Ivan Zanardi

Aerospace Engineer · Computational Physicist

204 E Clark St, Champaign, IL 61820, USA

zanardi3@illinois.edu | ivanzanardi.github.io | ivanZanardi | ivanzanardi95

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 — *Urbana, IL, USA*

Ph.D. in Aerospace Engineering - GPA 4/4 — *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 — *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*

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 — *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.

Freelancer — *Bergamo, Italy*
Python Code Developer — *Jul. 2020 - Dec. 2020*
- Developed Python-based codes for data analysis and web scraping.

Brembo — *Stezzano, Italy*
3D Systems Designer - Systems Design Area — *Mar. 2020 - Jun. 2020*
- 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*
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, S. Venturi, and M. Panesi. *MENO: Hybrid Matrix Exponential-based Neural Operator for Stiff ODEs. Application to Thermochemical Kinetics*. 2025.

[3] **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.

[4] 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.

[5] **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.

[6] **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.

[7] 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.

[8] **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.

[9] 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 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

Karthik Duraisamy, Professor and Director of MICDE and CASLAB

Department of Aerospace Engineering, University of Michigan

1320 Beal Avenue Ann Arbor, MI 48109-2140, U.S.A. | kdur@umich.edu

Youngsoo Choi, Research Scientist Staff

Physics Division, Lawrence Livermore National Laboratory

7000 East Avenue, Livermore, CA 94550, U.S.A. | choi15@llnl.gov

Simone Venturi, Senior AI Engineer

Atomic Machines

950 Gilman Street Berkeley, CA 94710, U.S.A. | sim.venturi@gmail.com

Amit Samanta, Research Staff

Physics Division, Lawrence Livermore National Laboratory

7000 East Avenue, Livermore, CA 94550, U.S.A. | samanta1@llnl.gov

Federico Piscaglia, Associate Professor

Department of Aerospace Science and Technology, Politecnico di Milano

Via La Masa, 34 20156 Milan, Italy | federico.piscaglia@polimi.it