

# WEISHUN ZHONG

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## EMPLOYMENT

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**Institute for Advanced Study**, Princeton, NJ

*Sep.2023-*

Member, Simons Center for Systems Biology, School of Natural Sciences

## EDUCATION

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**Massachusetts Institute of Technology**, Cambridge, MA

*Sep.2017-June.2023*

**Ph.D. Department of Physics**

Advisors: Haim Sompolinsky (Harvard) and Mehran Kardar (MIT)

**Thesis:** Non-equilibrium Physics: from Spin Glasses to Machine and Neural Learning

**University of Chicago**, Chicago, IL

*Sep.2016-Jun.2017*

**M.S., *Physical Sciences Division*, Physics**

GPA: 3.93/4.0

Advisors: Arvind Murugan and David J. Schwab

**University of Michigan**

*Sep.2013-May.2016*

**B.S., *highest distinction*, Physics and Mathematics**

GPA: 3.97/4.0

Advisor: James T. Liu

## PUBLICATIONS

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1. “Hierarchical Working Memory and a new Magic Number”, **Weishun Zhong**, Mikhail Katkov, Misha Tsodyks, *arXiv: 2408.07637*
2. “Advantage of Quantum Neural Networks as Quantum Information Decoders”, **Weishun Zhong**, Oles Shtanko, Ramis Movassagh, *arXiv:2401.06300*
3. “A Theory of Weight Distribution-constrained Learning”, **Weishun Zhong**, Ben Sorscher, Daniel D Lee, Haim Sompolinsky, *arXiv:2206.08933; NeurIPS 2022*
4. “Many-body Localized Hidden Born Machine”, **Weishun Zhong**, Xun Gao, Susanne Yelin, Khadijeh Najafi, *arXiv: 2207.02346; under review*
5. “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*
6. “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)*
7. “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)*
8. “A Closer Look at Disentangling in  $\beta$ -VAE”, Harshvardhan Sikka\*, **Weishun Zhong\***, Jun Yin, Cengiz Pehlevan, *arXiv:1912.05127; 53rd Asilomar Conference on Signals, Systems, and Computers (2019)*
9. “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*
10. “A Holographic c-Theorem for Schrödinger Spacetimes”, James T. Liu and **Weishun Zhong**, *arXiv: 1510.06975; JHEP 1512 (2015) 179*

## RESEARCH EXPERIENCE

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**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  $\beta$ -VAE**

- Established a theoretical trade-off between disentangling ability and Bayesian inference error in  $\beta$ -VAE
- Demonstrated the trade-offs on the rotated MNIST dataset
- Calculated optimal  $\beta$  for toy model  $\beta$ -VAEs

**Massachusetts Institute of Technology**

Cambridge, MA

*Graduate Researcher in Department of Physics***Project: Learning about learning by many-body systems**

- Applied representation learning (VAEs) to study statistical mechanical learning by many-body systems
- Characterized different facets of many-body system's learning: classification ability, memory capacity, discrimination ability, and novelty detection

**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

**IBM Research (Quantum)**

Cambridge, MA

*Research Intern at IBM Quantum Computing Theory Group***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: 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**


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• C.V. Starr Membership, <i>C.V. Starr Foundation</i>	2023
• NeurIPS Scholar Award, <i>Neural Information Processing Systems Foundation</i>	2022
• First-year Graduate Fellowship, <i>Massachusetts Institute of Technology</i>	2017
• Physical Sciences Division Tuition Award, <i>University of Chicago</i>	2016
• George Eugene Uhlenbeck Award, <i>University of Michigan</i>	2016
• Division of Particle and Fields Travel Award, <i>American Physical Society</i>	2016
• Division of Gravitational Physics Travel Award, <i>American Physical Society</i>	2016
• Otto Graf Scholarship, <i>University of Michigan</i>	2015
• James B. Angell Scholar, <i>University of Michigan</i>	2015

**TEACHING EXPERIENCE**


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• Teaching assistant for various MIT undergraduate and graduate physics courses	2018-2021
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