

# SHAOWU PAN

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## RESEARCH INTERESTS

- Deep learning for fluid mechanics
- High fidelity simulations for compressible turbulence
- Data-driven methodology for modeling and control of turbulent flows
- Parametric reduced-order modeling for complex dynamical systems
- Operator-theoretic methods for nonlinear dynamical systems

## AFFILIATIONS

**Rensselaer Polytechnic Institute**, Troy, NY, USA Aug. 2022 – present  
*Assistant Professor of Mechanical Engineering*

## ACADEMIC EXPERIENCES

**University of Washington**, Seattle, WA, USA Jan. 2021 – Aug. 2022  
*Postdoctoral Scholar*, AI Institute in Dynamic Systems  
Mentors: J. Nathan Kutz, Steven Brunton

## EDUCATION

**University of Michigan**, Ann Arbor, Michigan, USA Sep. 2016 – Apr. 2021  
*Ph.D. in Aerospace Engineering and Scientific Computing*

- Thesis: Operator theoretic learning and decomposition of non-linear dynamics
- Advisor: Karthik Duraisamy

**University of Michigan**, Ann Arbor, Michigan, USA Sep. 2014 – Dec. 2015  
*M.S.E. in Mechanical Engineering*

- Topic: Role of bulk viscosity on compressible isotropic turbulence
- Advisor: Eric Johnsen

**Beihang University**, Beijing, China Sep. 2009 – July. 2013  
*B.E. in Aerospace Engineering & B.S. in Applied Mathematics (dual)*

- Thesis: Combustion heat-release effects on supersonic compressible turbulent boundary layers
- Advisor: Chun-hian Lee

## HONORS AND AWARDS

Chinese Outstanding Student Abroad Award	2021
Richard and Eleanor Towner Prize for Outstanding Ph.D. Research (Nominee)	2019
Honorable Mention in Student Poster Competition in MICDE symposium	2019
SIAM Student Travel Grant	2018
MICDE Fellowship, University of Michigan, Ann Arbor	2018
Doctoral Fellowship, University of Michigan, Ann Arbor	2016
Rackham Summer Award, University of Michigan, Ann Arbor	2015
Outstanding Undergraduate Thesis Winner in Fluid Mechanics	2013
Outstanding Student of Beihang University	2012

JOURNAL  
PUBLICATIONS

- [12] **Shaowu Pan**, Steven Brunton, Nathan Kutz,  
Neural Implicit Flow: a mesh-agnostic representation paradigm of spatio-temporal fields  
*Journal of Machine Learning Research (under review)*
- [11] Qi Gao, **Shaowu Pan**, Hongping Wang, Runjie Wei, and Jinjun Wang.  
Particle reconstruction of volumetric particle image velocimetry with strategy of machine learning.  
*Advances in Aerodynamics* (2021)
- [10] Weiqi Ji, Weilun Qiu, Zhiyu Shi, **Shaowu Pan**, and Sili Deng  
Stiff-PINN: Physics-Informed Neural Network for Stiff Chemical Kinetics  
*Journal of Physical Chemistry A* (2021)
- [9] **Shaowu Pan**, Nicholas Arnold-Medabalimi, and Karthik Duraisamy.  
Sparsity-promoting algorithms for the discovery of informative Koopman invariant subspaces  
*Journal of Fluid Mechanics* 917 (2021)
- [8] **Shaowu Pan**, and Eric Johnsen.  
The role of bulk viscosity on the decay of compressible, homogeneous, isotropic turbulence  
*Journal of Fluid Mechanics* 833 (2017): 717-744.
- [7] **Shaowu Pan**, and Karthik Duraisamy.  
Physics-Informed Probabilistic Learning of Linear Embeddings of Non-linear Dynamics With Guaranteed Stability.  
*SIAM Journal on Applied Dynamical Systems* 19, no. 1 (2020): 480-509.
- [6] **Shaowu Pan**, and Karthik Duraisamy.  
Data-driven Discovery of Closure Models  
*SIAM Journal on Applied Dynamical Systems* 17, no. 4 (2018): 2381-2413.
- [5] **Shaowu Pan**, and Karthik Duraisamy.  
On the Structure of Time-delay Embedding in Linear Models of Non-linear Dynamical Systems  
*Chaos: An Interdisciplinary Journal of Nonlinear Science* 30, 073135 (2020).
- [4] **Shaowu Pan**, and Karthik Duraisamy.  
Long-time predictive modeling of nonlinear dynamical systems using neural networks  
*Complexity* (invited), (2018).
- [3] Luning Sun, Han Gao, **Shaowu Pan**, and Jian-Xun Wang.  
Surrogate Modeling for Fluid Flows Based on Physics-Constrained Deep Learning Without Simulation Data.  
*Computer Methods in Applied Mechanics and Engineering* 361 (2020): 112732. (**Fifth most downloaded article between 06/2020 to 09/2020.**)
- [2] Saakaar Bhatnagar, Yaser Afshar, **Shaowu Pan**, Karthik Duraisamy, and Shailendra Kaushik.  
Prediction of Aerodynamic Flow Fields Using Convolutional Neural Networks.  
*Computational Mechanics* (invited), 64, no. 2 (2019): 525-545.

[1] Zhenxun Gao, Chongwen Jiang, **Shaowu Pan**, and Chun-Hian Lee.  
Combustion Heat-Release Effects on Supersonic Compressible Turbulent Boundary Layers.  
*AIAA Journal* 53, no. 7 (2015): 1949-1968.

CONFERENCE  
PAPERS

[4] Anand Pratap Singh, **Shaowu Pan**, and Karthik Duraisamy.  
Characterizing and improving predictive accuracy in shock-turbulent boundary layer interactions  
using data-driven models.  
*55th AIAA Aerospace Sciences Meeting*, p. 0314. 2017.

[3] Karthik Duraisamy, Anand Pratap Singh, and **Shaowu Pan**.  
Augmentation of turbulence models using field inversion and machine learning  
*55th AIAA Aerospace Sciences Meeting*, p. 0993. 2017.

[2] Ning Zhou, Yuanhao Wu, Wenbin Han, and **Shaowu Pan**.  
An extended CFD model to predict the pumping curve in low pressure plasma etch chamber  
*29th International Symposium on Rarefied Gas Dynamics*, AIP Conference Proceedings, vol. 1628,  
no. 1, pp. 1378-1383. American Institute of Physics, 2014.

[1] **Shaowu Pan**, Zhenxun Gao, and Chunhian Lee.  
Numerical investigation of rarefaction effects in the vicinity of a sharp leading edge.  
*29th International Symposium on Rarefied Gas Dynamics*, AIP Conference Proceedings, vol. 1628,  
no. 1, pp. 185-191. American Institute of Physics, 2014.

INVITED TALKS

[6] **Shaowu Pan**,  
Neural Implicit flow: mesh-agnostic representation learning paradigm beyond POD and CNN, *Intelligent and Bio-inspired Mechanics Seminar Series, Department of Mechanical and Material Engineering, Queen's University, Canada, 2021*

[5] **Shaowu Pan**,  
From Koopman Operator to AI for Physical Engineering, *Computer Vision, Machine Learning and Computer Graphics, Ann Arbor, USA, 2021*

[4] **Shaowu Pan**,  
Robust and Interpretable Learning for Operator-Theoretic Modeling of Non-linear Dynamics, *Scientific Computing and Flow Physics Laboratory, University of Michigan, Ann Arbor, USA, 2021*

[3] **Shaowu Pan**,  
Robust and Interpretable Learning for Operator-Theoretic Modeling of Non-linear Dynamics, *Los Alamos National Laboratory, USA, 2021*

[2] **Shaowu Pan**, Karthik Duraisamy,  
Physically-informed Bayesian Learning of Linear Embeddings for Fluid Dynamics Problems, *SIAM Conference on Computational Science and Engineering, Spokane, WA, USA, 2019*

[1] **Shaowu Pan**, Karthik Duraisamy,  
Improving Accuracy and Robustness of Artificial Neural Networks to Discover Dynamical Systems from Data, *SIAM Conference on Uncertainty Quantification, Garden Grove, CA, USA, 2018*

RESEARCH GRANTS  
AND RESOURCES

XSEDE Startup allocation TG-CIS210090: Latent Representation Learning Paradigm for Reduced-Order Modeling for Turbulent Flows, 08/13/2021 - 08/12/2022, 4,500 GPU hours awarded on PSC Bridges-2. **Project PI: Shaowu Pan**

## SOFTWARE

**CHIT:** Highly parallel hybrid DNS code on 3D compressible Navier-Stokes in a periodic box with Helmholtz decomposition

**spKDMD:** Sparsity-promoting Kernel Dynamic Mode Decomposition for Nonlinear Dynamical Systems

**DDC:** closure model for nonlinear ODE system

**spark:** Stabilized Probabilistic deep leaRning Koopman operator

## SERVICES

### **Mentoring:**

- Saakaar Bhatnagar, *Next position: graduate student at Stanford University*
- Weitao Sun, *Next position: software engineer at Converge CFD*

### **Professional membership:**

- American Institute of Aeronautics and Astronautics (AIAA)
- American Physical Society (APS)
- Society for Industrial and Applied Mathematics (SIAM)

### **Organized Symposia:**

- IEEE SSCI-PHYCI (2022)

### **Reviewing:**

- Nature Communications
- Journal of Fluid Mechanics
- Physical Review Fluids
- Physics of Fluids
- PLOS One
- Lab on a chip
- Computer Physics Communications
- Computers and Fluids
- International Journal for Numerical Methods in Engineering
- Scientific Reports
- SIAM Journal on Scientific Computing
- SIAM Journal on Applied Dynamical Systems
- Journal of Nonlinear Science
- Proceedings of Royal Society A
- Journal of Sound and Vibration
- AIAA Journal
- IEEE Access
- IEEE Transactions on Artificial Intelligence
- IEEE Transactions on Network Science and Engineering
- IEEE Computational Intelligence Magazine
- IEEE Control Systems Letters
- IEEE/CAA Journal of Automatica Sinica
- Entropy

- Acta Mechanica Sinica
- Applied Sciences
- Mathematical Reviews

## REFERENCES

**Prof. Nathan Kutz**

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Department of Applied Mathematics, University of Washington, Seattle, USA

**Prof. Steven Brunton**

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Department of Mechanical Engineering, University of Washington, Seattle, USA

**Prof. Karthik Duraisamy**

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