Nan Li

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Education

Ph.D. in Mathematics (candidate)	University of Minnesota	Advisor: Arnd Scheel	2022 – 2027
M.S. in Mathematics	University of Minnesota		2022 – 2024
B.S. in Mathematics	University of California Los Angeles		2020 – 2022

Research Interests

- Machine Learning
- Mathematical Biology
- Data Science
- Numerical Methods
- Partial Differential Equations
- Dynamical Systems
- Pattern Formation
- Nonlinear Waves

Technical Skills

- **Programming Languages:** Python, MATLAB, C/C++
- **Machine Learning Frameworks and Libraries:** PyTorch, NumPy, SciPy, Matplotlib, Pandas, Scikit-learn
- **Mathematical Software:** Wolfram Mathematica, LaTeX
- **Version Control:** Git, GitHub

Projects

10. **2D Allen-Cahn Equation via Modified DeepONet** — Code
    - Developed a surrogate model for the Allen-Cahn PDE by training a PyTorch-based DeepONet on data generated from a high-fidelity pseudo-spectral solver.
9. **FitzHugh Nagumo Equation via Extended Physics-Informed Neural Networks (XPINN)** — Code
    - Developed and benchmarked a domain-decomposed PINN in PyTorch, demonstrating superior accuracy over a monolithic PINN architecture for solving the stiff Fitzhugh-Nagumo ODE system.
8. **2D Kuramoto-Sivashinsky Equation via Fourier Neural Operator (FNO)** — Code
    - Implemented a Fourier Neural Operator in PyTorch to create a data-driven surrogate model for the 2D Kuramoto-Sivashinsky equation, trained on solutions generated via a pseudo-spectral solver.
7. **Burger's Equation via Physics-Informed Neural Networks (PINN)** — Code
    - Implemented a PyTorch-based Physics-Informed Neural Network to obtain a mesh-free solution to the Burgers' equation by optimizing a loss function consisting of the PDE residual and boundary conditions.
6. **Ideal Mass-Spring via Hamiltonian Neural Network (HNN)** — Code
    - Implemented a Hamiltonian Neural Network in PyTorch that enforces energy conservation to deliver superior long-term stability for dynamical systems compared to baseline MLP models.
5. **Damped Mass-Spring via Hamiltonian Neural Network (HNN)** — Code
    - Developed a Dissipative Neural Network in PyTorch that accurately models non-conservative systems by learning both the underlying dynamics and a data-driven energy dissipation function.
4. **Darcy Flow and 1D Kuramoto-Sivashinsky Equation via Fourier Neural Operator (FNO)** — Code
    - Utilized PyTorch-based Fourier Neural Operators to construct data-driven surrogate models for simulating complex systems governed by PDEs, such as Kuramoto-Sivashinsky and Darcy Flow.
3. **Advection-Diffusion via DeepONet** — Code
    - Developed a surrogate model for 1D diffusion PDE using a PyTorch-based Deep Operator Network, trained on data generated from Gaussian Random Fields.
2. **Damped Harmonic Oscillator via Neural ODE** — Code
    - Implemented a PyTorch-based Neural Ordinary Differential Equation to learn the governing vector field of a continuous dynamical system directly from noisy observational data.

1. **A Portfolio of Nonlinear Dynamics/PDE Solvers and Visualizations**
   Leveraging **Python** and **MATLAB**, this portfolio analyzes nonlinear dynamical systems and PDEs in biological and physical phenomena. It employs **numerical continuation** and **bifurcation analysis** to map stability boundaries, using **direct numerical simulation** to characterize pattern formation, complex dynamics, and **data visualization**.

- **2D Kuramoto-Sivashinsky Equation (Python)** Code
- **2D Swift-Hohenberg Equation: Stripes (Python)** Code
- **2D Cahn-Hilliard Equation: Turing Patterns (Python)** Code
- **1D and 2D Allen-Cahn Equation: Bifurcation and Patterns (Python)** Code
- **1D FitzHugh-Nagumo Equation: Pulses (Python)** Code
- **2D FitzHugh-Nagumo Equation Spirals and Turing Patterns (Python)** Code
- **Bratu Equation (Python)** Code
- **Spiral Waves in the Theta Mode (MATLAB)** Code
- **Spiral Waves in Geometric Flows (MATLAB)** Code

Publications and Preprints

4. **N. Li**, A. Scheel — 2025
   Existence and Stability of Anchored Spiral Waves in Phase Oscillators
   In preparation
3. A. Cortez, **N. Li**, N. Mihm, A. Xu, X. Yu, A. Scheel — 2025
   Instability of Anchored Spirals in Geometric Flows
   Submitted
2. **N. Li**, A. Scheel — 2024
   Anchored Spirals in the Driven Curvature Flow Approximation
   London Mathematical Society Lecture Note Series
1. M. Hill, J. Meng, **N. Li** — 2024
   Counting Compatible Indexing Systems for C_{p^n}
   Orbita Mathematicae

Talks and Presentations

2. **Anchored Spirals in the Theta Model** — May 2026
   - SIAM Conference on Nonlinear Waves and Coherent Structures — Montréal, QC, CA
1. **Anchored Spirals in Sharp-Interface and Phase Oscillator Models** (poster) — May 2025
   - SIAM Conference on Applications of Dynamical Systems — Denver, CO
   - Joint Alabama-Florida Conference on Differential Equations, Dynamical Systems and Applications — Birmingham, AL

Awards and Honors

1. **SIAM Student Travel Award** — 2025

Teaching and Mentorship

3. **Teaching Assistant, University of Minnesota** — 2022–Present
   - MATH 3593H: Honors Mathematics II — S26
   - MATH 3592H: Honors Mathematics I — F25
   - MATH 2374: Multivariable Calculus — S25, F24
   - MATH 2373: Linear Algebra and Differential Equations — S24, F23
   - MATH 1031: College Algebra & Probability — S23
   - MATH 1271: Calculus I — F22
2. **Graduate Mentor, UMN Directed Reading Program** — Spring 2025
   - Project: Physics-informed machine learning
1. **Graduate Mentor, UMN Complex Systems REU** — Summer 2024
   - Project: Transverse instability of anchored spirals