

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, (adjoint-based) 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

Poster Presenter

"Scalable nonlinear manifold reduced order model for dynamical systems"

Vancouver, BC, Canada

Dec. 2024

APS Division of Fluid Dynamics Annual Meeting 2024

Presenter

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

Salt Lake City, UT, USA

Nov. 2024

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

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Federico Piscaglia, Associate Professor

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