Chan Li

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Education

- **University of California San Diego** — La Jolla, USA
  Ph.D. Candidate in *Physics*, expected graduation 06/2027; *GPA: 3.96/4.0* — *Sep. 2023 – Present*
- **Sun Yat-sen University** — Guangzhou, China
  Master of Science in *Theoretical Physics; GPA: 89/100 (3.55/4.0)* — *Aug. 2020 – Jun. 2023*
- **Sun Yat-sen University** — Guangzhou, China
  Bachelor of Science in *Optoelectronic Information Science and Engineering; GPA: 88/100 (3.78/4.0)* — *Aug. 2016 – Jun. 2020*

Selected Honors and Awards

- **Physics Excellence Award** — Sep. 2023
  Physics department, University of California San Diego (top 10%)
- **Chinese National Scholarship** — Oct. 2019; Oct. 2021
  Ministry of Education of P. R. China (top 1%)
- **Chen-Ning Franklin Yang Scholarship (for Graduate students in Physics)** — Nov. 2021
  Sun Yat-sen University (top 1%)
- **University First-Class Scholarship for Outstanding Students** — Oct. 2019
  Sun Yat-sen University (top 10%)
- **3rd Prize, Three-Minute Video Presentation Contest** — May 2021
  IOP Publishing & X-MOL (top 10%)

Research Interests

- Machine learning methods for analyzing high-dimensional data, with an emphasis on pattern discovery and understanding model behavior.
- Investigating how structure, noise, and model architecture affect learning processes and generalization in large neural networks.
- Combining physical intuition with machine learning techniques to model nonlinear, high-dimensional scientific systems.
- Exploring emergent behavior in learning systems and identifying principles that lead to stable and robust model performance.

Research Experience

University of California San Diego (UCSD), La Jolla, CA, USA.
Ph.D. Researcher in Physics; Advisor: Prof. Nigel Goldenfeld.

- **Project 1: Learning Dynamics and Scaling in Large Neural Networks** — *Oct 2024 – Oct 2025*
  Developed theory-guided models to explain the mechanism behind the “double descent” phenomenon, showing that it emerges from a sharp transition in training dynamics.
  Identified the scaling behavior governing the shift from memorization to feature learning, providing a principled view of capability emergence and stability in high-dimensional learning systems.
  These insights offer general principles for analyzing model behavior, improving training efficiency, and understanding emergent dynamics in large-scale AI systems (under review at *Physical Review Letters*, a top-tier physics journal).
- **Project 2: Learning Algorithms for Emergent Symmetry Discovery in Physical Systems** — *Apr 2025 – Present*
  Designed and implemented machine learning methods to identify latent symmetries, structural patterns, and departures from expected behavior in complex physical datasets.
  Combined data-driven modeling with theoretical analysis to improve robustness, interpretability, and generalization when learning from noisy, high-dimensional data (manuscript in preparation).

Sun Yat-sen University, Guangzhou, China.
Researcher in PMI Lab; Advisor: Prof. Haiping Huang.

- **Project 1. Interpretable Learning Frameworks for Neural Networks** *Aug 2019 – Oct 2021*
  Developed probabilistic and mean-field models to study how deep and recurrent neural networks organize and update parameters during training. Identified functional roles of different connections and uncovered interpretable, data-driven learning mechanisms across hierarchical and temporal structures. Integrated Bayesian inference, optimization theory, and large-scale simulations; results published in **Physical Review Letters 125, 178301 (2020)** and **Physical Review E 107, 024307 (2023)**.
- **Project 2. Hierarchical Representations in Deep Learning** *Aug 2021 – Oct 2022*
  Designed algorithms that decompose neural network weights into latent components to reveal hierarchical structure and feature organization. Provided a quantitative framework for interpreting learned representations; published in **Physical Review Research 5, L022011 (2023)**.
- **Project 3. Continual and Multi-Task Learning Frameworks** *Aug 2020 – Oct 2022*
  Developed physics-inspired learning frameworks for continual and multi-task settings to reduce catastrophic forgetting and improve cross-task transfer. Established principles for stable long-term learning and adaptive representation reuse; published in **Physical Review E 108, 014309 (2023)**.
- **Project 4. Predictive Coding Models for Language Processing** *Apr 2023 – Apr 2024*
  Implemented predictive coding models for language tasks to analyze information flow, adaptive updates, and representation dynamics in neural circuits. Combined theoretical modeling with empirical evaluation; published in **Physical Review E 109, 044309 (2024)**.

Publications (peer-reviewed, comparable to top-tier AI/ML conferences)

[5] **C. Li**, Junbin Qiu, and H. Huang, *Meta predictive learning model of languages in neural circuits*, Phys. Rev. E 109,044309(2024).
[4] **C. Li**, Zhenye Huang, Wenxuan Zou, and H. Huang, *Statistical mechanics of continual learning: variational principle and mean-field potential*, Phys. Rev. E 108, 014309 (2023).
[3] **C. Li** and H. Huang, *Emergence of hierarchical modes from deep learning*, Phys. Rev. Research 5, L022011 (2023).
[2] W. Zou, **C. Li** (co - first author) and H. Huang, *Ensemble perspective for understanding temporal credit assignment*, Phys. Rev. E 107, 024307 (2023).
[1] **C. Li** and H. Huang, *Learning credit assignment*, Phys. Rev. Lett. 125, 178301 (2020).

Selected poster and oral representations

- American Physical Society Joint March Meeting and April Meeting 2025 in Anaheim, California (oral presentation).
- Chinese National Conference on statistical physics and complex systems, 2021 in Changchun, China (1^{st} Prize for poster).
- Chinese National Conference on computational and cognitive neuroscience (poster), 2021 online.
- Annual meeting of Guangdong Physics Society, 2020 and 2021 in Guangdong, China (1^{st} Prize for poster).

Professional Skills

- **Programming and Software**: Proficient in **Python** for machine learning, scientific computing, and data analysis; experienced with **PyTorch** for model development and training; comfortable working in **Linux** environments with **Git** and shell workflows; familiar with **C/C++**, LaTeX, and scientific computing tools such as **Matlab** and **Mathematica**.
- **Machine Learning and Optimization**: Skilled in building, training, and evaluating neural networks; experienced with optimization algorithms (SGD, Adam) and tackling challenges related to training stability, generalization, and scaling. Proficient in numerical simulation and statistical data analysis using **NumPy**, **SciPy**, and **Matplotlib**.
- **Statistical and Probabilistic Modeling**: Strong background in **statistical physics**, **Bayesian inference**, and **probabilistic modeling**; apply analytical tools such as mean-field methods and random matrix theory to design interpretable and data-efficient learning frameworks.
- **Communication and Collaboration**: Effective in cross-disciplinary teamwork and in presenting complex technical concepts to audiences across physics, machine learning, and applied mathematics.
- **Languages**: Native Chinese; fluent in English (IELTS 7.5).

Selected Coursework

- Machine Learning and Neural Computation
- Advanced Computational Modeling
- Nonlinear Dynamics and Complex Systems
- Statistical Physics and Stochastic Processes
- Optimization and Numerical Methods
- Phase Transitions and Critical Phenomena