

# Tian Lan

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## Education

- 2013–2017 PhD in Theoretical Physics  
Perimeter Institute for Theoretical Physics & University of Waterloo  
Thesis: [A Classification of \(2+1\)D Topological Phases with Symmetries](#)  
Supervisor: Xiao-Gang Wen
- 2012–2013 MSc in Theoretical Physics, Perimeter Scholars International (PSI)  
Perimeter Institute for Theoretical Physics & University of Waterloo
- 2008–2012 BSc in Mathematics and Physics, Tsinghua University

## Experience

- 2018–2020 Postdoctoral Fellow  
Institute for Quantum Computing, University of Waterloo  
Supervisors: Raymond Laflamme, Bei Zeng
- 2021.6–now Assistant Professor  
The Chinese University of Hong Kong

## Research Interests

My research focuses on the theory of topological phases of matter:

- intrinsic topological order,
- symmetry protected topological (SPT) phases, which include topological insulators as a special case,
- symmetry enriched topological (SET) phases,
- higher dimensional generalization of symmetry and topological phases,
- ...

and their mathematical foundation:

- tensor category,
- higher category, higher algebra,
- group cohomology, algebraic topology,
- ...

I am also interested in understanding the nature of phases of matter from a quantum information perspective, and possible applications of topological materials such as quantum computing.

## Grants

Direct Grant No. 4053501, The Chinese University of Hong Kong  
Early Career Scheme (ECS) No. 24304722, Hong Kong Research Grants Council

## Teaching

2021-23 Fall    PHYS5410(M) Advanced Quantum Mechanics  
2024 Spring    PHYS1111B University Physics I, Introduction to Mechanics, Fluids and Waves

## Referee

Physical Review X, Physical Review X Quantum, Physical Review Letters, Physical Review Research, Physical Review B, Journal of High Energy Physics, Scipost, Quantum, Communications in Mathematical Physics.

## Editor

Advances in Theoretical and Mathematical Physics.

## Awards and Honors

Early Career Award 2021/22, University Grants Committee  
2017 Chinese Government Award for Outstanding Self-financed Students Abroad  
Scholarship of Tsinghua Xuetaang  
Scholarship of Tsinghua-Zhenggeru  
Scholarship of Shanghai Institute of Microsystem

## Talks

- A “Periodic Table” of Topological Orders
  - SIAM Annual Meeting (AN16), Boston, Massachusetts, USA, July, 2016  
invited but was not able to attend due to visa delay

- Department of Physics, Fudan University, May, 2018
- Department of Physics, Tsinghua University, July, 2018
- Graduate School of China Academy of Engineering Physics, July, 2018
- Department of Physics, Southern University of Science and Technology, July, 2019
- The Chinese University of Hong Kong, October, 2020
- Non-Abelian Family of Topological Order<sup>18</sup>
  - Croucher Summer Course “Quantum Entanglement and Topological Order”, The Chinese University of Hong Kong, June, 2017
  - Department of Physics, Southern University of Science and Technology, July, 2019
- Matrix Formulation of Non-Abelian Family<sup>10</sup>
  - Topological Quantum Computing (TQC2019), Shenzhen, China, December, 2019
- Higher Dimensional Topological Order, Higher Category and A Classification in 3+1D<sup>11,14</sup>
  - Department of Physics, Tsinghua University, May, 2018
  - Séminaire de mathématiques supérieures (SMS) 2018, Fields Institute for Research in Mathematical Sciences, June, 2018
  - Quantum Information and Operator Algebras III, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, July, 2018
  - Department of Physics, Sun Yat-Sen University, July, 2019
  - QuIST V: The 5th International Conference on Quantum Information, Space-time, and Topological order, Kunming, China, August, 2019
  - Department of Physics, Southern University of Science and Technology, August, 2019
  - The Chinese University of Hong Kong, October, 2020
  - CMSA, Harvard University, June, 2021
  - BIMSA, March, 2022
- The Modular Extension Characterization of SPT/SET Phases<sup>16,17,20</sup>
  - BIMSA, December, 2021
- Introduction to Categorical Approach to Topological Phases in Arbitrary Dimensions
  - Center of Mathematical Sciences and Applications, Harvard University, April 15, 2020
- Higher symmetry enriched topological phases<sup>7,8</sup>
  - Topological Orders and Higher Structures, Erwin Schrödinger Institute for Mathematics and Physics, University of Vienna, August, 2020
- Quantum Current<sup>2</sup>
  - Croucher Summer Course “Quantum Entanglement and Topological Order”, CUHK, June, 2023
  - The first International Congress of Basic Science (ICBS), BIMSA, July, 2023
  - Entangled Quantum Matter Workshop, Tsinghua University, August, 2023
- Gauging of generalized symmetry<sup>4</sup>
  - Mini-Workshop on Unconventional Superconductivity and Correlated Electron Systems, CUHK, Dec, 2023

## Publications

- [1] Ying Chan, **Tian Lan**, and Linqian Wu, “Torus algebra and logical operators at low energy”, [10.48550/ARXIV.2403.01577](#) (2024), [arXiv:2403.01577 \[cond-mat.str-el\]](#).
- [2] **Tian Lan** and Jing-Ren Zhou, “Quantum current and holographic categorical symmetry”, *SciPost Physics* **16**, 053 (2024), [arXiv:2305.12917 \[cond-mat.str-el\]](#).
- [3] Gen Yue, Longye Wang, and **Tian Lan**, “Condensation completion and defects in 2+1d topological orders”, [10.48550/ARXIV.2402.19253](#) (2024), [arXiv:2402.19253 \[cond-mat.str-el\]](#).
- [4] **Tian Lan**, Gen Yue, and Longye Wang, “Gauging of generalized symmetry”, [10.48550/ARXIV.2312.15958](#) (2023), [arXiv:2312.15958 \[cond-mat.str-el\]](#).
- [5] Wenjie Xi, **Tian Lan**, Longye Wang, Chenjie Wang, and Wei-Qiang Chen, “On a class of fusion 2-category symmetry: condensation completion of braided fusion category”, [10.48550/ARXIV.2312.15947](#) (2023), [arXiv:2312.15947 \[hep-th\]](#).
- [6] Wenjie Xi, Ya-Lei Lu, **Tian Lan**, and Wei-Qiang Chen, “A lattice realization of general three-dimensional topological order”, [10.48550/ARXIV.2110.06079](#) (2021), [arXiv:2110.06079 \[cond-mat.str-el\]](#).
- [7] Liang Kong, **Tian Lan**, Xiao-Gang Wen, Zhi-Hao Zhang, and Hao Zheng, “Algebraic higher symmetry and categorical symmetry: a holographic and entanglement view of symmetry”, *Physical Review Research* **2**, 043086 (2020), [arXiv:2005.14178 \[cond-mat.str-el\]](#).
- [8] Liang Kong, **Tian Lan**, Xiao-Gang Wen, Zhi-Hao Zhang, and Hao Zheng, “Classification of topological phases with finite internal symmetries in all dimensions”, *Journal of High Energy Physics* **2020**, 93 (2020), [arXiv:2003.08898 \[math-ph\]](#).
- [9] **Tian Lan**, Xueda Wen, Liang Kong, and Xiao-Gang Wen, “Gapped domain walls between 2+1D topologically ordered states”, *Physical Review Research* **2**, 023331 (2020), [arXiv:1911.08470](#).
- [10] **Tian Lan**, “Matrix formulation for non-Abelian families”, *Physical Review B* **100**, 241102(R) (2019), [arXiv:1908.02599](#).
- [11] **Tian Lan** and Xiao-Gang Wen, “Classification of 3+1D bosonic topological orders (II): the case when some pointlike excitations are fermions”, *Physical Review X* **9**, 021005 (2019), [arXiv:1801.08530](#).
- [12] **Tian Lan**, Chenchang Zhu, and Xiao-Gang Wen, “Fermion decoration construction of symmetry-protected trivial order for fermion systems with any symmetry and in any dimension”, *Physical Review B* **100**, 235141 (2019), [arXiv:1809.01112](#).
- [13] Chenchang Zhu, **Tian Lan**, and Xiao-Gang Wen, “Topological nonlinear  $\sigma$ -model, higher gauge theory, and a systematic construction of 3+1D topological orders for boson systems”, *Physical Review B* **100**, 045105 (2019), [arXiv:1808.09394](#).
- [14] **Tian Lan**, Liang Kong, and Xiao-Gang Wen, “Classification of 3+1D bosonic topological orders: the case when pointlike excitations are all bosons”, *Physical Review X* **8**, 021074 (2018), [arXiv:1704.04221](#).
- [15] **Tian Lan**, “A classification of (2+1)D topological phases with symmetries”, PhD thesis (University of Waterloo, Sept. 2017), p. 86, [arXiv:1801.01210 \[cond-mat.str-el\]](#).
- [16] **Tian Lan**, Liang Kong, and Xiao-Gang Wen, “Classification of (2+1)-dimensional topological order and symmetry-protected topological order for bosonic and fermionic systems with on-site symmetries”, *Physical Review B* **95**, 235140 (2017), [arXiv:1602.05946](#).
- [17] **Tian Lan**, Liang Kong, and Xiao-Gang Wen, “Modular extensions of unitary braided fusion categories and 2+1D topological/SPT orders with symmetries”, *Communications in Mathematical Physics* **351**, 709–739 (2017), [arXiv:1602.05936](#).
- [18] **Tian Lan** and Xiao-Gang Wen, “Hierarchy construction and non-Abelian families of generic topological orders”, *Physical Review Letters* **119**, 040403 (2017), [arXiv:1701.07820](#).
- [19] Keren Li, Yidun Wan, Ling-Yan Hung, **Tian Lan**, Guilu Long, Dawei Lu, Bei Zeng, and Raymond Laflamme, “Experimental identification of non-Abelian topological orders on a quantum simulator”, *Physical Review Letters* **118**, 080502 (2017), [arXiv:1608.06932](#).
- [20] **Tian Lan**, Liang Kong, and Xiao-Gang Wen, “Theory of (2+1)-dimensional fermionic topological orders and fermionic/bosonic topological orders with symmetries”, *Physical Review B* **94**, 155113 (2016), [arXiv:1507.04673](#).

- [21] **Tian Lan**, Juven C. Wang, and Xiao-Gang Wen, “Gapped domain walls, gapped boundaries, and topological degeneracy”, [Physical Review Letters](#) **114**, 076402 (2015), [arXiv:1408.6514](#).
- [22] **Tian Lan** and Xiao-Gang Wen, “Topological quasiparticles and the holographic bulk-edge relation in (2+1)-dimensional string-net models”, [Physical Review B](#) **90**, 115119 (2014), [arXiv:1311.1784](#).