Fei Cao

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Current position

Visiting Researcher in Applied Mathematics, Amherst College, Amherst, MA, USA.

Research interests

- Interacting particle systems with applications to econophysics and sociophysics
- Probability theory and related fields (such as gradient-based optimization algorithms)
- Derivation of macroscopic models from microscopic interactions
- Applications of ordinary, partial, and stochastic differential equations

Employment

2025-2026 Visiting Researcher at Amherst College
2022-2025 Visiting Assistant Professor at the University of Massachusetts Amherst
2017-2022 Graduate Teaching Assistant at Arizona State University

Education

2017-2022 PH.D in Applied Mathematics, Arizona State University.
2013-2017 BACHELOR in Applied Mathematics, Southwestern University of Finance and Economics.

Publications

2020 F. Cao, S. Motsch, A. Reamy, R. Theisen, *Asymptotic flocking for the three-zone model*, Mathematical Biosciences and Engineering, AIMS Press, 17 (6) (**2020**) 7692–7707.
2021 F. Cao, *K-averaging agent-based model: propagation of chaos and convergence to equilibrium*, Journal of Statistical Physics, Springer, 184 (2) (**2021**) 1–19.
2022 F. Cao, *Explicit decay rate for the Gini index in the repeated averaging model*, Mathematical Methods in the Applied Sciences, 46 (4) (**2023**) 3583–3596.
2023 F. Cao, P-E. Jabin, S. Motsch, *Entropy dissipation and propagation of chaos for the uniform reshuffling model*, Mathematical Models and Methods in Applied Sciences, 33 (4) (**2023**) 829–875.
2023 F. Cao, S. Motsch, *Derivation of wealth distributions from biased exchange of money*, Kinetic &

Related Models, 16 (5) (**2023**) 764–794.

2023 F. Cao, S. Motsch, *Uncovering a two-phase dynamics from a dollar exchange model with bank and debt*, SIAM Journal on Applied Mathematics, 83 (5) (**2023**) 1872–1891.

2024 F. Cao, N. Marshall, *From the binomial reshuffling model to Poisson distribution of money*, Networks and Heterogeneous Media, 19 (1) (**2024**) 24–43.

2024 F. Cao, P-E. Jabin, *From interacting agents to Boltzmann-Gibbs distribution of money*, Nonlinearity, 37 (12) (**2024**) 125020.

2025 F. Cao, R. Cortez, *Uniform propagation of chaos for a dollar exchange econophysics model*, European Journal of Applied Mathematics, 36 (1) (**2025**) 27–39.

2025 F. Cao, R. Cortez, *Fractal opinions among interacting agents*, SIAM Journal on Applied Dynamical Systems, 24 (2) (**2025**) 1529–1552.

2025 F. Cao, S. Reed, *A biased dollar exchange model involving bank and debt with discontinuous equilibrium*, Mathematical Modelling of Natural Phenomena, 20 (**2025**) 5.

2025 F. Cao, S. Motsch, *Sticky dispersion on the complete graph: a kinetic approach*, SIAM Journal on Mathematical Analysis, 57 (4) (**2025**) 3953–3980.

2025 F. Cao, S. Reed, *The iterative persuasion-polarization opinion dynamics and its mean-field analysis*, SIAM Journal on Applied Mathematics, 85 (4) (**2025**) 1596–1620.

2026 F. Cao, J. Yang, *Quantitative convergence guarantees for the mean-field dispersion process*, Discrete and Continuous Dynamical Systems, 47 (**2026**) 487–518.

Submitted papers

2025 F. Cao, X. Gong, *On the equivalence between Fourier-based and Wasserstein distances for probability measures on* $\mathbb{N}$ (**2025**)

2025 F. Cao, *From Gini index as a Lyapunov functional to convergence in Wasserstein distance* (**2025**)

2025 F. Cao, *Mean-field analysis of a random asset exchange model with probabilistic cheaters* (**2025**)

2025 F. Cao, K. Johnston, T. Laurent, J. Li, S. Motsch, *Generative diffusion models from a PDE perspective* (**2025**)

2025 F. Cao, N. Loy, *The Bennati–Dragulescu–Yakovenko model in the continuous setting: PDE formulation and long-time behavior* (**2025**)

2026 F. Cao, R. Cortez, *The fractal geometry of opinion formation*

Working in progress (incomplete list)

2025 J. Brust, M. Badal, F. Cao, S. Motsch, *Natural projected flow: PDE solvers using neural networks* (tentative title).

2025 F. Cao, X. Gong, A. Keimer, *Analysis for the large-time behavior of the "Bando-Follow-the-Leader" car-following model* (tentative title).

2026 F. Cao, R. Cortez, *From opinion fragmentation to generalized Bernoulli convolution* (tentative title).

2026 F. Cao, X. Gong, *A bias-amplifying opinion dynamics and its mean-field analysis* (tentative title).

2026 F. Cao, S. Motsch, A. Mellet, M. Rozowski, A. Ullah, *Continuous Lloyd's algorithm and its PDE counterpart* (tentative title).

Teaching experience

2018 **Teaching Assistant**, *Applied Probability and Stochastic Processes*, Arizona State University
2019 **Recitation Instructor**, *Precalculus* (Math 171), Arizona State University
2020 **Teaching Assistant**, *Introduction into Deep Neural Networks*, Arizona State University
2021 **Teaching Assistant**, *Ordinary Differential Equations*, Arizona State University
2022 **Instructor**, *Calculus II*, University of Massachusetts Amherst
2023 **Instructor**, *Ordinary Differential Equations*, University of Massachusetts Amherst
2024 **Instructor**, *Calculus I*, University of Massachusetts Amherst
2025 **Instructor**, *Ordinary Differential Equations*, University of Massachusetts Amherst

Miscellaneous

2025 **2025 AMS-Simons Travel Grant** awarded by the American Mathematical Society during Summer 2025.
2025 **Visiting Scholar** in the Department of Mathematics at The Pennsylvania State University (02/13/2025 - 02/24/2025), hosted by Professor Pierre-Emmanuel Jabin.
2024 **FY25 MSP Research Support Fund** A intramural grant ($ 1,000) allocated by University of Massachusetts Amherst during 2024 - 2025 to support research-related expenses.
2023 **FY24 MSP Research Support Fund** A intramural grant ($ 1,000) allocated by University of Massachusetts Amherst during 2023 - 2024 to support research-related expenses.
2023 **Visiting Scholar** in the School of Mathematical and Statistical Sciences at Arizona State University (11/06/2023 - 11/10/2023), hosted by Associate Professor Sebastien Motsch.
2022 **Visiting Scholar** in the Department of Mathematics at The Pennsylvania State University (02/02/2022 - 02/18/2022), hosted by Professor Pierre-Emmanuel Jabin.
2023 **REU mentor** during summer 2023, the undergraduate mentee Minh Le is guided to work on gradient descent and related optimization algorithms.
2022 **Graduate Student Research Award** awarded by School of Mathematical and Statistical Sciences at Arizona State University.

Skills

- **Programming:** LaTeX, Julia, Matlab, Python
- **Language:** English (fluent), Chinese (native language), Japanese (basic), Germany (basic)

Referee Service for

- Mathematical Modelling of Natural Phenomena
- Methods and Applications of Analysis
- Networks and Heterogeneous Media
- SIAM Journal on Applied Mathematics

Invited Talks

SIAM Conference on Applications of Dynamical Systems (DS25) *Summer 2025*
Invited talk at a mini-symposium as part of the SIAM Dynamical Systems conference held from May 11 to May 15, 2025 in Denver, Colorado, USA.
Financial Mathematics Seminar at Worcester Polytechnic Institute *Spring 2025*
Invited talk at on March 31, 2025 at Worcester Polytechnic Institute, Worcester, Massachusetts, USA.
Dynamical Systems Seminar at Boston University *Spring 2025*
Invited talk on March 24, 2025 at Boston University, Boston, Massachusetts, USA.
Tufts Ergodic and Dynamical Systems Seminar *Fall 2023*
Invited talk on November 28, 2023 at Tufts University, Boston, Massachusetts, USA.

Conferences and Summer Schools

2025 Seminar on Stochastic Processes *Spring 2025*
Three days conference on stochastic processes at Indiana University Bloomington, Bloomington, USA.
ICERM Topical Workshop "Patterns, Dynamics, and Data in Complex Systems" *Winter 2025*
Four days workshop on patterns, dynamics, and data in complex systems at the Institute for Computational and Experimental Research in Mathematics, Rhode Island, USA.
New England Dynamics Seminar 2024 *Fall 2024*
A joint one-day seminar on dynamical systems and PDEs at the University of Massachusetts Amherst, Amherst, USA.
ICERM Topical Workshop "Robust Optimization and Simulation of Complex Stochastic Systems" *Fall 2024*
Three days workshop on optimization and simulation of stochastic systems at the Institute for Computational and Experimental Research in Mathematics, Rhode Island, USA.
Graduate Student Probability Conference 2024 *Fall 2024*
Two days conference on probability theory at University of Wisconsin–Madison, Madison, USA.
13th Cornell Probability Summer School *Summer 2024*
Two weeks workshop on probability theory and related fields at Cornell University, Ithaca, USA.
Recent Progress in Stochastic Analysis and its Applications *Summer 2024*
One week workshop on stochastic analysis at Loyola University Chicago, Chicago, USA.
Mathematical Problems in Industry (MPI) Workshop *Summer 2024*
One week workshop on problems of interest to science and industry at the University of Vermont, Burlington, USA.
The 52nd John H. Barrett Memorial Lectures *Summer 2024*
Three days workshop on stochastic analysis and its application at the University of Tennessee, Knoxville, USA.
ICERM Topical Workshop "Interacting Particle Systems: Analysis, Control, Learning and Computation" *Spring 2024*
One week workshop on interacting particle systems at the Institute for Computational and Experimental Research in Mathematics, Rhode Island, USA.
49th Annual New York State Regional Graduate Mathematics Conference *Spring 2024*
One day conference on mathematics focusing on graduate research at Syracuse University, Syra-

cuse, USA.

2024 Seminar on Stochastic Processes *Spring 2024*
Three days conference on stochastic processes at Rice University, Houston, USA.

Probability and Algebra: New Expressions in Mathematics *Summer 2023*
One week workshop in analysis and probability at Texas A&M University, Texas, USA.

21st International Conference on Random Structures & Algorithms *Summer 2023*
One week conference on random structures and algorithms at Carnegie Mellon University, Pennsylvania, USA.

Current Developments in Mathematics 2023 *Spring 2023*
Two days conference on mathematics at Harvard University, Boston, USA.

2023 Seminar on Stochastic Processes *Spring 2023*
Three days conference on stochastic processes at University of Arizona, Tucson, USA.

2022 Fall Eastern Sectional Meeting *Fall 2022*
Two days AMS sectional meeting at University of Massachusetts Amherst, Amherst, USA.

2022 PIMS-IFDS-NSF Summer School on Optimal Transport *Summer 2022*
Two weeks summer school on optimal transport at Seattle, Washington, USA.

2022 MRC Conference: Data Science at the Crossroads of Analysis, Geometry, and Topology *Summer 2022*
One week workshop on mathematics, statistics, and related fields at Beaver Hollow Conference Center, Java Center, NY, USA.

2022 Seminar on Stochastic Processes *Spring 2022*
Three days conference on stochastic processes at Lehigh University, Pennsylvania, USA.

2021 Frontier Probability Days *Fall 2021*
Three days conference on probability theory and related fields at University of Nevada, Las Vegas, USA.

2021 Blackwell Tapia Conference *Fall 2021*
Three days conference focusing on diversity in mathematics at UCLA, California, USA.

2021 CRM-PIMS Summer School in Probability (Online) *Summer 2021*
Four weeks graduate summer school at the Mathematical Sciences Research Institute (MSRI), Canada.

2021 Summer Program in Partial Differential Equations (Online) *Summer 2021*
Two weeks of concentrated study of topics in analysis at graduate level, USA.

2021 AMS Short Course on Mathematical and Computational Methods for Complex Social Systems (Online) *Spring 2021*
Three days short course at the American Mathematical Society (AMS), USA.

2020 Introduction to water waves graduate summer school (Online) *Summer 2020*
Two weeks graduate summer school at the Mathematical Sciences Research Institute (MSRI), Berkeley, USA.

2020 Summer School: Ergodic Theory via Continued Fractions (Online) *Summer 2020*
One week graduate summer school at the University of North Carolina Greensboro, North Carolina, USA.

2020 Hot Topics: Optimal transport and applications to machine learning and statistics (Online) *Summer 2020*
One week workshop at the Mathematical Sciences Research Institute (MSRI), Berkeley, USA.

45-th Annual New York State Regional Graduate Mathematics Conference (Online) *Spring 2020*
One day conference on mathematics focusing on graduate research at Syracuse University, Syra-

cuse, USA.

2020 Seminar on Stochastic Processes *Spring 2020*
Three days seminar on stochastic processes at the Michigan State University, Michigan, USA.

2019 AARMS Summer School on Dynamical Systems, Differential Equations, and Special Functions *Summer 2019*
Four weeks summer school on dynamical systems, differential equations, and special functions at Charlottetown, Prince Edward Island, Canada.

2019 RMMC Summer School on Inverse Problems in Imaging *Summer 2019*
One week summer school on inverse problems at Laramie, Wyoming, USA.

2019 Interacting Particle Systems, Statistical Mechanics and Related Topics *Spring 2019*
Three days conference on interacting particle systems at UCLA, California, USA.

2018 Advances in Asymptotic Probability *Winter 2018*
One week conference on theory of Asymptotic Probability at Stanford, California, USA.

2018 Institute for Advanced Study *Summer 2018*
IAS/PCMI 2018: Harmonic Analysis, Park City, Utah, USA.

2018 Boston City Limits *Summer 2018*
Two weeks summer School on Mathematical General Relativity and the Geometric Analysis of Waves of Fluids at MIT, Boston, USA.

Short Course on Free Boundary Problems *Summer 2017*
Free boundary problems in mathematical finance, Cheng Du, China.

References

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