MARIO DE FLORIO

Postdoctoral Researcher at the National Renewable Energy Laboratory

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About

Research engineer with expertise in mathematical modeling of differential equations for complex systems, collaborating with subject matter experts in a variety of fields, such as neuroscience, electrophysiology pharmacokinetics, systems biology, chemical kinetics, epidemiology, chaotic systems, nuclear dynamics, astrodynamics, and energy systems, to help them understand the underlying phenomena using first principles and experimental data. Multidisciplinary researcher with background in energy and nuclear engineering, applied mathematics, AI/ML, focused on developing Physics-Informed Machine Learning algorithms for solving real-world multiscale systems. Skilled in multiple programming languages and analysis tools (MATLAB, Python) and machine learning frameworks (PyTorch, Tensorflow).

EXPERIENCE

Postdoctoral Researcher

National Renewable Energy Laboratory
Hybrid Energy Systems Research

September 2024 – Present — Golden, CO

- Machine Learning for energy systems

Postdoctoral Research Associate

Brown University
Division of Applied Mathematics

January 2023 – September 2024 — Providence, RI

- Development of Physics-Informed Machine Learning algorithms for Black-Box and Gray-Box models identification.
- Applications to energy systems, pharmacokinetics, systems biology, neuroscience, and chaotic systems.
- Quantification of total uncertainty for cardiovascular models.
- Time-series analysis with physics-informed machine learning, MLP, LSTM, GRU, and transformers.
- Deep Neural operators for chemical kinetics reactions.
- Biologically plausible neuron models for regression in Scientific Machine learning with spiking neural networks.
- Supervising PhD students and PostDocs, leading funded research projects in collaboration between Academia, Industry, and National Laboratories.

Graduate Research Associate

The University of Arizona
Department of Systems & Industrial Engineering
Space Systems Engineering Laboratory
Lunar & Planetary Laboratory

January 2020 – December 2022 — Tucson, AZ

- Developing and applying Physics-Informed Machine Learning algorithms to orbit propagation, radiative transfer, rarefied-gas dynamics, nuclear reactor dynamics, chemical kinetics, epidemiological models
- Remote Sensing for Earth systems characterization and space exploration
- Meteorites parameters estimation via Hapke model inversion in collaboration with Lunar & Planetary Laboratory
- Supervising MSc and PhD visiting students.

Visiting Researcher

The University of Arizona
Department of Systems & Industrial Engineering

January 2019 – May 2019 — Tucson, AZ

- Applied Physics-Informed Neural Networks to radiative transfer and rarefied-gas dynamics

- Developed a software for Binary Asteroid Systems characterization via light-curves inversion, in collaboration with the Planetary Science Institute

Intern

Alma Mater Studiorum - Università di Bologna
Laboratorio di Ingegneria Nucleare di Montecuccolino

November 2017 – January 2018 | Bologna, ITA

- Centered learning of Plasma Physics and FORTRAN 90 programming language
- FORTRAN 90 for simulations of a fusion plasma.

Intern

Futura S.p.A.

August 2015 – September 2015 | Lucera, ITA

- Control of the ordinary operation of Photovoltaic and Wind power plants
- Detection of production data, drafting technical reports, drafting requests for new plant connections

EDUCATION

Ph.D. in Systems & Industrial Engineering

The University of Arizona

January 2020 – December 2022 | Tucson, AZ

- Dissertation Title: Physics-Informed Neural Networks and Functional Interpolation for Initial Value Problems with Applications to Integro-Differential and Stiff Differential Equations
- Advisor: Prof. Roberto Furfaro
- Grade Point Average: 3.9 out of 4
- Major in Systems Engineering, Minor in Statistics & Machine Learning
- Elected peer representative of Ph.D. students to the SIE Graduate Studies Committee.
- Courses: Stochastic Modeling I, Engineering Statistics, Fundamentals of Optimization, Systems Theory, Introduction to Machine Learning, Advanced Statistical Regression Analysis, Design & Analysis of Experiments, Statistical Machine Learning & Data Mining, Meteorites

M.S. in Energy & Nuclear Engineering

Alma Mater Studiorum - Università di Bologna

September 2016 – July 2019 | Bologna, ITA

- Dissertation Topic: Numerical Solutions of Radiative Transfer Problem
- Advisor: Prof. Domiziano Mostacci
- Grade Point Average: 3.9 out of 4
- Courses: Heat Transmission & Applied Thermo-Fluid Dynamics, Management & Environmental Impact of Energy Systems, Mathematical & Numerical Methods for Energetics, Sustainable Technologies for Energy Resources, Modern Physics, Plasma Industrial Applications, Modeling & Simulation Techniques for Energy, Neutronics & Plasma, Radioprotection.

Erasmus+ European Master of Science in Nuclear Fusion and Engineering Physics

Universidad Complutense de Madrid
Universidad Carlos III de Madrid

January 2018 – June 2018 | Madrid, ESP

- Courses: Computational Physics, Statistical Physics, Electric Power Stations II

B.S. in Energy & Nuclear Engineering

Alma Mater Studiorum - Università di Bologna

September 2012 – July 2016 | Bologna, ITA

- Dissertation Topic: Description of the ITER Tokamak Cooling Water System
- Advisor: Prof. Emanuele Ghedini
- Grade Point Average: 3.1 out of 4
- Laboratories: general technologies of materials and industrial applications of plasma, Testing of Machines and Power Systems, Radioprotection, Thermo-Fluid Dynamics Computational Laboratory

PUBLICATIONS

Journal Articles (h-index = 11)

[1] **De Florio, M.**, Kevrekidis, I.G. and Karniadakis, G.E., 2024. AI-Lorenz: A physics-data-driven framework for black-box and gray-box identification of chaotic systems with symbolic regression. *Chaos, Solitons & Fractals*, 188, p.115538. https://doi.org/10.1016/j.chaos.2024.115538.

[2] Sanchez, J.A., Reddy, V., Thirouin, A., Bottke, W.F., Kareta, T., **De Florio, M.**, Sharkey, B.N., Battle, A., Cantillo, D.C. and Pearson, N., 2024. The Population of Small Near-Earth Objects: Composition, Source Regions, and Rotational Properties. *The Planetary Science Journal*, 5(6), p.131. https://doi.org/10.3847/PSJ/ad445f

[3] **De Florio, M.**, Ahmadi Daryakenari, N., Shukla, K. and Karniadakis, G.E., 2024. AI-Aristotle: A physics-informed framework for systems biology gray-box identification. PLOS Computational Biology, 20(3), p.e1011916. https://doi.org/10.1371/journal.pcbi.1011916

[4] Taccari, M.L., Wang, H., Goswami, S., **De Florio, M.**, Nuttall, J., Chen, X. and Jimack, P.K., 2023. Developing a cost-effective emulator for groundwater flow modeling using deep neural operators. Journal of Hydrology, p.130551. https://doi.org/10.1016/j.jhydrol.2023.130551.

[5] Cantillo, D.C., Reddy, V., Battle, A., Sharkey, B.N., Pearson, N.C., Campbell, T., Satpathy, A., **De Florio, M.**, Furfaro, R. and Sanchez, J., 2023. Grain Size Effects on UV–MIR (0.2–14 um) Spectra of Carbonaceous Chondrite Groups. *The Planetary Science Journal*, 4(9), p.177. http://dx.doi.org/10.3847/PSJ/acf298

[6] **De Florio, M.**, Schiassi, E., Calabrò, F., and Furfaro, R. (2024). Physics-Informed Neural Networks for 2nd order ODEs with sharp gradients. *Journal of Computational and Applied Mathematics*, 436, 115396. https://doi.org/10.1016/j.cam.2023.115396

[7] Bowen, B., Reddy, V., **De Florio, M.**, Kareta, T., Pearson, N., Furfaro, R., ... and Battle, A. (2023). Grain Size Effects on Visible and Near-infrared (0.35–2.5 μm) Laboratory Spectra of Ordinary Chondrite and HED Meteorites. *The Planetary Science Journal*, 4(3), 52. https://doi.org/10.3847/PSJ/acb268

[8] Laghi, L., Schiassi, E., **De Florio, M.**, Furfaro, R., and Mostacci, D. 2023. Physics-Informed Neural Networks for 1-D Steady-State Diffusion-Advection-Reaction Equations, *Nuclear Science and Engineering*. https://doi.org/10.1080/00295639.2022.2160604

[9] **De Florio, M.**, Schiassi, E., and Furfaro, R., Physics-informed neural networks and functional interpolation for stiff chemical kinetics, *Chaos* 32, 063107 (2022). https://doi.org/10.1063/5.0086649

[10] **De Florio, M.**, Schiassi, E., Ganapol, B.D., and Furfaro, R., 2022. Physics-Informed Neural Networks for rarefied-gas dynamics: Poiseuille flow in the BGK approximation. *Z. Angew. Math. Phys.* 73, 126. https://doi.org/10.1007/s00033-022-01767-z

[11] Schiassi, E., **De Florio, M.**, Ganapol, B.D., Picca, P. and Furfaro, R., 2022. Physics-informed neural networks for the point kinetics equations for nuclear reactor dynamics. *Annals of Nuclear Energy*, 167, p.108833. https://doi.org/10.1016/j.anucene.2021.108833

[12] **De Florio, M.**, Schiassi, E., D'Ambrosio, A., Mortari, D. and Furfaro, R., 2021. Theory of Functional Connections Applied to Linear ODEs Subject to Integral Constraints and Linear Ordinary Integro-Differential Equations. *Mathematical and Computational Applications*, 26(3), p.65. https://doi.org/10.3390/mca26030065

[13] Schiassi, E., **De Florio, M.**, D'Ambrosio, A., Mortari, D. and Furfaro, R., 2021. Physics-informed neural networks and functional interpolation for data-driven parameters discovery of epidemiological compartmental models. *Mathematics*, 9(17), p.2069. https://doi.org/10.3390/math9172069

[14] Schiassi, E., Furfaro, R., Leake, C., **De Florio, M.**, Johnston, H. and Mortari, D., 2021. Extreme theory of functional connections: A fast physics-informed neural network method for solving ordinary and partial differential equations. *Neurocomputing*, 457, pp.334-356. https://doi.org/10.1016/j.neucom.2021.06.015

[15] **De Florio, M.**, Schiassi, E., Ganapol, B.D. and Furfaro, R., 2021. Physics-informed neural networks for rarefied-gas dynamics: Thermal creep flow in the Bhatnagar–Gross–Krook approximation. *Physics of Fluids*, 33(4), p.047110. https://doi.org/10.1063/5.0046181

[16] **De Florio, M.**, Schiassi, E., Furfaro, R., Ganapol, B.D. and Mostacci, D., 2021. Solutions of Chandrasekhar's basic problem in radiative transfer via theory of functional connections. *Journal of Quantitative Spectroscopy and Radiative Transfer*, 259, p.107384. https://doi.org/10.1016/j.jqsrt.2020.107384

Preprints

[1] **De Florio, M.**, Zongren, Z., Schiavazzi, D.E., and Karniadakis, G.E., 2024. Quantification of total uncertainty in the physics-informed reconstruction of CVSim-6 physiology. *arXiv preprint* https://www.arxiv.org/abs/2408.07201.

[2] Sanchez, J.A., Reddy, V., Thirouin, A., Bottke, W.F., Kareta, T., **De Florio, M.**, Sharkey, B.N., Battle, A., Cantillo, D.C. and Pearson, N., 2024. The population of small near-Earth objects: composition, source regions and rotational properties. *arXiv preprint* https://arxiv.org/abs/2404.18263.

[3] **De Florio, M.**, Kahana, A. and Karniadakis, G.E., 2023. Analysis of biologically plausible neuron models for regression with spiking neural networks. *arXiv preprint* https://doi.org/10.48550/arXiv.2401.00369.

[4] **De Florio, M.**, Kevrekidis, I.G. and Karniadakis, G.E., 2023. AI-Lorenz: A physics-data-driven framework for black-box and gray-box identification of chaotic systems with symbolic regression. *arXiv preprint*. https://doi.org/10.48550/arXiv.2312.14237.

[5] **De Florio, M.**, Daryakenari, N.A., Shukla, K. and Karniadakis, G.E., 2023. AI-Aristotle: A Physics-Informed framework for Systems Biology Gray-Box Identification. *arXiv preprint*. https://doi.org/10.48550/arXiv.2310.01433

[6] Schiassi, E., D'Ambrosio, A., **De Florio, M.**, Furfaro, R. and Curti, F., 2020. Physics-informed extreme theory of functional connections applied to data-driven parameters discovery of epidemiological compartmental models. *arXiv preprint arXiv:2008.05554*.

https://arxiv.org/abs/2008.05554v1

[7] Schiassi, E., Leake, C., **De Florio, M.**, Johnston, H., Furfaro, R. and Mortari, D., 2020. Extreme theory of functional connections: A physics-informed neural network method for solving parametric differential equations. *arXiv preprint arXiv:2005.10632*. https://arxiv.org/abs/2005.10632v1

Conference Proceedings

[1] Frankel, M., **De Florio, M.**, Schiassi, E. and Sela, L., 2024. Hybrid Chemical and Data-Driven Model for Stiff Chemical Kinetics Using a Physics-Informed Neural Network. Engineering Proceedings, *69*(1), p.40.

[2] Schiassi, E., D'Ambrosio, A., Johnston, H., **De Florio, M.**, Drozd, K., Furfaro, R., Curti, F. and Mortari, D., 2020, August. Physics-informed extreme theory of functional connections applied to optimal orbit transfer. In *Proceedings of the AAS/AIAA Astrodynamics Specialist Conference, Lake Tahoe, CA, USA* (pp. 9-13).

[3] Sonnett, S., Grav, T., Williamson, B., Witry, J., Reddy, V., Furfaro, R., **De Florio, M.**, Schiassi, E., Chatelain, J., Lejoly, C. and Le Corre, L., 2019, September. Lightcurves, Shape Models, and HG Parameters of Trojan and Hilda Binary Candidates. In *EPSC-DPS Joint Meeting 2019* (Vol. 2019, pp. EPSC-DPS2019).

Dissertations

[1] Mario De Florio, 2022. "Physics-Informed Neural Networks and Functional Interpolation for Initial Value Problems with Applications to Integro-Differential and Stiff Differential Equations". PhD dissertation. The University of Arizona.

[2] Mario De Florio, 2019. "Accurate Solutions of the Radiative Transfer Problem via Theory of Connections". MS thesis. Alma Mater Studiorum - Università di Bologna. https://amslaurea.unibo.it/18553/

[3] Mario De Florio, 2016. "Description of the ITER Tokamak Cooling Water System". BS thesis. Alma Mater Studiorum - Università di Bologna. https://amslaurea.unibo.it/11098/

CONFERENCE TALKS

- 32nd International Symposium on Rarefied Gas Dynamics (RGD32), Seoul, South Korea, 4-8 July 2022. *Physics-informed Neural Network and Functional Interpolation for Rarefied-Gas Dynamics in the BGK Approximation*.
- 19th U.S. National Congress on Theoretical and Applied Mechanics (USNC/TAM 2022), Austin, Texas, 19-24 June 2022. *Boltzmann Neural Networks and Theory of Functional Connections for Rarefied-Gas Dynamics problems in the BGK approximation*.
- **1st World Online Conference on Theory of Functional Connections**, 22 May 2020. *Physics-Informed Solutions for Rarefied Gas Dynamics Problems via Theory of Functional Connections*.
- Los Alamos - Arizona days, Online Workshop, 18-19 May 2020. *Physics-Informed Solutions of Radiative Transfer Problems*.
- 26th International Conference on Transport Theory (ICTT-26), Paris, France, 22-27 September 2019. *Accurate Solutions of the Radiative Transfer Problem via Theory of Connections*.

AWARDS

- Finalist of the Mario Gerla Award for research in Computer Science. Young Investigator Awards of 2024. ISSNAF (Italian Scientists & Scholars in North America Foundation).

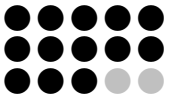
PEER REVIEW ACTIVITY

Active peer reviewer for the following journals:

- Physics of Fluids — AIP Publishing
- Journal of Computational Physics – Elsevier
- Scientific Reports — Springer Nature
- Computational Materials Science — Elsevier
- Journal of Computational Science — Elsevier
- Neural Networks — Elsevier
- Sustainable Computing: Informatics and Systems — Elsevier

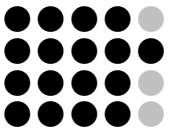
SKILLS

MATLAB
Python
Fortran



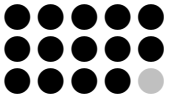
R
SAS

Microsoft Office
LaTeX
Solid Edge
Linux (Ubuntu)



LANGUAGES

Italian
English
Spanish



REFERENCES

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Energy Conversion and Storage Systems Center, National Renewable Energy Laboratory (NREL)

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School of Information, The University of Arizona

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