ALAN A. KAPTANOGLU

Assistant Professor, Courant Institute, NYU
Affiliate Assistant Professor**,** Mechanical Engineering, University of Washington

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RESEARCH INTERESTS

- Plasma physics and nuclear fusion, including stellarators, optimization, and control.
- Computational physics and high performance computing, with emphasis on high-dimensional, nonconvex, and constrained optimization.
- Reduced-order models and machine-learning.
- Control theory, dynamical systems, and nonlinear stability theory.

EDUCATION

University of Washington, Seattle WA
Doctor of Philosophy in Physics, 2021

PhD Thesis: An Exploration of Data-Driven System Identification and Machine Learning for Plasma Physics

PhD advisor: Professor Steven Brunton

Stanford University, Stanford CA
Bachelor of Science in Physics, Theoretical Concentration, 2016

AWARDS & HONORS

- Next-Generation follow-on grant awardee, 2021-2022
- Next-Generation Fellowship, Physicists Coalition for Nuclear Threat Reduction, 2020-2021
- APS Five Sigma Physicist Award, 2021
- Best student presentation award, Sherwood Fusion Theory Conference, 2021
- Outstanding graduate student TA, with Distinction, 2019
- NSF GRFP Honorable Mention, 2018

PROFESSIONAL EXPERIENCE

Assistant Professor, Mathematics, Courant Institute, NYU, Sept. 2023 - current
Research in plasma physics, including in stellarator optimization and nonlinear dynamics.

Postdoctoral Researcher, University of Maryland, College Park, Mar. 2022 - July 2023
Research in high-dimensional, constrained optimization, greedy algorithms, and other techniques for stellarators with Dr. Matt Landreman. Research in machine learning, including supervision of a graduate student project on physics-informed neural networks.

Affiliate Assistant Professor, University of Washington, Mar. 2022 - current
Research in sparse system identification techniques and nonlinear stability theory, including supervision of an undergraduate senior thesis project and masters thesis project.

Postdoctoral Researcher, Brunton Lab, University of Washington, Jan. 2022 - Mar. 2022
Research in sparse system identification techniques and nonlinear stability theory.

Plasma Physics Internship, PPPL, Princeton, Jan. 2017 - May 2017
Performed 2D scrape-off-layer simulations of the PFRC fusion device with the UEDGE code. Performed full 3D particle-in-cell calculations of the PRFC device with the LSP code.

Particle Physics Internship, DOE-INFN Program, Bologna, Italy, Sep. 2016 - Nov. 2016
Optimized supervised clustering algorithms for top quark jets at CERN.

Plasma Physics Internship, LLNL, Livermore, June 2015 - Sep. 2015
Performed 2D fluid simulations of inertial confinement fusion (ICF) implosions. Co-Authored "Evaluating the suitability of BLAST, a High Order Finite Element Hydro Code, for running ICF implosions", which was accepted at the classified 2015 NEDPC Conference.

JOURNAL PUBLICATIONS

314 Google scholar citations; h-index 7; i10-index 7

Published Articles:

1. **A. Kaptanoglu**, C. Hansen, J. Lore, M. Landreman, and S. Brunton
Sparse regression for plasma physics
Physics of Plasmas, 2023 - ***Selected as an Editor's Suggestion paper.***

2. **A. Kaptanoglu**, L. Zhang, Z. Nicolaou, U. Fasel, S. Brunton
Benchmarking sparse system identification with low-dimensional chaos
Nonlinear Dynamics, 2023.

3. J. Lore, S. De Pascuale, P. Laiu, B. Russo, J.S. Park, J.M. Park, S. Brunton, J.N. Kutz, and **A. Kaptanoglu**
Time-Dependent SOLPS-ITER Simulations of the Tokamak Plasma Boundary for Model Predictive Control using SINDy
Nuclear Fusion, 2023.

4. **A. Kaptanoglu**, R. Conlin, and M. Landreman
Greedy permanent magnet optimization
Nuclear Fusion, 2023.

5. **A. Kaptanoglu**, T. Qian, F. Wechsung, and M. Landreman
Permanent magnet optimization for stellarators as sparse regression
Physical Review Applied, 2022 - ***Selected as an Editor's Suggestion paper***.

6. J. Brooks, M. McDonald, and **A. Kaptanoglu**
A comparison of Fourier and POD mode decomposition methods for high-speed Hall thruster video
Frontiers in Space Technologies, 2022.

7. **A. Kaptanoglu**, B. de Silva, U. Fasel, K. Kaheman, A. Goldschmidt, J. Callaham, C. Delahunt, Z. Nicolaou, K. Champion, J.C. Loiseau, and J.N. Kutz
PySINDy: A comprehensive Python package for robust sparse system identification
Journal of Open Source Software, 2022.

8. **A. Kaptanoglu,** A. Jalalvand, A. Garcia, M. Austin, G. Verdoolaege, J. Schneider, C. Hansen, S. Brunton, W. Heidbrink, E. Kolemen
Exploring data-driven models for spatiotemporally local classification of Alfvén eigenmodes.
Nuclear Fusion, 2022.

9. M. Fenstermacher, J. Abbate, S. Abe, T. Abrams, …, **A. Kaptanoglu**, et al.
DIII-D research advancing the physics basis for optimizing the tokamak approach to fusion energy
Nuclear Fusion, 2022.

10. **A. Kaptanoglu**, J. Callaham, A. Aravkin, C. Hansen, and S. Brunton
Promoting global stability in data-driven models of quadratic nonlinear dynamics
Phys. Rev. Fluids, 2021 - ***Selected as an Editor's Suggestion paper***.

11. **A. Kaptanoglu**, K. Morgan, C. Hansen, and S. Brunton
Physics-constrained, low-dimensional models for magnetohydrodynamics: First-principles and data-driven approaches
Physical Review E, 2021.

12. A. Jalalvand, **A. Kaptanoglu,** A. Garcia, A. Nelson, J. Abbate, M. Austin, G. Verdoolaege, S. Brunton, W. Heidbrink, E. Kolemen.
Alfvén eigenmode classification based on ECE diagnostics at DIII-D using deep recurrent neural networks
Nuclear Fusion, 2021.

13. **A. Kaptanoglu,** K. Morgan, C. Hansen, and S. Brunton
Characterizing magnetized plasmas with dynamic mode decomposition
Physics of Plasmas, 2020.

14. **A. Kaptanoglu**, T. Benedett, K. Morgan, C. Hansen, and T. Jarboe
Two-temperature effects in Hall-MHD simulations of the HIT-SI experiment
Physics of Plasmas, 2020.

Preprints:

15. C. Oishi, **A. Kaptanoglu**, J.N. Kutz, S. Brunton
Nonlinear parametric models of viscoelastic fluid flows
arXiv:2308.04405, 2023.

16. **A. Kaptanoglu**, G. Langlois, M. Landreman
Topology optimization for inverse magnetostatics as sparse regression: application to electromagnetic coils for stellarators
arXiv:2306.12555, 2023.

17. **A. Kaptanoglu**, K. Morgan, C. Hansen, and S. Brunton.
The structure of global conservation laws in Galerkin plasma models
arXiv:2101.03436, 2021.

General Audience Articles:

18. **A. Kaptanoglu**, S. Prager
US defense to its workforce: Nuclear war can be won
Bulletin of the Atomic Scientists, 2022.

19. S. Prager, **A. Kaptanoglu**
Rebuttal: Current nuclear weapons policy not safe or sane
Bulletin of the Atomic Scientists, 2022.

PRESENTATIONS & INVITED TALKS

Invited Talks:

1. **A. Kaptanoglu**, C. Hansen, S. Brunton, and M. Landreman
Bringing advanced sparse system identification to plasma physics
Bulletin of the American Physical Society, APS Division of Plasma Physics (2022)

2. **A. Kaptanoglu**, J. Callaham, C. Hansen, S. Brunton, UW data-driven dynamics lab

Machine Learning for discovering sparse models of fluids, plasmas, and much more.
2nd Machine Learning in Heliophysics Conference (2022)

3. **A. Kaptanoglu**, J Callaham, A. Aravkin, C. Hansen, and S. Brunton
Promoting global stability in data-driven models of quadratic nonlinear dynamics
Physical Review Fluids Journal Club (2021)

Contributed Talks:

4. **A. Kaptanoglu**, J. Callaham, C. Hansen, and S. Brunton
Machine Learning to Discover Interpretable Models in Fluids and Plasmas
Bulletin of the American Physical Society, APS March Meeting (2022)

5. **A. Kaptanoglu**, J. Callaham, K. Morgan, C. Hansen, A. Aravkin, and S. Brunton.
Data-driven, interpretable plasma models
Sherwood Fusion Theory Conference (2021). ***Award for best student presentation.***

6. **A. Kaptanoglu**, K. Morgan, C. Hansen, and S. Brunton.
Physics-constrained data-driven methods in MHD
Bulletin of the American Physical Society (2020). Presented at APS DFD, 2020 and APS DPP, 2020.

Academic Posters:

7. **A. Kaptanoglu**, A. Jalalvand, A. Garcia, A. Nelson, J. Abbate, G. Verdoolaege, S. Brunton, W. Heidbrink, and E. Kolemen
Spatially-localized Alfvén eigenmode classification using convolutional neural networks.
Bulletin of the American Physical Society. *APS Division of Plasma Physics* (2021)

8. **A. Kaptanoglu**, T. Benedett, C. Hansen, K. Morgan, T. Jarboe
Two temperature effects in the HIT-SI experiment
Bulletin of the American Physical Society, APS Division of Plasma Physics (2019)

FUNDING

$600k NSF/DOE. Improving Interpretable Machine Learning for Plasmas: Towards Physical Insight, Data-Driven Models, and Optimal Sensing. (PI: Chris Hansen, co-PI: Steven Brunton)
Led the conception and execution of this successful NSF/DOE proposal.

XSEDE Startup Allocation PHY180064. Computational Feedback Control for HITSI, 2019-2020, 100,000 SUs, 1,500 GB storage, PI Alan Kaptanoglu.
Wrote a successful proposal for a startup allocation through NSF's XSEDE program.

XSEDE Startup Allocation PHY180064 (Renewal). Simulation and feedback control for liquid metal divertors, 2020-2021, 50,000 SUs, 1,000 GB storage, PI Alan Kaptanoglu.
Wrote a successful renewal proposal for a startup allocation through NSF's XSEDE program.

MENTORING & ADVISING

Graduate student projects:

Byoungchan Jang, *Physics-informed neural networks for forward and inverse MHD equilibrium calculations*, 2022 - current.

Mai Peng, *Promoting local and global stability in data-driven fluid models*, 2022 - current.

Undergraduate projects:

Lanyue Zhang, *Evaluation of sparse regression techniques on a large database of chaotic, polynomial dynamical systems*, 2022 - 2023.

Zachary Daniel, *Analytic and data-driven circuit models for the HIT-SI plasma experiments.* 2022 - current.

Xi Liu, *Improving the stability and robustness of system identification using the N-step prediction error.* 2023 - current.

TEACHING

Instructor, NYU:

- Numerical Analysis I, Fall 2023, 35 students.
- A crash in magnetohydrodynamics, Spring 2023.

Instructor, University of Washington:

- ME564 - Mechanical Engineering Analysis I,
  Fall 2022, 158 students, co-taught with Professor Steven Brunton.

Teaching Assistant, University of Washington:

- PHYS228: Elementary Mathematical Physics, Winter 2017
- PHYS115: Heat, Fluids and Electricity and Magnetism, Fall 2017
- PHYS121: Mechanics (three sections), Fall 2017

Awarded outstanding graduate student TA, with Distinction, 2019

Teaching Assistant, Stanford University:

- PHYS 45: Light and Heat, Fall 2015

Video abstracts and Tutorials:

YouTube channel metrics: 850+ subscribers, 35000+ views, 1800+ hours watched

1. PySINDy Tutorial Videos - How to effectively use the SINDy method for system identification
   A. Kaptanoglu, B. de Silva, U. Fasel, K. Kaheman, A. Goldschmidt, J. Callaham, C. Delahunt, Z. Nicolaou, K. Champion, J.C. Loiseau, and J.N. Kutz
   Journal of Open Source Software, 2022

2. Permanent Magnet Optimization
   A. Kaptanoglu, T. Qian, F. Wechsung, and M. Landreman
   Physical Review Applied (2022).
   A. Kaptanoglu, Rory Conlin, and Matt Landreman
   Nuclear Fusion (2023).

3. Promoting global stability in data-driven models of quadratic nonlinear dynamics
   A. Kaptanoglu, J. Callaham, A. Aravkin, C. Hansen, and S. Brunton
   Phys. Rev. Fluids (2021)

4. Physics-constrained, low-dimensional models for magnetohydrodynamics: First-principles and data-driven approaches
   A high level view of reduced order modeling for plasmas
   A. Kaptanoglu, K. Morgan, C. Hansen, and S. Brunton
   Physical Review E (2021)

5. Characterizing magnetized plasmas with dynamic mode decomposition
   A. Kaptanoglu, K. Morgan, C. Hansen, and S. Brunton
   Physics of Plasmas (2020)

6. Two-temperature effects in Hall-MHD simulations of the HIT-SI experiment

A. Kaptanoglu, T. Benedett, K. Morgan, C. Hansen, and T. Jarboe
Physics of Plasmas (2020)

SOFTWARE

Software contributions below include only packages for which I have contributed roughly 10,000 lines of code or more.

PySINDy for sparse system identification. Developed by myself, Brian de Silva, Kathleen Champion, and many others. Annually has ~500 unique clones, ~65,000 views, and ~13,000 unique visitors.

SIMSOPT for stellarator optimization. Development led by Dr. Matt Landreman. Annually has ~1,040 unique clones, ~39,000 views, and ~1,300 unique visitors.

SERVICE

- Ally training and role during the APS DPP annual meeting, 2021, 2022
- President, Research Computing Club @ UW, 2020-2021
- Training Coordinator, Research Computing Club @ UW, 2019-2020
- XSEDE EMPOWER Program Application Reviewer, 2019-2021
- XSEDE EMPOWER Program Mentor, 2019-2020
- Volunteer, 350 Seattle, 2019-2021
- Volunteer, Washington Against Nuclear Weapons, 2019-2021
- Volunteer, Physicists for Diversity and Inclusion (PIE), 2018-2019