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 and optimization
- · 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
- 5+ years experience in hypersonics and aerothermodynamics

EDUCATION



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

Urbana, IL, USA

Jan. 2021 - Sep. 2025

- Dissertation: "Physics-aware thermochemical surrogates for next-generation aerothermal 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

Milan, Italy

M.S. in Aeronautical Engineering - Grade 110/110

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

Milan, Italy

B.S. in Aerospace Engineering - Grade 110/110

Oct. 2014 - Sep. 2017

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 Teaching Assistant - Aerospace Engineering Department

Urbana, IL, USA 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

May 2024 - Aug. 2024

Data Science Researcher - Data Science Summer Institute (DSSI)

Developing data-driven nonlinear-manifold reduced order models with domain decomposition 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 deterministic autoencoders, with a focus on applications to the nonlinear Burgers' equation.
- 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 Machine Learning Researcher - Physics Division

Livermore, CA, USA

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.



Freelancer Bergamo, Italy Jul. 2020 - Dec. 2020 Python Code Developer

· Developed Python-based codes for data analysis and web scraping.



Brembo

Stezzano, Italy

Mar. 2020 - Jun. 2020

- 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.



Politecnico di Milano

Milan, Italy

Graduate Research Assistant - Aerospace Engineering Department

Sep. 2019 - Feb. 2020 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.

HONORS & AWARDS

Aug. 2024 Top presenter - DSSI Summer Slam, Lawrence Livermore National Laboratory Livermore, CA, USA Best student award - Merit project, Politecnico di Milano Jun. 2016 Milan, Italy

SELECTED PUBLICATIONS

- [1] **I. Zanardi**, S. Venturi, and M. Panesi. *Hybrid matrix exponential-based neural operator for stiff thermochemical kinetics*. In preparation. 2025.
- [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.
- 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.
- 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.
- 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 nonequilibrium 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.
- 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

Dec. 2024

"Scalable nonlinear manifold reduced order model for dynamical systems"

APS Division of Fluid Dynamics Annual Meeting 2024

Salt Lake City, UT, USA

Nov. 2024

Presenter

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

AIAA SciTech Forum and Exposition

Paper Presenter

Poster 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

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 and Director of CHESS

Department of Aerospace Engineering, University of Illinois Urbana-Champaign 104 S Wright St, Urbana, IL 61801, U.S.A. | mpanesi@illinois.edu

Youngsoo Choi, Research Scientist Staff

Physics Division, Lawrence Livermore National Laboratory 7000 East Avenue, Livermore, CA 94550, U.S.A. | choi15@llnl.gov

Amit Samanta, Research Staff

Physics Division, Lawrence Livermore National Laboratory 7000 East Avenue, Livermore, CA 94550, U.S.A. | samanta1@llnl.gov

Karthik Duraisamy, Professor and Director of MICDE and CASLAB

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Simone Venturi, Senior AI Engineer

Atomic Machines

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Federico Piscaglia, Associate Professor

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