

# Brandon T. Shapiro

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## Research Interests

Combinatorial approaches to topology, geometry,  $K$ -theory, higher categories, and applied category theory.

## Employment

- 2023–Present **Whyburn Research Associate and Lecturer**, *University of Virginia*, Charlottesville, VA.
- 2022–2023 **Research Associate**, *Topos Institute*, Berkeley, CA.
- 2015 **Formal Methods Intern**, *Draper Laboratories*, Cambridge, MA.

## Education

- 2022 **PhD in Mathematics**, *Cornell University*, Advisor: Inna Zakharevich.  
Thesis: Shape Independent Category Theory.
- 2019 **Master of Science in Computer Science**, *Cornell University*.
- 2017 **Bachelor of Arts with Highest Honors in Mathematics**, *Brandeis University*.
- 2017 **Bachelor of Science in Computer Science**, *Brandeis University*.
- 2017 **Bachelor of Arts in Physics**, *Brandeis University*.
- 2016 **Brandeis India Science Scholars Program**, *Indian Institute of Science*.

## Papers

- 2025 **Categorical Tiling Theory: Constructing Directed Planar Tilings via Edge Reversal**. *Preprint*. With Catherine DiLeo and Preston Sessoms. [[arXiv:2509.06363](https://arxiv.org/abs/2509.06363)]
- 2025 **Additivity and Fiber Sequences for Combinatorial K-Theory**. *Submitted for publication*. With Maru Sarazola. [[arXiv:2107.07701](https://arxiv.org/abs/2107.07701)]
- 2024 **A Combinatorial Construction of Homology via ACGW Categories**. *To appear in Contemporary Mathematics*. With Maru Sarazola and Inna Zakharevich. [[arXiv:2410.00276](https://arxiv.org/abs/2410.00276)]
- 2024 **All Concepts are  $\mathbb{C}at^\#$** . *Submitted for publication*. With Owen Lynch and David Spivak. [[arXiv:2305.02571](https://arxiv.org/abs/2305.02571)]
- 2024 **A Polynomial Construction of Nerves for Higher Categories**. *Submitted for publication*. With David Spivak. [[arXiv:2405.13157](https://arxiv.org/abs/2405.13157)]
- 2023 **Structures in Categories of Polynomials**. *Submitted for publication*. With David Spivak. [[arXiv:2305.00167](https://arxiv.org/abs/2305.00167)]
- 2023 **A Compositional Account of Motifs, Mechanisms, and Dynamics in Biochemical Regulatory Networks**. *Compositionality* 6, 2, 2024. With Rebekah Aduddell, James Fairbanks, Amit Kumar, Pablo Ocal, and Evan Patterson. [[arXiv:2301.01445](https://arxiv.org/abs/2301.01445)]
- 2022 **Duoidal Structures for Compositional Dependence**. *Submitted for publication*. With David Spivak. [[arXiv:2210.01962](https://arxiv.org/abs/2210.01962)]
- 2022 **Dynamic Operads, Dynamic Categories: From Deep Learning to Prediction Markets**. *Electronic Proceedings in Theoretical Computer Science*, 2022. With David Spivak. [[arXiv:2205.03906](https://arxiv.org/abs/2205.03906)]
- 2022 **Enrichment of Algebraic Higher Categories**. *Preprint*. [[arXiv:2205.12235](https://arxiv.org/abs/2205.12235)]

- 2021 **Familial Monads as Higher Category Theories.** *Submitted for publication.* [\[arXiv:2111.14796\]](#)
- 2021 **Weak Cartesian Properties of Simplicial Sets.** *Journal of Homotopy and Related Structures*, 18, 477-520, 2023. With Carmen Constantin, Tobias Fritz, and Paolo Perrone. [\[arXiv:2105.04775\]](#)
- 2020 **Partial Evaluations and the Compositional Structure of the Bar Construction.** *Theory and Applications of Categories*, Vol. 39, No. 11, 322-364, 2023. With Carmen Constantin, Tobias Fritz, and Paolo Perrone. [\[arXiv:2009.07302\]](#)
- 2016 **Densities of Hyperbolic Cusp Invariants.** *Proceedings of the American Mathematical Society*, Volume 146, Number 9, 4073-4089, 2018. With Colin Adams, Rose Kaplan-Kelly, Michael Moore, Shruthi Sridhar, and Josh Wakefield. [\[arXiv:1701.03479\]](#)
- 2016 **specgen: A Tool for Modeling Statecharts in CSP.** *Nasa Formal Methods* 282, 2017. With Chris Casinghino.
- 2015 **Nonstandard Neutrino Interactions In Supernovae.** *Physical Review D* 94, 093007, 2016. With C.J. Stapleford, D.J. Väänänen, J.P. Kneller, and G.C. McLaughlin. [\[arXiv:1605.04903\]](#)

## Teaching

- 2025 **Differential Equations**, *University of Virginia*, Math 3250), both semesters
- 2024 **Algebraic Topology II**, *University of Virginia*, Math 7810
- 2024 **Linear Algebra**, *University of Virginia*, Math 3351
- 2023 **Differential Geometry**, *University of Virginia*, Math 4720
- 2021 **Calculus I**, *Cornell University*, Math 1110
- 2019 **Applied Linear Algebra (Teaching Assistant)**, *Cornell University*, Math 2310
- 2018 **Geometric Group Theory (Teaching Assistant)**, *Cornell University*, Math 4560
- 2016 **Discrete Math (Teaching Assistant)**, *Brandeis University*, COSI 29a
- 2015 **Java Programming (Teaching Assistant, Tutor)**, *Brandeis University*, COSI 12b

## Mentorship

- 2025 **Summer Research Mentor**, *University of Virginia*, Triangle algebras  
Worked with an undergraduate on developing the theory of a 2-dimensional algebraic structure for composing grids of triangles.
- 2024-2025 **Peer Mentoring Initiative**, *University of Virginia*, Organizer and mentor  
Students at different career stages are paired with more experienced students or postdocs for meetups and mentorship.
- 2024 **REU Mentor**, *University of Virginia*, Categorical tiling theory  
Lead a group of undergraduates pursuing original research over the summer on a categorical approach to combinatorial geometry.
- 2023-2025 **Geometry Lab Mentor**, *University of Virginia*, Zome geometry group  
Lead groups of beginning undergraduates in semester-long exploratory projects.
- 2023 **Workshop on  $(\infty, 2)$ -Categories**, *Online*  
Mentored a student in preparation for an expository talk based on a research paper.
- 2020-2022 **Directed Reading Program**, *Cornell University*  
Mentored three undergraduates in projects on constructive type theory, categorical algebra, and combinatorial topology.
- 2020 **Julia Robinson Math Festival Volunteer**, *Cornell University*

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## Honors and Awards

- 2021 **Bättig Prize for Excellence and Promise in Mathematics**, Cornell University.
- 2017-2021 **National Defense Science & Engineering Graduate Fellowship**.
- 2017 **Summa Cum Laude**, Brandeis University.
- 2017 **Arnold Shapiro Prize in Mathematics**, Brandeis University.
- 2017 **Michtom Prize in Computer Science**, Brandeis University.
- 2016 **Phi Beta Kappa**, Brandeis University Chapter, Junior Year Inductee.
- 2016 **Outstanding Presentation Award**, MAA MathFest 2016.
- 2013 **Presidential Merit Scholarship**, Brandeis University.
- 2013 **National Merit Scholarship**, Brandeis University.

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## Conference Organizing

- 2023 **Special Session on Category Theory and Machine Learning**. CALCO, Bloomington.

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## Conference Talks

- 2025 **Directed Tilings of the Euclidean and Hyperbolic Plane**. MAA Spring 2025 DC-MD-VA Section Meeting, Fairfax.
- 2024 **Homotopy Theory of Double Categories for Algebraic  $K$ -Theory**. AMS Spring Southeastern Sectional Meeting, Tallahassee.
- 2024 **CGW Categories**. Workshop on Higher Segal Spaces and their Applications to Algebraic  $K$ -Theory, Hall Algebras, and Combinatorics, BIRS.
- 2023 **Finite Posets as Algebraic Expressions in Duoidal Categories**. Category Theory OctoberFest, Online.
- 2023 **A Dynamic Monoidal Category for Deep Learning**. CALCO, Bloomington.
- 2022 **Polynomial Functors for Categorical Open Dynamics**. Joint Math Meetings, Special Session on Applied Category Theory, Boston.
- 2022 **Double Presheaf Categories via Polynomial Functors**. Virtual Double Categories Workshop, Online.
- 2022 **Dynamic Operads for Evolving Organizations**. Applied Category Theory, Glasgow.
- 2022 **Familial Monads for Higher and Lower Category Theory**. Workshop on Polynomial Functors, Online.
- 2021 **Compositional Structure of Partial Evaluations**. Categories and Companions Symposium, Online.
- 2019 **Shape Independent Category Theory**. Category Theory OctoberFest, Baltimore.
- 2019 **Types as Weak  $\omega$ -Groupoids**. School and Workshop on Univalent Foundations, Birmingham.
- 2018 **Cell Shapes for Higher Structures**. Young Topologists Meeting, Copenhagen.
- 2016 **The Geometry of Knots**. With S. Sridhar. MAA MathFest, Columbus.
- 2016 **Cusp Density: Dense or Knot?** Unknot III, Columbus.

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## Seminar and Colloquium Talks

- 2025 **Chain Complexes of Finite Sets and Venn Diagrams for Homological Algebra.** Virginia Commonwealth University Analysis, Logic, and Physics Seminar.
- 2023 **Combinatorial Homological Algebra and  $K$ -Theory.** University of Minnesota Topology Seminar.
- 2023 **Higher Category Theory in  $\mathbf{Cat}^\#$ .** Topos Institute Colloquium, Online.
- 2023 **Combinatorial Homological Algebra and  $K$ -Theory.** University of Minnesota Topology Seminar.
- 2020 **Compositional Structure of Partial Evaluations.** MIT Categories Seminar, Online.
- 2020 **Cubical  $\omega$ -Categories and Cubical  $\Theta$ .** MSRI Cubical Sets Seminar, Online.
- 2020 **Test Category Structure of Cubes.** MSRI Cubical Sets Seminar, Online.
- 2020 **Constructing Cubes from Semicubes.** MSRI Cubical Sets Seminar, Online.

## Workshop Participation

- 2024 **Polynomial Functors at Work,** *Topos Institute*
- 2023 **Talbot Workshop,** *Online*, Scissors Congruence  $K$ -Theory, Presenter
- 2023 **Math and Metaphysics Symposium,** *Austin, TX*, Presenter
- 2023 **Finding the Right Abstractions for Healthy Systems,** *Bodega Bay, CA*
- 2021 **Equivariant Algebra Seminar,** *eCHT*, Presenter
- 2019 **Applied Category Theory Adjoint School & Workshop,** *University of Oxford*
- 2019 **School & Workshop on Univalent Foundations,** *University of Birmingham*
- 2018 **Homotopy Theory Summer,** *Berlin Mathematical School*
- 2018 **Talbot Workshop,** *Govt. Camp, OR*, Model Independent  $\infty$ -Category Theory
- 2016 **SMALL REU,** *Williams College*, Hyperbolic Knot Theory Group
- 2014 **Computational Astrophysics REU,** *North Carolina State University*

## Local Seminars

- 2023- **Homotopy Theory Group Meeting,** *University of Virginia*, Organizer, Presenter
- 2023- **Topology Seminar,** *University of Virginia*, Organizer, Presenter
- 2024 **Spectra Reading Group,** *University of Virginia*, Presenter
- 2022-2023 **Berkeley Seminar,** *Topos Institute*, Organizer, Presenter
- 2018-2022 **Homotopy Group,** *Cornell University*, Organizer, Presenter
- 2017-2022 **Topology Seminar,** *Cornell University*, Presenter
- 2020 **Logic Seminar,** *Cornell University*, Presenter
- 2019 **"What is...?" Seminar,** *Cornell University*, Organizer
- 2018  **$\infty$ -Category Theory Reading Group,** *Cornell University*, Presenter
- 2018 **Homotopy Type Theory Group,** *Cornell University*, Organizer, Presenter
- 2017-2022 **Olivetti Club,** *Cornell University*, Presenter
- 2016-2017 **Floer Homology Group,** *Brandeis University*
- 2015 **Haskell and Type Theory Group,** *Brandeis University*