# ALAN A. KAPTANOGLU

Post-doctoral Researcher, Landreman Group
Affiliate Assistant Professor**,** 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

**Postdoctoral Researcher,** University of Maryland, College Park, Mar. 2022 - current
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

175 Google scholar citations; h-index 6; i10-index 4

## Published Articles:

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

2. **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***.

3. **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

4. **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).

5. 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).

6. **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***.

7. **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)

8. 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)

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

10. **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:

11. J. Brooks, M. McDonald, and **A. Kaptanoglu**
    A comparison of Fourier and POD mode decomposition methods for high-speed Hall thruster video
    *arXiv:2205.14207* (2022)

12. **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:

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

14. 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.

## Master thesis projects:

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

## Undergraduate senior thesis projects:

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

# TEACHING

### Instructor, University of Washington:

- ME564 - Mechanical Engineering Analysis I,
  Fall 2022, 145 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: 650+ subscribers, 22000+ views, 1000+ hours watched, 98%+ likes vs dislikes

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