

Ivan Zanardi

AEROSPACE ENGINEER · COMPUTATIONAL PHYSICIST

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SUMMARY

PhD candidate in Aerospace Engineering applying machine learning and model reduction techniques to multiphysics, multiscale numerical simulations. Passionate about developing fast, accurate, and physics-aware simulation tools for real-world engineering challenges.

- 4+ years experience in machine learning, optimization, and uncertainty quantification
- 4+ years experience in surrogate and reduced-order modeling
- 4+ years experience in numerical methods for partial differential equations
- 5+ years experience in high-speed and reactive flows modeling

EXPERIENCE



University of Illinois Urbana-Champaign

Urbana, IL, USA

Graduate Research Assistant - Aerospace Engineering Department

Jan. 2021 - Sep. 2025

Applying reduced-order modeling and physics-informed operator learning to improve accuracy and efficiency in multiphysics and multiscale simulations of high-speed reactive plasma flows.

- Mentored by Prof. Marco Panesi.
- Reduced-order models (ROMs):
 - Developed ROMs for thermochemical nonequilibrium systems, achieving up to 700x speedup with 1% error.
 - Applied ROMs to multidimensional CFD simulations, ensuring stable and accurate performance in complex plasma flow environments.
- Physics-informed neural operators (PINOs):
 - Designed physics-constrained and physics-inspired neural operator architectures to surrogate thermochemical operators in reactive flow simulations, achieving over 100x speedup with 1% error.
 - Created and actively developing PyCOMET, a modular TensorFlow-based library for physics-informed machine learning for scientific computing and operator discovery.
 - Integrated TensorFlow C-based models with in-house Fortran CFD code for high-speed flow simulations.
- Research conducted at the Center for Hypersonics and Entry Systems Studies (CHESS) under the Vannevar Bush Faculty Fellowship, in collaboration with the Computational Aerosciences Lab at the University of Michigan.
- Presented research findings to senior scientists and program managers from NASA (Dr. Michael Wright, Dr. Aaron Brandis) and the Department of Defense (Dr. Jean-Luc Cambier).



University of Illinois Urbana-Champaign

Urbana, IL, USA

Teaching Assistant - Aerospace Engineering Department

Aug. 2024 - Dec. 2024

Assisted in the course AE512 - Molecular gas dynamics.

- Conducted weekly office hours, supporting over 40 students.
- Developed and prepared assignments and exam materials.
- Managed and updated course materials through online learning platforms.



Lawrence Livermore National Laboratory

Livermore, CA, USA

Data Science Researcher - Data Science Summer Institute (DSSI)

May 2024 - Aug. 2024

Co-developed the Data-Driven Finite Element Method (DD-FEM), a novel data-driven foundation model for partial differential equations.

- Mentored by Dr. Youngsoo Choi.
- Contributed to the development of an object-oriented Python library for constructing nonlinear-manifold reduced-order models using domain decomposition and nonlinear autoencoders.
- Recognized as one of the top presenters in the DSSI Summer Slam competition, where projects from all DSSI scholars were evaluated.
- Work presented at the Machine Learning for Physical Sciences (ML4PS) workshop at NeurIPS 2024.



Lawrence Livermore National Laboratory

Livermore, CA, USA

Machine Learning Researcher - Physics Division

May 2023 - Aug. 2023

Designed a novel quantum hydrodynamics formulation for DFT-based Born-Oppenheimer molecular dynamics (BOMD) using adjoint-based ML.

- Mentored by Dr. Amit Samanta.
- Developed PyDeFT, an object-oriented PyTorch-based library for constructing new PDE formulations for the DFT-BOMD method, featuring:
 - PDE-constrained optimization via the adjoint method.
 - PDE solver supporting implicit/explicit time integrators and a hybrid FD/FV method for space discretization.
 - Flexible deep neural network models for integration into the framework.

**Brembo****3D Systems Designer - Systems Design Area**

- Designed 3D parts and assemblies for supercars braking system.
- Tested and managed new CAD/PLM tools to optimize design activities.
- Worked on 2D and 3D parametric modeling and compiled related documentation.

Stezzano, Italy

Mar. 2020 - Jun. 2020

**Politecnico di Milano****Graduate Research Assistant - Aerospace Engineering Department**

Validated and extended an open-source hypersonic CFD code written in the OpenFOAM C++ toolbox.

- Mentored by Prof. Federico Piscaglia.
- Implemented new thermochemical libraries for nonequilibrium processes.
- Designed practical testing codes for academic purposes.

Milan, Italy

Sep. 2019 - Feb. 2020

EDUCATION

**University of Illinois Urbana-Champaign****Ph.D. in Aerospace Engineering - GPA 4/4**

Urbana, IL, USA

Jan. 2021 - Sep. 2025

- **Dissertation:** "Physics-informed neural surrogates for next-generation aerothermochemical modeling"
- **Mentor:** Prof. Marco Panesi
- **Major:** Aerodynamics, Fluid Mechanics, Combustion and Propulsion (AFMCP)
- **Elective coursework:** Machine Learning · Numerical Methods for PDEs · Uncertainty Quantification · Spectral Element Methods · Computational Plasma Physics · Plasma Waves · Advanced Gas Dynamics
- **Activities and Societies:** Member of Center for Hypersonics and Entry Systems Studies (CHESS) · Member of American Institute of Aeronautics and Astronautics (AIAA) · Member of Society for Industrial and Applied Mathematics (SIAM)

**Politecnico di Milano****M.S. in Aeronautical Engineering - Grade 110/110**

Milan, Italy

Sep. 2017 - Apr. 2020

- **Dissertation:** "Effects of non-equilibrium oxygen dissociation and vibrational relaxation in hypersonic flows"
- **Mentor:** Prof. Federico Piscaglia
- **Major:** Combustion and Propulsion

**Politecnico di Milano****B.S. in Aerospace Engineering - Grade 110/110**

Milan, Italy

Oct. 2014 - Sep. 2017

HONORS & AWARDS

Aug. 2024 **Top presenter - DSSI Summer Slam**, Lawrence Livermore National Laboratory

Livermore, CA, USA

Jun. 2016 **Best student award - Merit project**, Politecnico di Milano

Milan, Italy

SELECTED PUBLICATIONS

- [1] **I. Zanardi**, S. Venturi, and M. Panesi. *MENO: Hybrid Matrix Exponential-based Neural Operator for Stiff ODEs. Application to Thermochemical Kinetics*. July 2025. DOI: 10.48550/arXiv.2507.14341.
- [2] **I. Zanardi**, A. Meini, A. Padovan, D. J. Bodony, and M. Panesi. *Petrov-Galerkin model reduction for collisional-radiative argon plasma*. June 2025. DOI: 10.48550/arXiv.2506.05483.
- [3] Y. Choi, S. W. Cheung, Y. Kim, P.-H. Tsai, A. N. Diaz, **I. Zanardi**, S. W. Chung, D. M. Copeland, C. Kendrick, W. Anderson, T. Iliescu, and M. Heinkenschloss. *Defining Foundation Models for Computational Science: A Call for Clarity and Rigor*. May 2025. DOI: 10.48550/arXiv.2505.22904.
- [4] **I. Zanardi**, A. Padovan, D. J. Bodony, and M. Panesi. "Petrov-Galerkin model reduction for thermochemical nonequilibrium gas mixtures". In: *Journal of Computational Physics* 533 (Apr. 2025), p. 113999. DOI: 10.1016/j.jcp.2025.113999.
- [5] **I. Zanardi**, A. N. Diaz, S. W. Chung, M. Panesi, and Y. Choi. *Scalable nonlinear manifold reduced order model for dynamical systems*. Nov. 2024. DOI: 10.48550/arXiv.2412.00507.
- [6] C. Jacobsen, **I. Zanardi**, S. Bhola, K. Duraisamy, and M. Panesi. "Information theoretic clustering for coarse-grained modeling of non-equilibrium gas dynamics". In: *Journal of Computational Physics* 507 (2024), p. 112977. DOI: 10.1016/j.jcp.2024.112977.
- [7] **I. Zanardi**, S. Venturi, and M. Panesi. "Adaptive physics-informed neural operator for coarse-grained non-equilibrium flows". In: *Scientific Reports* 13 (Sept. 2023), pp. 1–22. DOI: 10.1038/s41598-023-41039-y.
- [8] M. S. Priyadarshini, S. Venturi, **I. Zanardi**, and M. Panesi. "Efficient quasi-classical trajectory calculations by means of neural operator architectures". In: *Physical Chemistry Chemical Physics* 25 (May 2023), pp. 13902–13912. DOI: 10.1039/D2CP05506F.

CONFERENCE PRESENTATIONS

NeurIPS 2024 - ML4PS Workshop

Vancouver, BC, Canada

Poster Presenter

Dec. 2024

"Scalable nonlinear manifold reduced order model for dynamical systems"

APS Division of Fluid Dynamics Annual Meeting 2024

Salt Lake City, UT, USA

Presenter

Nov. 2024

"Projection-based model reduction for thermo-chemical non-equilibrium gas mixtures"

AIAA SciTech Forum and Exposition

Paper Presenter

Talks: [2022] [2023] [2024] [2025]

SIAM Annual Meeting

Minisymposium Presenter

Talks: [2021] [2022]

ADDITIONAL SKILLS & COMPETENCES

Coding Languages

Python, C/C++, Fortran, MATLAB, Bash

Version Control Systems

Git

Machine Learning Libraries

TensorFlow, Keras, PyTorch, scikit-learn, JAX

Scientific and Data Libraries

NumPy, SciPy, SQL, Pandas, H5py, HDF5

CFD Softwares

OpenFOAM, CHESS in-house codes

Scientific Visualization

ParaView, Matplotlib

REFERENCES

Marco Panesi, Professor

Department of Mechanical and Aerospace Engineering

University of California, Irvine

Engineering Gateway 4200, Irvine, CA 92697, USA | mpanesi@uci.edu

Youngsoo Choi, Research Scientist Staff

CASC Group, Lawrence Livermore National Laboratory

7000 East Avenue, Livermore, CA 94550, USA | choi15@llnl.gov

Simone Venturi, Senior AI Engineer

Atomic Machines

950 Gilman Street, Berkeley, CA 94710, USA | sim.venturi@gmail.com

Karthik Duraisamy, Professor and Director of MICDE

Department of Aerospace Engineering

University of Michigan

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Amit Samanta, Research Staff

Physics Division, Lawrence Livermore National Laboratory

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Federico Piscaglia, Associate Professor

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