Norman M. Cao, Ph.D.

Plasma Physicist | Scientific Computing | Cross-Domain Expertise

https://maplenormandy.github.io/
maplenormandy@gmail.com
(631)-383-2142

SUMMARY

Plasma physicist and computational scientist with expertise in data-driven modeling, experimental uncertainty quantification, and establishing cross-domain collaboration efforts. Research spans plasma turbulence, geophysical fluid dynamics, and dynamical systems, with a consistent theme of connecting theoretical insight with data-driven modeling. Grounding experiences from carrying out experimental validation studies for plasma turbulence models, and engineering design studies for integrated fusion power plant design. Machine learning background centers on Bayesian inference and Gaussian process-based methods, with exploratory experience training small physics-informed neural network models.

PROFESSIONAL EXPERIENCE

Research Fellow

Institute for Fusion Studies, UT Austin (2023–Present)

- Implemented theory + data-driven Python/JAX-accelerated methods to reproduce turbulent mixing patterns in terabyte-scale particle-in-cell simulation datasets in realistic scenarios with high-fidelity tokamak geometry
- Developed and applied metrics for certifying the effective resolution and credibility of Gaussian process-based profile regression, enabling robust inference of fine-scale features from experimental plasma measurements
- *(Manuscript in progress)* Derived rigorous geometric model reduction techniques for speedup of simulation of coupled multi-physics systems with multiple timescales

Courant Instructor (Non-Tenure Track Asst. Professor)

Courant Institute of Mathematical Sciences, NYU (2020–2023)

- Built cross-disciplinary collaborations across geophysical fluid dynamics, plasma physics, and pure & applied mathematics as a faculty fellow in the Simons Collaboration on Wave Turbulence
- Received *Joseph B. Keller Postdoctoral Fellowship* (2022-2023) for innovative work combining theoretical physics & data-driven methods for explaining pattern formation in turbulence
- Wrote and deployed MPI-accelerated simulation post-processing code on HPC for reduced order modeling developed using theoretical insights from physical symmetries

Research Assistant

Plasma Science and Fusion Center, MIT (2015–2020)

- Designed and led “hysteresis” experiments on the Alcator C-Mod tokamak, providing controlled comparison of plasma turbulence across differing regimes to validate turbulence models against experiment
- Co-led thermo-fluid analysis team in ~15-person engineering design study using COMSOL for heat exhaust in integrated ARC fusion pilot plant design, leading to highly-cited foundational publication in the field
- Responsible for development and maintenance of IDL codebase for x-ray spectroscopy data analysis suite, contributing data and expertise to 20 publications led by 8 different authors

Industry Internships

- Mission Assurance Intern at SpaceX (Summer 2014);
- Flight Systems Engineering Intern at NASA JPL (Summer 2013)

EDUCATION

Ph.D. in Applied Plasma Physics, Massachusetts Institute of Technology, Cambridge, MA (2015-2020)
B.S. in Aerospace Engineering and Physics, Massachusetts Institute of Technology, Cambridge, MA (2011-2015)

SKILLS

Scientific Computing: Python, JAX, MPI, HPC workflows, matplotlib, git, MATLAB, COMSOL
Statistics & ML: Gaussian process regression, topological data analysis, Bayesian inference
Experimental Physics: experimental design, plasma diagnostics, x-ray spectroscopy

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PUBLICATIONS

Complete bibliography available online: https://scholar.google.com/citations?user=WQRmB8MAAAAJ

Geometric Mechanics

1. **N. M. Cao**, I. A. Maldonado, J. W. Burby, M. Leok, "Geometric Slow Manifold Reduction for Multi-Component Systems with Contrasting Asymptotics", *(manuscript under preparation for submission to J. Nonlinear Sci.)*

Bayesian Inference and Machine Learning

2. **N. M. Cao**, D. R. Hatch, C. Michoski, T. A. Oliver, D. Eldon, A. O. Nelson, M. Waller, "Quantifying Resolution Limits in Pedestal Profile Measurements with Gaussian Process Regression", *Nucl. Fusion* **66**, 026016 (2026)
3. **N. M. Cao** and F. Sciortino, "Bayesian Spectral Moment Estimation and Uncertainty Quantification", *IEEE Trans. Plasma Sci.* **48**, 22 (2020).

Fluid and Plasma Turbulence Modeling

4. **N. M. Cao**, H. Zhu, G. C. Grime and T. Stoltzfus-Dueck, "Detecting Shearless Phase-Space Transport Barriers in Global Gyrokinetic Turbulence Simulations with Test Particle Map Models", *J. Plasma Phys.* **92**, E17 (2026)
5. **N. M. Cao** and D. Qi, "The maintenance of coherent vortex topology by Lagrangian chaos in drift-Rossby wave turbulence", *Phys. Fluids* **36**, (2024).
6. **N. M. Cao** and D. Qi, "Nearly integrable flows and chaotic tangles in the Dimits shift regime of plasma edge turbulence", *Phys. Plasmas* **30**, (2023).
7. **N. M. Cao**, "Rossby waves past the breaking point in zonally-dominated turbulence", *J. Fluid Mech.* **958**, A28 (2023).

Experimental Plasma Physics

8. **N. M. Cao**, J. E. Rice, P. H. Diamond, A. E. White, M. A. Chilenski, P. C. Ennever, J. W. Hughes, J. Irby, M. L. Reinke, and P. Rodriguez-Fernandez, "Evidence and modeling of turbulence bifurcation in L-mode confinement transitions on Alcator C-Mod", *Phys. Plasmas* **27**, 052303 (2020).
9. **N. M. Cao**, J. E. Rice, P. H. Diamond, A. E. White, S. G. Baek, M. A. Chilenski, J. W. Hughes, J. Irby, M. L. Reinke, and P. Rodriguez-Fernandez, "Hysteresis as a probe of turbulent bifurcation in intrinsic rotation reversals on Alcator C-Mod", *Nucl. Fusion* **59**, 104001 (2019).

Fusion Reactor Engineering

10. A. Q. Kuang, **N. M. Cao**, A. J. Creely, C. A. Dennett, J. Hecla, B. LaBombard, R. A. Tinguely, E. A. Tolman, H. Hoffman, M. Major, J. Ruiz Ruiz, D. Brunner, P. Grover, C. Laughman, B. N. Sorbom, and D. G. Whyte, "Conceptual design study for heat exhaust management in the ARC fusion pilot plant", *Fusion Eng. Des.* **137**, 221 (2018).

SELECTED PRESENTATIONS

- "Nearly-Laminar Flows and Coherent Structures in Fusion Plasma Turbulence", KAIST seminar; March 25, 2024; Daejeon, South Korea
- *Invited Talk:* "Hysteresis as a Probe of Turbulent Bifurcation in Intrinsic Rotation Reversals on Alcator C-Mod", 61st APS-DPP Meeting; October 21-25, 2019; Fort Lauderdale, Florida
- ***Best Student Poster Prize Winner:*** "Observation and Quasilinear Modeling of Rotation Reversal Hysteresis in Alcator C-Mod Plasmas", 24th Joint US-EU Transport Task Force Meeting; March 18-21, 2019; Austin, Texas
- *Invited Talk:* "Observation and Quasilinear Modeling of Rotation Reversal Hysteresis in Alcator C-Mod Plasmas", 2nd Asia-Pacific Conference on Plasma Physics; November 12-17, 2018; Kanazawa, Japan

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HONORS AND AWARDS

- Joseph B. Keller Postdoctoral Fellowship *Sep 2022*
- Promising Young Scientist Prize at 10th Festival de Théorie in Aix-en-Provence *Jul 2019*
- Best Student Poster Prize at 24th Joint US-EU Transport Task Force Meeting *Mar 2019*
- Student Festival Fellow at 9th Festival de Théorie in Aix-en-Provence *Jul 2017*
- U.S. NRC Nuclear Education Graduate Fellowship Recipient *Sep 2016*

TEACHING

Instructor of Record:

- NYU Courant
  - MATH-UA 140 (Linear Algebra) *Fall 2020*
  - MATH-UA 148 (Honors Linear Algebra) *Spring 2022*
  - MATH-UA 325 (Analysis) *Spring 2021, Fall 2021, Fall 2022*
- NYU Tandon
  - MA-UY 4414 (Applied Partial Differential Equations) *Spring 2023*
- Sample syllabi available at https://maplenormandy.github.io/teaching/

Teaching Assistantships:

- TA for MIT 22.63 (Engineering Principles for Fusion Reactors) *Fall 2018*
- Lab Instructor for MIT 2.00b (Toy Product Design) *Spring 2018*

Students Mentored:

- Ivan Maldonado (UT Austin grad. *Sep 2025 – current*)
- Weiyu Lin (UT Austin undergrad. *Sep 2023 – Sep 2024): Using Computer Vision to find Wave-like Behavior in Fluids*
- Tanuj Sistla (NYU undergrad. *Jan – May 2023*): *Using Computer Vision to Track Coherent Vortices in Fusion Plasma Turbulence*
- Sander Miller (high school student. *Oct 2020 – Nov 2021*): *The Effects of Core-Edge Temperature Gradients on Intrinsic Rotation during H-Mode in Tokamak Reactors*