Baoli Hao

+1 (312) 973-9890 | bhao2@hawk.illinoistech.edu | https://baolihao.github.io/
Baoli's Google Scholar

EDUCATION

Illinois Institute of Technology Aug. 2022 – Apr. 2027
Ph.D. in Applied Mathematics Chicago, IL

- **Advisors**: Prof. Chun Liu & Prof. Ming Zhong
- **GPA**: 3.93/4.0
- **Research Interests**: Scientific Machine Learning (SciML) and Physics-Informed AI (e.g., PINNs, Operator learning); Inverse problems and system identification in ODE/PDE systems; Data-driven discovery and modeling of complex dynamical systems; Collective dynamics and large-scale interacting particle systems.

City University of Hong Kong Aug. 2017 – Apr. 2021
BSc in Computing Mathematics (First Class Honours) Hong Kong

- **GPA**: 3.7/4.3 | **Minor**: Computer Science

PUBLICATIONS

1. **Baoli Hao**, Mauro Maggioni, and Ming Zhong. One Shot of Learning of Collective Dynamics from Equilibrium in Interacting Agent Systems. In preparation, 2026.
2. **Baoli Hao**, Kamrun Mily, Annalisa Quaini, and Ming Zhong. **Crime hotspot dynamics in residential burglary models with police response.** arXiv: 2605.17709, 2026.
3. **Baoli Hao**, Fanze Kong, Kei Fong Lam, and Chun Liu. **Global Finite-Energy Weak Solutions and Sharp Entropy Decay for a Poisson-Nernst-Planck System with Interspecies Drag and Steric Effects.** arXiv: 2607.21742, 2026.
4. **Baoli Hao**, Chenxi Hu, Ming Zhong, and Ren Wang. **Event-Structured Physics-Informed Neural Networks for Differentiable Critical Clearing Boundaries.** arXiv: 2607.27681, 2026.
5. **Baoli Hao**, Kamrun Mily, Annalisa Quaini, and Ming Zhong. **A finite element framework for simulating residential burglary in realistic urban geometries.** *Mathematical Models and Methods in Applied Sciences*, 36(5), 1019–1050, 2026.
6. Kin Shing Chan, **Baoli Hao**, Kei Fong Lam, and Björn Stinner. **On a phase field model for binary mixtures of micropolar fluids with non-matched densities and moving contact lines.** *Interfaces and Free Boundaries*, published online first, DOI: 10.4171/IFB/570, 2026.
7. **Baoli Hao**, Ulisses Braga-Neto, Chun Liu, Lifan Wang, and Ming Zhong. **Stability in training PINNs for stiff PDEs: Why initial conditions matter.** *Foundations of Data Science*. DOI: 10.3934/fods.2026016, 2026.
8. **Baoli Hao**, Ming Zhong, and Kevin O'Keeffe. **Attractive and repulsive interactions in the one-dimensional swarmalator model.** *Physical Review E*, 108(6), 064214, 2023.

RESEARCH & PROJECTS

Mathematical Modeling, Simulation & Analysis

- **Mathematical Modeling of Urban Crime Dynamics**: Developed and analyzed a nonlinear PDE system for crime hotspot formation derived from agent-based models via the mean-field limit. Implemented finite element simulations on realistic urban geometries, capturing spatial heterogeneity and natural boundary conditions. Published in *Mathematical Models and Methods in Applied Sciences (M3AS)* with open-source implementation available on **GitHub**. Extended to a coupled multi-variable system incorporating adaptive intervention mechanisms, exhibiting feedback-driven suppression and emergent spatial oscillations. (Manuscript in preparation)

- **Ion Transport Models with Dynamic Boundary Conditions**: Developed and analyzed a novel Poisson–Nernst–Planck framework with cross-diffusion and dynamic boundary conditions for ion transport in electrochemical systems. Proved global existence of weak solutions and established stability properties, supported by numerical simulations capturing interfacial dynamics.
- **Emergent Behaviors in Synchronization and Swarming**: Developed and analyzed models of large-scale coupled oscillator systems with heterogeneous interactions, published in *Physical Review E*. Employed stability analysis and phase diagram characterization, combined with large-scale simulations, to classify emergent collective states. Current work extends to graph-structured networked systems.
- **Phase Field Modeling for Binary Micropolar Fluids**: Developed a thermodynamically consistent phase field model for binary mixtures of incompressible micropolar fluids, coupling a Navier–Stokes–Cahn–Hilliard system with micro-rotation dynamics. The model incorporates non-matched densities and moving contact line effects, and generalizes existing formulations. Established global existence of weak solutions in three dimensions for singular logarithmic and double-obstacle potentials.

Inverse Problems & Data-Driven System Identification

- **Learning Collective Dynamics from Equilibrium Patterns**: Studied the inverse problem of recovering interaction laws in multi-agent systems from single steady-state observations. Addressed severe ill-posedness via distribution-based regularization, energy-based sign determination from the gradient flow structure, and a stopping-time strategy for time-scale recovery. Extended to multi-species and second-order systems.
- **Topological Interaction Learning in Multi-Agent Systems**: Developed a data-driven framework to learn interaction laws under adaptive and topological neighborhoods (e.g., KNN, radius-based, and density-weighted interactions), unifying a broad class of agent-based models. Enabled robust recovery of interaction kernels across deterministic and stochastic systems, including Langevin and self-propelled dynamics, with validation on both simulated and real-world data.

Scientific Machine Learning & Physics-Informed AI

- **PINNs for Stiff Dynamical Systems**: Developed and benchmarked hard-constrained PINN architectures for stiff, time-dependent PDEs, achieving improved robustness, training stability, and accuracy over state-of-the-art methods across diverse benchmarks including sharp transitions and high-frequency coupled systems; grounded findings via Neural Tangent Kernel analysis and large-scale ablation studies.
- **Physics-Informed ML for Power System Stability**: Built an end-to-end pipeline for multi-bus power system transient stability, covering AC load flow initialization, fault scenario data generation, and a domain-decomposed energy-guided PINN in PyTorch with SIREN activations and Mixture-of-Experts (MoE) routing. Ongoing extensions target AI datacenter applications including burst event detection and grid stability analysis under high-variance GPU-driven load demands.

TALKS & PRESENTATIONS

SIAM Texas-Louisiana Sectional Meeting Sept. 2025
Title: *Stability in training PINNs for stiff PDEs: Why initial conditions matter* Austin, TX

Central AMS Sectional Meeting Apr. 2025
Title: *Modeling and analysis of Poisson-Nernst-Planck systems with steric effects and relative drags* Lawrence, KS

Summer School and Workshop on Computational & Data Science at Duke Aug. 2023
Title: *Mixed sign interactions in the 1D swarmalator model* Durham, NC

INTERNSHIPS

HKU Business School, The University of Hong Kong Jul. 2021 – May 2022
Data Scientist Hong Kong

- Supervisor: Dr. Qingchen Wang
- Applied machine learning (LightGBM, logistic regression, NLP) and predictive analytics to large-scale electronic patient record (ePR) data covering approx- imately 90% of Hong Kongs population. Developed risk stratification and survival prediction models through feature engineering on clinical, laboratory, and prescription data. Utilized SHAP explainability to identify key predictors, improving model accuracy via cross-validation and hyperparameter optimization, and supporting data-driven healthcare decisions.

SERVICES

Coordinator, Multiscale Modeling and Computation Seminar, Illinois Tech — Aug. 2022 – Present

Sponsorship and Student Support Chair, ACM HyperText 2025 Conference, Illinois Tech — Oct. 2024 – Sept. 2025

Reviewer, AAAI Conference on Artificial Intelligence (AAAI 2025) — Sept. 2025

Reviewer, ACM Transactions on Modeling and Computer Simulation (TOMACS) — Jan. 2026

TEACHING

Illinois Institute of Technology

MATH Graduate Qualifying Exam Analysis Prep Session (*Leader & Mentor*) — Fall 2025 – Present

MATH 500: Applied Analysis I (*Teaching Assistant*) — Fall 2025

MATH 578: Computational Mathematics II (*Grader*) — Spring 2025

MATH 151: Calculus I (*Recitation Instructor*) — Spring 2023

MATH 230: Introduction to Discrete Mathematics (*Teaching Assistant*) — Spring 2023

MATH 252: Introduction to Differential Equations (*Teaching Assistant*) — Fall 2022

HONORS & AWARDS

Full Tuition Scholarship, City University of Hong Kong — 2017 – 2021

Deans List, City University of Hong Kong — 2018 – 2021

SKILLS

Programming : Python, R, MATLAB, SQL

Frameworks & Libraries: PyTorch, JAX, TensorFlow, DeepXDE, FEniCS, Scikit-learn, SciPy, NumPy, Chebfun

Languages : English (Fluent), Mandarin (Native), Cantonese (Good)

Others : LaTeX, Microsoft Office, Git