Gustafson, Y. Qiu, and Q. Zhang. "From Torus Bundles to Particle-Hole Equivariantization". Letters in Mathematical Physics 112.15 (2022).

[22]   B. Yan, P. Chen, and S. X. Cui. "Ribbon operators in the generalized Kitaev quantum double model based on Hopf algebras". Journal of Physics A: Mathematical and Theoretical 55.18 (2022), p. 185201.

[21]   S. X. Cui, Y. Qiu, and Z. Wang. "From three dimensional manifolds to modular tensor categories". Communications in Mathematical Physics (2022), pp. 1–45.

[20]   R. Selvarajan, V. Dixit, X. Cui, T. S. Humble, and S. Kais. "Prime factorization using quantum variational imaginary time evolution". Scientific reports 11.1 (2021), pp. 1–8.

[19]   S. X. Cui, D. Ding, X. Han, G. Penington, D. Ranard, B. C. Rayhaun, and Z. Shangnan. "Kitaev's quantum double model as an error correcting code". Quantum 4 (2020), p. 331.

[18]   S. X. Cui, K. T. Tian, J. F. Vasquez, Z. Wang, and H. M. Wong. "The search for leakage-free entangling Fibonacci braiding gates". Journal of Physics A: Mathematical and Theoretical 52.45 (2019), p. 455301.

[17]   S. X. Cui, M. S. Zini, and Z. Wang. "On generalized symmetries and structure of modular categories". Science China Mathematics 62.3 (2019), pp. 417–446.

[16] S. X. Cui, P. Hayden, T. He, M. Headrick, B. Stoica, and M. Walter. "Bit threads and holographic monogamy". Communications in Mathematical Physics (2019), pp. 1–40.

[15] L. Chang and S. X. Cui. "On two invariants of three manifolds from Hopf algebras". Advances in Mathematics 351 (2019), pp. 621–652.

[14] S. X. Cui. "Four dimensional topological quantum field theories from G-crossed braided categories". Quantum Topology 10.4 (2019), pp. 593–676.

[13] S. X. Cui and Z. Wang. "State sum invariants of three manifolds from spherical multi-fusion categories". Journal of Knot Theory and Its Ramifications 26.14 (2017), p. 1750104.

[12] S. X. Cui, D. Gottesman, and A. Krishna. "Diagonal gates in the Clifford hierarchy". Physical Review A 95.1 (2017), p. 012329.

[11] S. X. Cui, Z. Ji, N. Yu, and B. Zeng. "Quantum capacities for entanglement networks". IEEE ISIT. 2016, pp. 1685–1689.

[10] A. Bocharov, S. X. Cui, M. Roetteler, and K. M. Svore. "Improved quantum ternary arithmetic". Quantum Information & Computation 16.9-10 (2016), pp. 862–884.

[9] S. X. Cui, C. Galindo, J. Y. Plavnik, and Z. Wang. "On gauging symmetry of modular categories". Communications in Mathematical Physics 348.3 (2016), pp. 1043–1064.

[8] S. X. Cui, M. H. Freedman, O. Sattath, R. Stong, and G. Minton. "Quantum max-flow/min-cut". Journal of Mathematical Physics 57.6 (2016), p. 062206.

[7] A. Bocharov, S. X. Cui, V. Kliuchnikov, and Z. Wang. "Efficient topological compilation for a weakly integral anyonic model". Physical Review A 93.1 (2016), p. 012313.

[6] S. X. Cui, M. H. Freedman, and Z. Wang. "Complexity classes as mathematical axioms II". Quantum Topology 7.1 (2016), pp. 185–201.

[5] S. X. Cui, N. Yu, and B. Zeng. "Generalized graph states based on Hadamard matrices". Journal of Mathematical Physics 56.7 (2015), p. 072201.

[4] L. Chang, M. Cheng, S. X. Cui, Y. Hu, W. Jin, R. Movassagh, P. Naaijkens, Z. Wang, and A. Young. "On enriching the Levin–Wen model with symmetry". Journal of Physics A: Mathematical and Theoretical 48.12 (2015), 12FT01.

[3] S. X. Cui and Z. Wang. "Framed cord algebra invariant of knots in $S^1 \times S^2$". Journal of Knot Theory and Its Ramifications 24.14 (2015), p. 1550067.

[2] S. X. Cui and Z. Wang. "Universal quantum computation with metaplectic anyons". Journal of Mathematical Physics 56.3 (2015), p. 032202.

[1] S. X. Cui, S.-M. Hong, and Z. Wang. "Universal quantum computation with weakly integral anyons". Quantum Information Processing 14.8 (2015), pp. 2687–2727.

Public Patents

○ Efficient Topological Compilation for Metaplectic Anyon Model,

Alex Bocharov, Xingshan Cui, Vadym Kliuchnikov, and Zhenghan Wang. US Patent NO. 11004008, May 11, 2021.

○ Method and System for Efficient Quantum Ternary Arithmetic,

Alex Bocharov, Xingshan Cui, Martin Roetteler, and Krysta Svore. US Patent NO. 10726350, July 28, 2020.

Selected Talks by Year

- 2024,

  Quantum Topology, Quantum Information, and Connections to Mathematical Physics, Texas A&M University, TX, May.

  Quantum Symmetries Conferences in the U.S. Midwest (QuaSy-Con II), University of Notre Dame, IN, May.

  Skew Braces, Braids and the Yang-Baxter Equation, Banff International Research Station, Alberta (Canada), May.

- 2023,

  Lectures on topological quantum computing, Undergraduate Faculty Program, PCMI, Park City, Utah, July.

  Physics Colloquium, Indiana University–Purdue University Indianapolis (IUPUI), February.

- 2022,

  Quantum Information Seminar, Yanqi Lake Beijing Institute of Mathematical Sciences and Applications, Dec.

  New Frontiers: Interactions between Quantum Physics and Mathematics, Harvard University, MA, June.

  Quantum Topology and Geometry conference in honor of Vladimir Turaev, Institut Henri Poincaré, Paris, June.

  Lectures on topological quantum computing, Institut Montpelliérain Alexander Grothendieck, Montpellier, June.

  General-Purpose Quantum Computing and Information Theory, Institute of Theoretical Physics, CAS, June.

  University Quantum Symmetries Lectures (UQSL), online, April.

- 2021,

  Yau Mathematical Sciences Center, Tsinghua University, Beijing China, October

  Topology seminar, Peking University, Beijing China, September

  SIAM Conference on Applied Algebraic Geometry, Session on Quantum symmetries, Texas A&M, August

  Quantum Spin Simulations Meet, DOE Quantum Science Center at Oak Ridge National Laboratory, May

  Fusion Friday seminar, American Inst. of Mathematics (AIM), April

  Geometry, Topology and Categorification Seminar, University of Southern California, April

  FRG seminar, jointly by UCSB, MIT, Texas A&M, and LSU, January

  Joint Mathematics Meetings, Special Session on Hopf Algebras and Tensor Categories, January

- 2020,

  Mathematical Picture Language Seminar, Harvard, MA, June

  Workshop on Tensor categories and topological quantum field theories, MSRI Berkeley, CA, March

  Purdue-IU Mini-Symposium, Indiana University, IN, March.

  Quantum topology seminar, UC Santa Barbara, CA, February.

- 2019,

  Conference on Topological Quantum Computing, Pengcheng Lab & SUSTech, Shenzhen, China, December.

  Workshop QLA meets QIT, Purdue University, IN, November.

  High energy physics seminar, Purdue University, IN, November.

  PQSEI seminar, Purdue University, IN, October.

  In and around Topological Physics, BICMR, Beijing, China, July.

  Summer research program on quantum symmetries, Ohio State University, OH, June

  10th Anniversary of the Enhanced Program for Graduate Study, BICMR, Peking University, China, May.

  Mathematical picture language seminar, Harvard, MA, April.

  Condensed matter seminar, Virginia Tech, VA, March.

  Quantum computation seminar, Texas A&M University, TX, March.

  Geometry seminar, University of Virginia, VA, March.

  Quantum algebra/topology seminar, UC Santa Barbara, CA, March.

  Mathematics Colloquium, Purdue University, IN, February.

  Higher Category Approach to Quantum Information Processing Systems, Beltsville, MD, February.

  Physics Colloquium, Purdue University, IN, January.

  Computer Science seminar, Sun Yat-Sen University, China, January.

  SIQSE seminar, Southern University of Science and Technology, China, January.

- 2018,

  Quantum Computation and Information Workshop, Texas A&M University, TX, September.

  AMS Sectional Meeting on Advances in Operator Algebras, Vanderbilt University, TN, April.

  AMS Sectional Meeting on Quantum Symmetries, Ohio State University, OH, March.

  IfQ Group Meeting, SITP, Stanford University, CA, March.

  Quantum topology seminar, University of Illinois at Chicago, IL, January.

  Colloquium, Louisiana State University, LA, January.

  Colloquium, Texas A&M University, TX, January.

  Colloquium, Virginia Tech, VA, January.

  JMM Session on Mathematics of Quantum Computing and Topological Phases, San Diego, CA, January.

- 2017,

  Algebra and Combinatorics Seminar, Texas A&M University, TX, November.

  Applied math seminar, Stanford University, CA, October.

  QMAP seminar, UC Davis, CA, September.

  Mathematics of Quantum Phases Session at Mathematical Congress of the Americas, Montreal, Canada, July.

- 2016,

  AMS Sectional Meeting on Topological Phases of Matter, Brunswick, ME, September.

  16th Asian Quantum Information Science Conference, Academia Sinica, Taiwan, September

  Modular Categories–Their Representations, Classification, and Applications, Oaxaca, Mexico, August.

  2016 SIAM Annual Meeting, Boston, MA, July.

  Department of Mathematics, Tsinghua University, China, July.

  Quantum Information and Operator Algebras Mini Workshop, Beijing, China, July.

- 2015,
  Perimeter Institute for Theoretical Physics, Waterloo, ON, Canada, December.
  Joint Center for Quantum Information and Computer Science, University of Maryland, College Park, December.
  Quantum Architectures and Computation Group, Microsoft Research, Redmond, WA, December.
  Workshop on Quantum Marginals and Numerical Ranges, University of Guelph, Canada, August.
  Quantum Information and Fusion Categories in AMS Joint Mathematics Meetings, San Antonio, TX, January.
  Knot Theory and Its Applications to Physics and Quantum Computing, University of Texas at Dallas, January.
- 2013,
  Seminar on Low Dimensional Topology, Liaoning Normal University, China, July.

Mentoring

Mentor for
- Nicolas Bridges (graduate, 2023-)
- Diego Romero (graduate, Universidad de los Andes, co-advise w. César Galindo, 2021-)
- Qing Zhang (postdoc, 2020-2023). Next position: Postdoc at UC Santa Barbara
- Penghua Chen (graduate, 2020-)
- Bowen Yan (graduate, 2020-)
- Colton Griffin (undergraduate). Next position: graduate at University of Pennsylvania

Short-term mentor for
- Ashton Keith (graduate, 2024 Summer, reading course)
- Vieri Mattei (graduate, 2024 Spring & Summer, reading course)
- Gustavo Cruz (undergraduate, 2023 Fall, one-semester project)
- Xiaoyu Liu (undergraduate, 2023 Fall, one-semester project)
- Mohamad Mousa (graduate, 2023 Spring & Summer, reading course)
- Nicolas Bridges (graduate, 2023 Spring & Summer & Fall, reading course)
- Soham Ray(graduate, 2022 Spring & Summer & Fall, reading course)
- Yibo Zhong (graduate, 2022 Spring & Summer, reading course)
- Shaver Phagan (graduate, 2021 Spring, reading course)
- Penghua Chen (graduate, 2020 Spring, reading course)
- Muhammad Ilyas (graduate , Portland State University, 2020&2021)

Serving on Ph.D. advisory committee for
- Sheng Tan (Math, 2023)
- Guangjie Li (Physics, 2022-)
- Shuang Liang (Physics, 2022-)
- Chris Bairnsfather (Math, 2022-)
- Yang Mo (Math, 2021-)
- Shoy Ouseph (Physics, 2021-)
- Junxu Li (Physics, 2021- 2023)
- Aaron Bagheri (Math, UC Santa Barbara, 2021-2023)

Service

Conference (co-)organizers:
- Topological quantum computing, ICMS, Edinburgh, Scotland, Oct. 9-13, 2023
- Midwest Topology Seminar, Purdue University, April 29-30, 2023
- AMS sectional meeting at Purdue, March 26-27, 2022
- Topological quantum computing, Shenzhen China, Dec. 16-20, 2019

Referee for journals:
- Communications in Mathematical Physics
- Quantum Topology
- Journal of the London Mathematical Society
- Topology and its Applications
- Journal of Mathematical Physics
- Journal of Pure and Applied Algebra
- Proc. of the American Mathematical Society
- Contemporary Mathematics
- Letters in Mathematical Physics
- Journal of High Energy Physics
- Annals of Physics
- Quantum Information & Computation
- Quantum
- Quantum Information Processing
- IEEE Journal on Information Theory
- International Journal of Modern Physics B
- International Journal of Quantum Information
- European Physical Journal C

Referee for conferences:
- Theory of Quantum Computation, Communication, and Cryptography (TQC 2021, 2023)
- Annual ACM Symposium on Theory of Computing (STOC 2022)
- Annual Conference on Quantum Information Processing (QIP 2022, 2023, 2024)
- Computational Complexity Conference (CCC 2023)

Committee work:
- Serving on University Senate, '24-'27.
- Serving on the QIS search committee for College of Science, '23-'24.
- Serving on the Computer Committee in Department of Mathematics, '22-'23, '23-'24.

Outreach:
- Lecturer for the Undergraduate Faculty Program, IAS/Park City Mathematics Institute, 2023.
- Examiner of master thesis dissertation for Nicolás Escobar, Universidad de los Andes, 2018.

Teaching

Purdue University:
- Fall 2024: Multivariate Calculus (Math 261)
- Spring 2024: Algebraic Topology (Math 572, graduate)
- Fall 2023: Ordinary Differential Equations (Math 266, two sections)
- Spring 2023: Mathematical Methods Of Physics II (Phys 307)
- Fall 2022: Elementary Topology (Math 571, graduate), Quantum Invariants (Math 697, graduate)
- Spring 2022: Algebraic Topology (Math 572, graduate), Multivariate Calculus (Math 261)
- Spring 2021: Mathematical Methods Of Physics II (Phys 307)
- Spring 2020: Linear Algebra (Math 265, two sections)

Virginia Tech:
o Spring 2019: Introduction to Linear Algebra
o Fall 2018: Introduction to Linear Algebra

Stanford University:
o Spring 2018: Topological Quantum Computation (graduate topic)

UC Santa Barbara, teaching assistant:

o Fall 2012: Calculus with Applications II
o Spring 2013: Vector Calculus I
o Winter 2014: Differential Equations
o Fall 2014: Linear Algebra with Applications
o Fall 2015: Calculus with Applications I

o Winter 2013: Calculus for Social Sciences II
o Fall 2013: Calculus for Social Sciences II
o Spring 2014: Vector Calculus II
o Winter 2015: Differential Equations