WEISHUN ZHONG

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EDUCATION

Massachusetts Institute of Technology, Cambridge, MA *Sep.2017-May.2023(expected)*
Ph.D. Department of Physics
Advisors: Haim Sompolinsky (Harvard) and Mehran Kardar (MIT)
Collaborators: Susanne Yelin, Nicole Yunger Halpern, Ramis Movassagh

University of Chicago, Chicago, IL *Sep.2016-Jun.2017*
M.S., *Physical Sciences Division*, Physics GPA: 3.93/4.0

University of Michigan *Sep.2013-May.2016*
B.S., *highest distinction*, Physics and Mathematics GPA: 3.97/4.0

RESEARCH BACKGROUND

My research area lies in the intersection between statistical physics and machine learning, also with interests toward quantum information sciences.

PUBLICATIONS

1. "Decoding Imperfect Stabilizer Codes with Quantum Neural Networks", **Weishun Zhong**, Oles Shtanko, Ramis Movassagh *to appear*
2. "A Theory of Weight Distribution-constrained Learning", **Weishun Zhong**, Ben Sorscher, Daniel D Lee, Haim Sompolinsky, *arXiv:2206.08933; accepted to NeurIPS 2022*
3. "Many-body Localized Hidden Born Machine", **Weishun Zhong**, Xun Gao, Susanne Yelin, Khadijeh Najafi, *arXiv: 2207.02346; under review*
4. "Quantifying Many-body Learning far from Equilibrium with Representation Learning", **Weishun Zhong***, Jacob M Gold*, Sarah Marzen, Jeremy L England, Nicole Yunger Halpern, *arXiv: 2001.03623; Scientific reports 11.1 (2021): 1-11*
5. "Learning about Learning by Many-body Systems", **Weishun Zhong***, Jacob M Gold*, Sarah Marzen, Jeremy L England, Nicole Yunger Halpern, *arXiv:2004.03604; ICML workshop ML Interpretability for Scientific Discovery (2020)*
6. "Non-equilibrium Statistical Mechanics of Continuous Attractors", **Weishun Zhong**, Zhiyue Lu, David J. Schwab, and Arvind Murugan, *arXiv: 1809.11167; Neural computation (2020) 32 (6)*
7. "A Closer Look at Disentangling in β-VAE", Harshvardhan Sikka*, **Weishun Zhong***, Jun Yin, Cengiz Pehlevan, *arXiv:1912.05127; 53rd Asilomar Conference on Signals, Systems, and Computers (2019)*
8. "Associative Pattern Recognition in Macro-Molecular Self-Assembly", **Weishun Zhong**, David J. Schwab, and Arvind Murugan, *arXiv: 1701.01769; J Stat Phys (2017) 167: 806*
9. "A Holographic c-Theorem for Schrödinger Spacetimes", James T. Liu and **Weishun Zhong**, *arXiv: 1510.06975; JHEP 1512 (2015) 179*

RESEARCH EXPERIENCE

Massachusetts Institute of Technology Cambridge, MA
Graduate Researcher in Department of Physics

Project: Many-body localized hidden Born machine

· Proposed a novel hidden architecture for the MBL Born machine
· Established a proof for the trainability and expressibility advantage of the hidden architecture

· Demonstrated the superiority of MBL hidden Born machine on both classical and quantum datasets

Project: Learning about learning by many-body systems

· Applied representation learning (VAEs) to study statistical mechanical learning by many-body systems

· Developed machine learning toolkits to measure classification ability, memory capacity, discrimination ability, and novelty detection in many-body system's learning

· Demonstrated machine learning approaches outperform traditional thermodynamic approaches in diagnosing many-body system's learning

Project: Non-equilibrium statistical mechanics of continuous attractors

· Found an analog of gravitational equivalence principle in neural networks

· Derived an absolute upper bound on how fast recurrent networks can track input signals

· Derived an analytical formula for capacity of non-equilibrium neural networks

Harvard University Cambridge, MA

Fellow in the Center for Brain Sciences

Project: Weight distribution-constrained learning

· Developed an theoretical framework for learning with weight distribution constraint

· Derived a learning algorithm from information geometry for weight distribution-constrained learning in neural networks

· Applied our theory and algorithm to study capacity and generalization in both feed-forward and recurrent neural networks

Project: Disentangling in β-VAE

· Established a theoretical trade-off between disentangling ability and Bayesian inference error in β-VAE

· Demonstrated the trade-offs on the rotated MNIST dataset

· Calculated optimal β for toy model β-VAEs

IBM Research (Quantum) Cambridge, MA

Research Intern at IBM Quantum Computing Theory Group

Project: Decoding quantum error-correcting codes with quantum neural networks

· Proved that logical decoding error in imperfect stabilizer codes are code distance-independent

· Proved an architecture-independent lower bound for QNNs decoding corrupted states

· Demonstrated QNNs outperform standard decoding procedure in imperfect stabilizer codes

AWARDS & HONORS

- NeurIPS Scholar Award, *Neural Information Processing Systems Foundation* 2022
- First-year Graduate Fellowship, *Massachusetts Institute of Technology* 2017
- Physical Sciences Division Tuition Award, *University of Chicago* 2016
- George Eugene Uhlenbeck Award, *University of Michigan* 2016
- Division of Particle and Fields Travel Award, *American Physical Society* 2016
- Division of Gravitational Physics Travel Award, *American Physical Society* 2016
- Otto Graf Scholarship, *University of Michigan* 2015
- James B. Angell Scholar, *University of Michigan* 2015

TEACHING EXPERIENCE

- Teaching assistant for MIT graduate physics course Statistical Physics in Biology (8.592) 2021
- Teaching assistant for various MIT undergraduate physics course (8.01-8.03) 2018-2020

SKILLS

Programming Python, Mathematica

Tools Quspin, Quskit, Tensorflow, High Performance Computing (Slurm), Numerical Methods