

Antonio Álvarez-López

Curriculum Vitae

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Research Interests

My current interests are driven by two themes: the mathematical foundations of machine learning, and turning that understanding into principled practical tools. On the theoretical side, I approach learning problems through the lens of controllability of dynamical systems and of flow-based models acting on probability spaces. I am also interested in sequence models (transformers, state-space), mean-field analysis, Wasserstein gradient flows, and optimal control. On the applied side, I focus on data-driven control, modeling, and decision-making. To date, most of my concrete work has centered on time-series in digital health, where I have combined neural ODEs with kernel methods.

Education

- Oct 2022–June 2026 **PhD in Mathematics**, *Universidad Autónoma de Madrid (UAM)*, Spain.
Controllability of Neural ODEs and Flow-Based Generative Models.
Advisor: Enrique Zuazua Iriondo. Co-advisor: Rafael Orive Illera.
- 2021–2022 **Master's degree in Advanced Mathematics**, *Universidad Complutense de Madrid*, Spain.
Master thesis: Parker's Problem in Magnetohydrodynamics and transition maps for force-free fields.
Advisor: Alberto Enciso.
- 2016–2021 **Bachelor's double degree in Mathematics and Physics**, *Universidade de Santiago de Compostela (USC)*, Spain, Academic year 2019–2020 in Universidad de Granada.
Highest Honors in 19 out of 59 courses.

Scholarships

- Aug 2025–Nov 2026 **FPU Mobility Supplement**, Ministerio de Universidades, Ranked #1 in Spain.
- Dec 2022–Dec 2026 **FPU Predoctoral Fellowship**, Ministerio de Universidades, Ranked #6 in Spain.
- June–July 2021 **Machine Learning Research Intern**, Advisor: Paulo Félix Lamas, Subject: Pattern recognition in cardiovascular diseases using machine learning, CiTIUS, Santiago de Compostela.
- July–Sept 2020 **Severo Ochoa-ICMAT Research Intern**, Advisor: Alberto Enciso, Subject: Mathematical problems in fluid mechanics, ICMAT, Madrid.

Scientific production

Published articles

Interplay between depth and width for interpolation in neural ODEs, with Arselane Hadj Slimane and Enrique Zuazua, *Neural Networks*, Volume 180, 106640, 2024.
<https://doi.org/10.1016/j.neunet.2024.106640>

Cluster-based classification with neural ODEs via control, with Rafael Orive-Illera and Enrique Zuazua, *Journal of Machine Learning*, Volume 4(2), 128–156, 2025.
<https://doi.org/10.4208/jml.241114>

Constructive approximate transport maps with normalizing flows, with Borjan Geshkovski and Domènec Ruiz-Balet, *Applied Mathematics and Optimization*, Volume 92, 33, 2025.
<https://doi.org/10.1007/s00245-025-10299-7>

Preprints (submitted)

Continuous Temporal Learning of Probability Distributions via Neural ODEs with Applications in Continuous Glucose Monitoring Data, with Marcos Matabuena, arXiv:2505.08698.
<https://arxiv.org/abs/2505.08698>

Convergence, design and training of continuous-time dropout as a random batch method, with Martín Hernández, arXiv:2510.13134.
<https://arxiv.org/abs/2510.13134>

Invited seminars

- Sept 29, 2025 Entropy-driven control of the continuity equation for normalizing flows. *Machine Learning and Scientific Computing Seminar*. **National University of Singapore**.
- Sept 16, 2025 Entropy-driven control of the continuity equation for normalizing flows. *Nonlinear PDE seminar*. Department of Mathematics. **Texas A&M University**.
- July 9, 2025 New deep learning models and perspectives for continuous-time glucose monitoring. *DeustoCCM Seminar*. **University of Deusto, DeustoTech**.
- 2024–2025 **Presentations in lecture seminars:** *Learning Rate — Machine Learning Series*, 4 sessions.
- April 1, 2024 Controllability of neural differential equations. *Seminario Fontán de Matemáticas*. **USC**.
- Feb 22, 2024 Stable Architectures for Deep Neural Networks. *Mathematics for Deep Learning reading group*. **Universities of Bath, Cambridge, and University College London**.
- Jan 25, 2024 Efficient classification and interpolation with neural ODEs. *Mathematics Seminar*. School of Mathematics. **Sichuan University**.
- March 1, 2023 On the separability of two finite sets of random points using hyperplanes. *Mini-workshop between Technische Universität München (Applied Numerical Analysis group) and FAU-DCN*.
- Feb 28, 2023 Breaking the curse of dimensionality with Barron Spaces. *Applied PDEs Seminar*. **Imperial College London**.
- Nov 14, 2022 Breaking the curse of dimensionality with Barron Spaces. **FAU-DCN**.
- April 4, 2021 Formation of singularities in the incompressible Euler fluid equations. *Seminarios de Iniciación a la Investigación*. Instituto de Matemáticas. **USC**.

Visits (at least one week)

- Aug–Nov 2025 **National University of Singapore, Singapore**, hosted by Qianxiao Li.
- May–July 2025 **Sorbonne Université, Laboratoire Jacques-Louis Lions, Paris, France**, Host: Borjan Geshkovski.
- May–June 2024 **FAU-DCN, Erlangen, Germany**, Host: Enrique Zuazua.
- Jan 2024 **Sichuan University, School of Mathematics, Chengdu, China**, Host: Qi Lü.
- Aug–Sept 2023 **Massachusetts Institute of Technology, Department of Mathematics, Cambridge, USA**, Host: Philippe Rigollet and Borjan Geshkovski.
- Feb–March 2023 **Imperial College London, Applied Mathematics and Mathematical Physics Section, London, United Kingdom**, Host: Domènec Ruiz-Balet.

Participation in scientific events

- June 2025 **Workshop, Mean Field Games, Optimal Transport, and Machine Learning**, NYU - Paris, France.
- April 2025 **Workshop, Machine Learning and PDEs**, FAU, Erlangen, Germany.
- Nov 2024 **Seminar, Oberwolfach Seminar: Control and Machine Learning**, Mathematisches Forschungsinstitut Oberwolfach, Oberwolfach, Germany.
- Oct 2024 **Conference, 2024 Conference on Control, Inversion and Numerics for PDEs**, Fudan University, Shanghai, China.
Presented poster: Controllability of Neural ODEs for Classification.
- Sept 2024 **Conference, Mathematical Aspects of Learning Theory – 20 years later**, Centre de Recerca Matemàtica, Barcelona, Spain.
Presented poster: Simultaneous Control of Neural ODEs for Data Classification.
- Aug 2024 **Conference, X Partial differential equations, optimal design and numerics**, Centro de Ciencias de Benasque Pedro Pascual, Huesca, Spain.
Two invited talks (Aug 26–27): Cluster-based classification with neural ODEs via control. Interplay between depth and width for interpolation in neural ODEs.
- July 2024 **Summer School, C.I.M.E. Session on “PDEs, Control and Deep Learning”**, Cetraro, Italy.
- July 2024 **Conference, Fourth Symposium on Machine Learning and Dynamical Systems**, Fields Institute, Toronto, Canada.
Presented poster: Simultaneous Control of Neural ODEs for Data Classification.
- June 2024 **Conference, 21 French-German-Spanish Conference on Optimization**, Universidad de Oviedo, Spain.
Invited talk (June 21): Controllability of neural ODEs for data classification.

- June 2024 **Conference**, *Trends in Mathematical Sciences*, FAU, Erlangen, Germany.
Presented poster: Optimized Classification with Neural ODEs.
- March 2024 **Workshop**, *Dynamics, Data and Deep Learning Workshop*, Engineers' House, Bristol, UK.
Presented poster: Optimized Classification with Neural ODEs (**Best Poster Award**).
- Dec 2023 **Workshop**, *Mathematical Opportunities in Digital Twins*, George Mason University, Fairfax, Virginia.
Presented poster: Optimized Classification with Neural ODEs.
- Nov 2023 **Conference**, *V BYMAT Conference*, ICMAT, Madrid, Spain.
Invited talk (Nov 14): Neural ODEs and data classification.
- July 2023 **Summer School**, *XV International ICMAT Summer School on Geometry, Dynamics and Field Theory*, ICMAT, Madrid, Spain.
- Feb 2023 **Workshop**, *Exploring foundation models*, The Alan Turing Institute, London, United Kingdom.

Teaching (assistant)

- Jan–May 2025 **Calculus II**, Bachelor's Degree in Data Science and Engineering, UAM.
- Jan–May 2025 **Probability and Statistical Inference**, Bachelor's Degree in Computer Science, UAM.
- Feb–May 2024 **Numerical Calculus**, Bachelor's double degree in Mathematics and Computer Science, UAM.
- Feb–May 2023 **Data Analysis**, Bachelor's degree in Biology, UAM.

Organization

- 2024–2025 **Machine Learning Seminars. Junior coloquia. Lecture group**, ICMAT, UAM, FAU-DCN.

Awards

- 2025 **Student Travel Award**, 2025 IMS International Conference on Statistics and Data Science (ICSDS).
- 2024 **Best Poster Award**, Workshop Dynamics, Data and Deep Learning, Bristol.
- 2021 **Research Fellowship “JAE Intro SOMdM 2021”**, ICMAT, 7 awards nationwide.
- 2018 **Academic Excellence Award**, Best qualifications of Galician University System.
- 2016 **USC's A Ponte Award**, Top students in the University Entrance Exam.
- 2016 **Physics Olympiad Awards**, (Regional) Third Place.
- 2014 **National Award for Academic Achievement**, Spanish Lower Secondary Education (ESO).

Others

- Languages **Spanish (Native), Galician (Native), English (C2), French (B2), German (Basic)**.
- Programming **Python, Matlab, R, Fortran**