# Curriculum Vitae Theo Johnson-Freyd, http://categorified.net/ February 13, 2024

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# Mathematical Biography

### Positions

2024 – Associate Professor, Department of Mathematics & Statistics, Dalhousie University

2021–2024 Assistant Professor, Department of Mathematics & Statistics, Dalhousie University

2021 – Associate Faculty, Perimeter Institute for Theoretical Physics

2016–2020 Senior Postdoctoral Fellow, Perimeter Institute for Theoretical Physics Supervisors: K. Costello and D. Gaiotto

2013–2016 NSF Postdoc and Boas Assistant Professor, Northwestern University Supervisors: K. Costello and E. Getzler

# Education

2007–13 Ph.D. in Mathematics, University of California, Berkeley Dissertation title: *Perturbative Methods in Path Integration* Supervisor: N. Reshetikhin

2003–07 B.Sc. in Mathematics, Stanford University, with distinction Supervisor: R. Vakil

# **Research Interests**

Higher algebra, quantum field theory, condensed matter, topology, moonshine, category theory

# Publications

For abstracts of all papers, see categorified.net/publications.html.

## Published and accepted for publication

- 1. Minimal nondegenerate extensions. With D. Reutter. *Journal of the American Mathematical Society*, Volume 37, Number 1, January 2024, Pages 81–150. arXiv:2105.15167.
- (3+1)D topological orders with only a Z₂-charged particle. Commun. Contemp. Math., 2024. arXiv: 2011.11165.
- 3. Ground-state degeneracy of twisted sectors of Conway Moonshine SCFT. With A. Furet. Commun. Contemp. Math., 2024. arXiv:2305.05081.
- 4. Mock modularity and a secondary elliptic genus. With D. Gaiotto. *Journal of High Energy Physics*, 2023. arXiv:1904.05788.
- 5. Topological Orders in (4+1)-Dimensions. With M. Yu. *SciPost Physics*, 13, 068 (2022). arXiv: 2104.04534. DOI:10.21468/SciPostPhys.13.3.068. MR4492330.

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- On the classification of topological orders. Communications in Mathematical Physics, 393, pp 989–1033 (2022). arXiv:2003.06663. DOI:10.1007/s00220-022-04380-3. MR4444089.
- Fusion 2-categories with no line operators are grouplike. With M. Yu. Bulletin of the Australian Mathematical Society, vol 104, issue 3, pp 434-442, December 2021. arXiv:2010.07950. DOI:10. 1017/S0004972721000095. MR4338473.
- Holomorphic SCFTs with small index. With D. Gaiotto. Canadian Journal of Mathematics, 2021:1-29. arXiv:1811.00589. DOI:10.4153/S0008414X2100002X. MR4411002.
- Supersymmetry and the Suzuki chain. Tunisian Journal of Mathematics, Vol 3, No 2, pp 309-359, 2021. DOI:10.2140/tunis.2021.3.309. MR4190470. arXiv:1908.11012. MR4190470.
- A note on some minimally supersymmetric models in two dimensions. With D. Gaiotto and E. Witten. Proceedings of Symposia in Pure Mathematics, volume 103.2, 2021. arXiv:1902.10249. MR4285698. DOI:10.1090/pspum/103.2/01857.
- 11. Galois action on VOA gauge anomalies. *Progr. Math.*, 340, 2021, pp345-370. arXiv:1811.06495. MR4391353. DOI:10.1007/978-3-030-78148-4\_12.
- Heisenberg-picture quantum field theory. Progr. Math., 340, 2021, pp371-409. arXiv:1508.05908. MR4391354. DOI:10.1007/978-3-030-78148-4\_13.
- Third homology of some sporadic finite groups. With D. Treumann. Symmetry, Integrability and Geometry: Methods and Applications 15 (2019), 059. DOI:10.3842/SIGMA.2019.059. MR3990846. arXiv:1810.00463.
- Symmetry protected topological phases and generalized cohomology. With D. Gaiotto. Journal of High Energy Physics. May 2019. DOI:10.1007/JHEP05(2019)007. MR3978827. arXiv:1712.07950.
- The Moonshine Anomaly. Communications in Mathematical Physics. February 2019, Volume 365, Issue 3, pp 943-970. DOI:10.1007/s00220-019-03300-2. MR3916985. arXiv:1707.08388.
- H<sup>4</sup>(Co<sub>0</sub>; Z) = Z/24. With D. Treumann. International Mathematics Research Notices, 2020, no. 21, 7873-7907. DOI:10.1093/imrn/rny219. MR4176841. arXiv:1707.07587.
- How to derive Feynman diagrams for finite-dimensional integrals directly from the BV formalism. With O. Gwilliam. *Topology and quantum theory in interaction*, Contemp. Math., 718, Amer. Math. Soc., Providence, RI, 2018, pp 175–185. MR3869644. arXiv:1202.1554.
- Spin, statistics, orientations, unitarity. Algebraic & Geometric Topology, Volume 17, No. 2, 2017, pp 917-956. DOI:10.2140/agt.2017.17.917. MR3623677. arXiv:1507.06297
- (Op)lax natural transformations, twisted quantum field theories, and "even higher" Morita categories. With C. Scheimbauer. Advances in Mathematics, Volume 307, 5 February 2017, pp 147-223. DOI: 10.1016/j.aim.2016.11.014. MR3590516. arXiv:1502.06526.
- The quaternions and Bott periodicity are quantum Hamiltonian reductions. Symmetry, Integrability and Geometry: Methods and Applications, 12 (2016), 116, 6 pages. DOI:10.3842/SIGMA.2016.116. MR3581593. arXiv:1603.06603.
- Tree- versus graph-level quasilocal Poincaré duality on S<sup>1</sup>. Journal of homotopy and related structures, June 2016, Volume 11, Issue 2, pp 333–374. DOI:10.1007/s40062-015-0110-2. MR3511825. arXiv: 1412.4664.
- Homological perturbation theory for nonperturbative integrals. Letters in Mathematical Physics, November 2015, Volume 105, Issue 11, pp 1605-1632. DOI:10.1007/s11005-015-0791-9. MR3406714. arXiv:1206.5319.
- Reflexivity and dualizability in categorified linear algebra. With M. Brandenburg and A. Chirvasitu. Theory and Applications of Categories, Vol. 30, No. 23, 2015, pp. 808-835. www.tac.mta.ca/tac/ volumes/30/23/30-23abs.html. MR3361309. arXiv:1409.5934.
- Poisson AKSZ theories and their quantizations. In Proceedings of the conference String-Math 2013, volume 88 of Proceedings of Symposia in Pure Mathematics, pp. 291-306, Providence, RI, 2014. Amer. Math. Soc. DOI:10.1090/pspum/088. MR3330296. arXiv:1307.5812.
- 25. The fundamental pro-groupoid of an affine 2-scheme. With A. Chirvasitu. Applied Categorical Struc-

*tures.* Vol 21, Issue 5 (2013), pp. 469-522. DOI:10.1007/s10485-011-9275-y. MR3097055. arXiv: 1105.3104.

- The formal path integral and quantum mechanics. Journal of Mathematical Physics. 51, 122103 (2010). DOI:10.1063/1.3503472. MR2779164. arXiv:1004.4305.
- Feynman-diagrammatic description of the asymptotics of the time evolution operator in quantum mechanics. Letters in Mathematical Physics. November 2010, Volume 94, Issue 2, pp 123–149. DOI: 10.1007/s11005-010-0424-2. MR2733558. arXiv:1003.1156.

#### Preprints submitted for publication

- 1. Topological Mathieu Moonshine. arXiv:2006.02922.
- 2. Condensations in higher categories. With D. Gaiotto. arXiv:1905.09566.

#### Other mathematical writings

- 1. Berkeley Lectures on Lie Groups and Quantum Groups. With R. Borcherds, M. Haiman, N. Reshetikhin, and V. Serganova. categorified.net/LieQuantumGroups.pdf.
- An approach to less climate-impactful conferences. With David Ayala, Lukas Brantner, André Henriques, and Aaron Mazel-Gee. Newsletter of the LMS, Issue 480, January 2019, pp32-33. www.lms. ac.uk/sites/lms.ac.uk/files/files/NLMS\_480.pdf

# Supervision

#### **Graduate Students**

- Jessica Weitbrecht, Perimeter Institute, MSc 2018. Thesis title: An Introduction to Lattice Vertex Operator Algabras, and their Topological Twist
- 2. Alissa Furet, Dalhousie, MSc 2022. Thesis title: Ground-state Degeneracy of Twisted Sectors of Conway Moonshine SCFT
- 3. Matthew Yu, Perimeter Institute, PhD 2023. Thesis title: (Non)-Invertible Topology in Quantum Field Theory
- 4. Ruizhi Liu, Dalhousie, MSc 2024 (expected), PhD 2028 (expected). Thesis title: Symmetries and Anomalies: with Applications to Condensed Matter and String Theory
- 5. Adrien DeLazzer Meunier, Dalhousie, PhD 2026 (expected).
- 6. Daniel Teixeira, Dalhousie, PhD 2026 (expected).

#### **Undergraduate Students**

- James Munday, Dalhousie, Summer 2022. Project title: The WKB Method in Homological Perturbation Theory
- 2. Eleanor Friddel, Dalhousie, BSc with honours 2025 (expected).

#### **Postdoctoral Scholars**

- 1. Lukas Mueller, Perimeter Institute (SCGCS), 2022–present.
- 2. Matt Magill, Dalhousie (joint with Uppsala), 2023-present.
- 3. Luuk Stehouwer, Dalhousie (AARMS), expected to begin January 2024.

# **Professional Activities**

### Grant support

- 1. Simons Collaboration for Global Categorical Symmetries, 2021-2025. ~\$160,000/annum. Note: This is a 16-person grant, worth a total of \$2,000,000USD/annum.
- 2. NSERC Discovery Grant, 2021-2026. \$26,000/annum.
- 3. NSERC Accelerator Supplement, 2021-2024. \$40,000/annum.
- 4. NSERC Early Career Researcher top-up, 2021. \$12,500.
- 5. Perimeter Institute Research Grant, 2021-2025. \$10,000.
- 6. Dalhousie Start-up Grant, 2021. \$20,000.

### Reviewing

- Reviewer for *Mathematical Reviews*
- Reviewer for zbMATH.
- Referee for Ann. Inst. Henri Poincaré D
- Referee for Canad. J. Math.
- Referee for Comm. Math. Phys.
- Referee for *Contemp. Math.*
- Referee for *Compositionality*
- Referee for *Grad. Studies Math.*
- Referee for *Invent. Math.*
- Referee for J. High Energy Phys.
- Referee for J. Homotopy Relat. Struct.
- Referee for J. Geom. Phys.
- Referee for Lett. Math. Phys.
- Referee for Phys. Rev. B: Cond. Mat.
- Referee for Proc. Symp. Pure. Math.
- Referee for SIGMA Symmetry Integrability Geom. Methods Appl.
- Referee for EPSCR.

### Conferences co-organized

- "Global Categorical Symmetries" conference and school at Institut Henri Poincaré, June 2025. With I. Bah, M. Del Zotto, R. Minasian, and C. Scheimbauer.
- "Atlantic TQFT Spring School" school at Memorial University Newfoundland, May 2024. With L. Stehouwer and Y. Sommerhäuser.
- "Subfactors and Fusion (2-)Categories" workshop at Banff Research Station, December 2023. With T. Gannon, J. Plavnik, and D. Penneys.
- "Dagger higher categories" online workshop, June 2023. With D. Penneys.
- "Atlantic TQFT Spring School" school in Wolfville, May 2023. With G. Vooys.
- "Global Categorical Symmetries" conference and school at Perimeter Institute, June 2022. With I. Bah, M. Del Zotto, J. Plavnik, and C. Teleman.
- "Women at the intersection of mathematics and theoretical physics" conference at Perimeter Institute, February 2021. With B. Dittrich, S. Paycha, K. Rejzner, A. Taormina, and R. Toriumi.
- "Elliptic cohomology and physics" online workshop at Perimeter Institute, May 2020. With D. Berwick-Evans, N. Ganter, Y. Yang, and G. Zhao.

- "Higher algebra and mathematical physics" conference at Perimeter Institute and Max Planck Institute, August 2018. With D. Ayala, K. Costello, O. Gwilliam, A. Henriques, A. Mazel-Gee, and P. Teichner.
- "Quantum Field Theory on Manifolds with Boundary and the BV Formalism" workshop at Perimeter Institute, May 2017. With R. Grady and P. Mnev.
- "Representation Theory, Integrable Systems and Quantum Fields" conference at Northwestern, April 2016. With T.S. Chen, X. Jin, and L. Shen.
- "QFTahoe 2013" workshop for young researchers, March 2013. With D. Berwick-Evans, O. Gwilliam, N. Reshetikhin, and J. Tener.
- "Representation Theory and Geometry" workshop at UC Berkeley, September 2011. With N. Reshetikhin and H. Williams.

#### Research seminars co-organized

- Mathematical Physics seminar, Perimeter Institute, 2016–17.
- Mathematical Physics group meeting, Perimeter Institute, 2016–17.
- Geometry and Physics seminar, Northwestern, 2015–16.
- Geometry, Representations, And Some Physics (GRASP) seminar, UC Berkeley, 2010–13.

#### Committee membership

- Undergraduate Curriculum Committee, Dalhousie Mathematics, 2023–24.
- Workshops & Conferences Committee, Perimeter Institute, 2022-24. As committee chair, 2022-23.
- FGS Faculty Council, Dalhousie Faculty of Graduate Studies, 2022.
- Graduate Committee, Dalhousie Mathematics, 2021–23. As committee chair and Acting Graduate Director, 2023.
- Health, Safety and Wellness Committee, Dalhousie Mathematics, 2021–22.

# **Teaching Activities**

For course materials, see categorified.net/teaching.html.

### At Dalhousie

- 2024 Winter. Instructor for "Lie Theory" (Math 4057/5057) Lie algebras and Lie groups class for graduate students.
- 2024 Winter. Instructor for "Advanced Algebra II" (Math 4055/5055) Galois theory class for first-year graduate students.
- 2023 Winter. Instructor for "Abstract Algebra II" (Math 3032) Ring theory class for math majors.
- 2023 Winter. Instructor for "Topics in Algebraic Topology" (Math 4180/5180) Algebraic topology class for graduate students.
- 2022 Fall. Organizer for "TQFT Reading Group" Weekly learning seminar for graduate students.
- 2022 Winter. Instructor for "Honours Linear Algebra" (Math 2135) Proof-based linear algebra class for math majors.
- 2022 Winter. Instructor for "Advanced Algebra II" (Math 4055/5055) Galois theory class for first-year graduate students.
- 2021 Winter. Instructor for "Abstract Algebra II" (Math 3032) Ring theory class for math majors.

### At Perimeter Institute

- 2020 Winter. Mentor for "PSI Winter School" Supervised a graduate-student research project.
- 2019 Fall. Instructor for "Graduate Seminar: Cohomology of Groups" Weekly lecture series for Ph.D. students in math, condensed matter, and quantum field theory.

#### At Northwestern

- 2016 Winter. Instructor for "Graduate Seminar: Topology and Geometry" (Math 448) Quantum topology class centred on student presentations.
- 2015 Fall. Instructor for "First-year Seminar: Theories of Mind and Mathematics" (Math 105) Seminar-based class combining mathematics, philosophy, and writing.
- 2015 Fall. First-year academic adviser Fifteen advisees. Individual and group meetings to discuss course schedules, requirements, and the transition from high school to university.
- 2014 Spring. Instructor for "Freshman Seminar: Theories of Mind and Mathematics" (Math 105) Seminar-based class combining mathematics, philosophy, and writing.
- 2013 Fall. Instructor for "Foundations of Higher Mathematics" (Math 300) Set theory class centred on student presentations.

#### At summer schools

- 2025 Summer. Organizer for "Global Categorical Symmetries" at Institute Henri Poincaré. Week-long school for graduate students featuring four pedagogical lecture series.
- 2024 Spring. Organizer for "TQFT Spring School" at Memorial University Newfoundland. Week-long school for graduate students featuring three pedagogical lecture series.
- 2023 Summer. Lecturer for "Topological Moonshine" at UIUC. Week-long school for graduate students featuring four research-level lecture series.
- 2023 Spring. Organizer for "TQFT Spring School" in Wolfville, NS. Week-long school for graduate students featuring three pedagogical lecture series.
- 2022 Summer. Organizer for "Global Categorical Symmetries" at Perimeter Institute. Week-long school for graduate students featuring three pedagogical lecture series.
- 2019 Summer. Lecturer for "Sporadic Groups and where to find them" at Canada/USA Mathcamp. Five-week summer camp for high school students.
- 2019 Summer. TA for "QFT for Mathematicians" at Perimeter Institute. Week-long school for graduate students featuring four pedagogical lecture series.
- 2014 Summer. TA for "String Math Summer School" at Pacific Institute for the Mathematical Sciences. Week-long school for graduate students featuring five research-level lecture series.

#### At Berkeley

- 2009 Summer. Instructor for Second-semester Calculus (Math 1B) Lectured, prepared homework and exams, etc.
- 2009 Spring. Teaching assistant for First-semester Calculus (Math 1A) with Z. Stankova Taught section 6 hours a week, held office hours, graded exams.
- 2008 Fall. Teaching assistant for Precalculus (Math 32) with C. Mitchell Taught section 6 hours a week, held office hours, graded exams.
- 2008 Summer. Instructor for Second-semester Calculus (Math 1B) Lectured, prepared homework and exams, etc.
- 2008 Spring. Teaching assistant for Multivariable Calculus (Math 53) with J. Neu

Taught section 6 hours a week, held office hours, graded exams.

- 2007 Fall. Teaching assistant for Second-semester Calculus (Math 1B) with N. Reshetikhin Taught section 6 hours a week, held office hours, graded exams.
- 2007 Fall. Participated in Berkeley Mathematics Department training course for graduate student instructors and the UC Berkeley Teaching Conference.

## **Recent research lectures**

For abstracts, slides, and videos, and for talks given in  $\leq 2018$ , see categorified.net/talks.html.

#### 2023

NYU Abu Dhabi (GT&P): Higher Dagger Categories Perimeter (Math. Phys.): Deeper Kummer theory Perimeter (Researcher Presentations): Quantum Homotopy Types Hamburg (TQFT Sem.): SVOAs and some exceptional groups Regensburg (Higher Str in TFT): Super duper vector spaces II: The higher-categorical Galois group UIUC (Top. Moonshine): Topological Umbral Moonshine Oxford (OWSM): Higher algebraic closure OSU (Colloquium): Higher algebraic closure Feza Gürsey Institute (Higher Str. Sem.): Higher algebraic closure

### 2022

Simons Foundation (GCS): Homotopy Quantum Groups CRM (Quantum Symmetries): SVOAs and some exceptional groups Perimeter (Math Phys.): Hypergroups and fusion higher categories Oxford (Sym. Sem.): A 4D TQFT which is not (quite) a gauge theory AIM (Higher cat. and top. order): Hypergroups and fusion higher categories Perimeter (PSI): Global categorical symmetry and higher fusion categories ACP (Higher sym. and QFT): What is a fusion higher category? MPIM (Math QFT): Classification of (semisimple) TQFTs Oxford (ST. Sem): Why the spaces of N=(0,1) susy QFTs form a spectrum? Dalhousie (ATCAT): Categorified algebraic closure

#### 2021

Haifa (G&T): Algebraically closed higher categories
Perimeter (Math Phys): Algebraically closed higher categories
QMUL (CTP): Classification of topological quantum field theories
ICTP (Generalized Coh. and Physics): TMF and SQFT: questions and conjectures
Kavli IPMU (NAAP): A menagerie of N=1 SVOAs
WHGCP: Semisimple higher categories
KIAS (AGQFT): Operators and (higher) categories in quantum field theory
Inst. Sup. Téc. (TQFT Club): Higher S-matrices
AIM (Fusion Fridays): Minimal nondegenerate extensions
Harvard (Quantum Matter): Minimal nondegenerate extensions and an anomaly indicator

CMS 75+1 (Quantum Math): Classification of topological orders UniVie (Higher Structures): Higher S-matrices Ohio State (Colloquium): The classification of topological orders AIM (Fusion categories and tensor networks): Fusion n-category Q&A IAS (Moonshine): Orbifolds Warwick (AGQFT): Higher Galois closures Amherst (Rep Thy): Strongly-fusion 2-categories are grouplike NCSU (UQSL): Condensations and components

#### 2020

KITP (Modularity in Quantum Systems): A topological umbral moonshine conjecture George Mason (TAGDS): Holomorphic SCFTs of small index Cardiff (MPPM): Pseudounitary slightly degenerate braided fusion categories admit minimal modular extensions Uppsala (GCS): Some examples in fusion 2-categories and 3+1D topological order Heidelberg (Math Phys): 3+1d topological orders with (only) an emergent fermion Berkeley (Rep Thy Math Phys): 3+1d topological orders with (only) an emergent fermion Dalhousie (ATCAT): Separable and central simple (higher) algebras ESI Vienna (Topological Orders and Higher Structures): Algebraic definition of topological order Stellenbosch (String Math): Mock modularity and a secondary invariant UBC (Algebraic structures in quantum computation IV): SPT phases and generalized cohomology Dalhousie (Colloquium): Phases of SQFTs Perimeter (Colloquium): On the classification of topological phases MSRI (Tensor Categories and TQFTs): Gapped condensation in higher categories Rutgers (NHETCS): A deformation invariant of 2D SQFTs Santa Barbara (Geo. Top. Phys.): A deformation invariant of 2D SQFTs Perimeter (QFT): A deformation invariant of 1+1D SQFTs

#### 2019

IAS (Hep Thy): TMF and SQFT.

Dalhousie (Colloquium): Bott periodicity from quantum Hamiltonian reduction.
Dalhousie (ATCAT): Condensation and idempotent completion.
McGill (Geometry): Bott periodicity from quantum Hamiltonian reduction.
Aspen Center for Physics (Gen'd Syms, Anoms and Obs): Phases of 2d SQFTs.
Oxford (Topology): Secondary invariants and mock modularity
Aspen Center for Physics (Higher Symmetries): The Galois action on VOA anomalies
Simons, NYC (NT, Geom., Moonshine & Strings): Galois actions on VOA gauge anomalies
Stanford (Analysis & PDE): Bott periodicity from quantum Hamiltonian reduction
UC Santa Cruz (Alg No Th): Galois actions on VOA gauge anomalies
UC Santa Cruz (Colloquium): Bott periodicity from quantum Hamiltonian reduction