

Donghao Liu

dliu354@wisc.edu | 773-872-7463 | <https://orcid.org/0009-0004-1152-3410>

EDUCATION

University of Wisconsin–Madison

B.S. in Mathematics (Mathematics for Physical and Biological Sciences)

September 2025 – May 2027

Madison, WI

Tiangong University

Mathematics and Applied Mathematics

September 2023 – June 2025

Tianjin, China

RESEARCH EXPERIENCE

Geometric Analysis of Reaction Systems, Madison Experimental Mathematics Lab

Fall 2026

Team Member

Faculty Mentor: Gheorghe Craciun, University of Wisconsin–Madison

- Study geometric approaches to reaction systems and the Global Attractor Conjecture, with an emphasis on translating dynamical properties into geometric structures and visualizing these constructions computationally.

Evolutionary Genomics of *dgcY* in Halophilic Bacteria

Aug. 2026 – Present

Research Assistant

PI: Chunyu Yang, Shandong University

- Investigate the evolutionary origin and potential horizontal gene transfer (HGT) of *dgcY* in *Vreelandella* Y2 using comparative genomics and phylogenetic analysis.
- Screen DgcY homologs across related bacterial taxa using BLASTP and curate candidate sequences for downstream phylogenetic analysis.
- Perform multiple sequence alignment, alignment quality control, and phylogenetic reconstruction to examine gene-tree patterns across species.
- Explore methods for testing phylogenetic incongruence and distinguishing horizontal gene transfer from within-genome rearrangement.

Chemical Reaction Network Theory

Mar. 2026 – Present

Undergraduate Researcher

Research Mentor: Diego Rojas La Luz, University of Wisconsin–Madison

PI: Gheorghe Craciun, University of Wisconsin–Madison

- Study Chemical Reaction Network Theory (CRNT) and generalized CRNT, including complex-balanced systems, dynamically equivalent networks, and weakly reversible deficiency-zero realizations.
- Investigate whether epidemic ODE models admit generalized reaction-network realizations with weakly reversible or complex-balanced structure.
- Explore stability frameworks for translated and generalized reaction networks by decomposing pseudo-Helmholtz dissipation into complex-balance and kinetic-defect terms.
- Investigate weighted Horn–Jackson Lyapunov functions for generalized mass-action systems, focusing on geometric and network conditions for global stability.

Mathematical Epidemiology and Ecology

Mar. 2026 – Sep. 2026

Research Assistant

PI: Maoxing Liu, Beijing University of Civil Engineering and Architecture

- Reproduced results on recovery times in complex ecosystems and dynamical analyses of epidemic models with time delays.
- Applied methods from CRNT and generalized CRNT to mathematical epidemiology, including searches for weakly reversible deficiency-zero and complex-balanced realizations of epidemic models.
- Studied extensions of the boundary reproduction number from mathematical epidemiology to more general reaction-network settings.

Mathematical Foundations of Machine Learning

Nov. 2024 – Jan. 2025

Undergraduate Researcher

PI: Jiachen Yang, Tianjin University

- Studied Bayesian optimization methods for model-parameter tuning and reviewed theoretical frameworks underlying decision-tree algorithms.
- Focused on optimization principles and probabilistic modeling.

Research on Stirling's Formula

Jun. 2024 – Dec. 2024

Undergraduate Researcher

Research Mentor: Dan Ciubotaru, University of Oxford

- Computed volumes and surface areas of n -dimensional balls, deriving recursive formulas and using Beta and Gamma functions for asymptotic estimation.
- Applied Stirling's formula to approximate factorial expressions in limits and infinite series.
- Estimated Bernoulli numbers and analyzed error terms in asymptotic expansions.
- Conducted analytical derivations, verified results, and contributed to a co-authored publication.

PUBLICATIONS AND MANUSCRIPTS

- [1] X. Cao, **D. Liu**, T. Zhao, and J. Zhu, "Stirling's Formula: An Exploration on Its Theoretical Foundation and Applications," *Journal of Physics: Conference Series*, 3042(1), 012007, 2025. doi:10.1088/1742-6596/3042/1/012007.
- [2] H. Chen, **D. Liu**, and M. Liu, "Epidemic Dynamics and Local Spectral Optimization of Heterogeneous Migration in Metapopulation Networks with Information-Induced Degree-Class Heterogeneity," *submitted to Physica Scripta*, 2026.
- [3] **D. Liu**, "Convex Geometric Criteria for Weighted Horn–Jackson Dissipation," *Zenodo*, Preprint, 2026. doi: 10.5281/zenodo.23608863.

PRESENTATIONS

- [1] **D. Liu**, "Convex Geometric Criteria for Weighted Horn–Jackson Dissipation," *poster presentation*, Undergraduate Mathematics Symposium (UMS), University of Illinois Chicago, Chicago, IL, Nov. 2026.

SCHOLARSHIPS AND HONORS

UW Undergraduate Scholarship for Summer Study
Dean's List, University of Wisconsin–Madison

Summer 2026
 Fall 2025, Spring 2026