Baoli Hao

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Education

2022 – 2027 **Ph.D. in Applied Mathematics**
Illinois Institute of Technology, Chicago, IL, United States.
Advisors: Prof. Chun Liu & Prof. Ming Zhong.
GPA: 3.93/4.0.
Researches: Mathematical modeling of complex systems, Numerical PDEs, Data-driven and machine learning approaches for dynamics, Quantitative analysis of emergent behaviors in multi-agent and electrochemical systems.
Courses: Partial Differential Equations, Data-driven Modeling, Numerical Analysis, Deep Learning, Probability, Statistics, Stochastic Processes, etc.

2017 – 2021 **BSc in Computing Mathematics (First Class Honours)**
City University of Hong Kong, Hong Kong.
Minor: Computer Science.

Publications

1. **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*, accepted, 2025. arXiv:2508.11055.
2. 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*, accepted, 2025. arXiv:2504.21258.
3. **Baoli Hao**, Ulisses Braga-Neto, Chun Liu, Lifan Wang, and Ming Zhong. **Stability in training PINNs for stiff PDEs: Why initial conditions matter.** arXiv:2404.16189, 2024.
4. **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

Emergent Patterns & Scientific Machine Learning

1. **Emergent Behaviors in Synchronization and Swarming:** Conducted research on collective dynamics in complex systems. Developed and analyzed mathematical models of coupled oscillators, uncovering novel emergent states through a combination of analytical methods and large-scale simulations. Currently extending this work to networked graph systems.
2. **Crime Pattern Modeling:** Designed and implemented a finite element framework for a PDE-based burglary prediction model, integrating urban geometries and heterogeneous parameters. Proposed an efficient decoupled numerical scheme that improves robustness, validated results against agent-based simulations, and released open-source code. Current work extends the model to incorporate police response, with applications to predictive analytics and decision support in complex systems.
3. **Learning from Steady-State Patterns:** Developed a data-driven machine learning framework for system identification from limited data, including the case of a single snapshot of interacting agents. Applied regularization and distribution-based methods to address ill-conditioning, enabling reliable recovery of underlying dynamics and emergent steady-state patterns.
4. **Physics-Informed Neural Networks (PINNs):** Built data-driven solvers enforcing physics constraints to mitigate ill-conditioning and spectral bias; validated via large-scale ablation benchmarks showing improved robustness, accuracy, and training efficiency for stiff/chaotic dynamics.

Mathematical Modeling & PDE Analysis

5. **Ion Transport Modeling:** Developed and analyzed a novel Poisson–Nernst–Planck (PNP) framework with cross-diffusion and dynamic boundary conditions, applicable to ion transport in battery systems. Established global existence of weak solutions, providing rigorous mathematical validation and stability guarantees for complex electrochemical dynamics.
6. **Phase Field Model for Binary Micropolar Fluids:** Developed a thermodynamically consistent PDE framework (Navier–Stokes–Cahn–Hilliard with microrotation) incorporating non-matched densities and moving contact lines. Provided rigorous mathematical analysis by proving global existence of weak solutions for singular logarithmic and double-obstacle potentials in 3D, ensuring model stability and reliability for simulations.

Internships

2021 – 2022 **HKU Business School**, *Research Assistant*, Hong Kong.

Advisor: Dr. Qingchen Wang.

Description: Applied machine learning (LightGBM, logistic regression, NLP) and predictive analytics to large-scale electronic patient record (ePR) data covering approximately 90% of Hong Kong's 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.

Awards

2018 – 2021 Dean's List, City University of Hong Kong, Hong Kong.

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

Talks and Presentations

Sep 2025 SIAM Texas-Louisiana Sectional Meeting, Austin, TX, United States.

Title: Stability in training PINNs for stiff PDEs: Why initial conditions matter.

Apr 2025 Central AMS Sectional Meeting, Lawrence, KS, United States.

Title: Modeling and analysis of Poisson-Nernst-Planck systems with steric effects and relative drags.

Aug 2023 Summer School and Workshop on Computational & Data Science at Duke, Durham, NC, United States.

Title: Mixed sign interactions in the 1D swarmalator model.

Services

2022 – Pres. **Coordinator**, Multiscale Modeling and Computation Seminar, Illinois Tech.

2024 – 2025 **Sponsorship and Student Support Chair**, ACM HyperText 2025 Conference, Chicago, IL.

Aug 2025 **Reviwer**, AAAI Conference on Artificial Intelligence (AAAI 2025).

Dec 2025 **Reviwer**, ACM Transactions on Modeling and Computer Simulation (TOMACS).

Skills

Programming: Python, R, MATLAB, SQL.

Languages: English (Fluent), Mandarin (Native), Cantonese (Intermediate).

Others: LaTeX, Microsoft Office.