

# Antonio Álvarez-López

## Curriculum Vitae

✉ (+34) 622692163  
✉ antonio.alvarezl@uam.es  
Web page  
Google Scholar  
GitHub  
Scopus Author ID: 58783459000  
ORCID: 0009-0004-1302-6389



### Research Interests

My research is organized around two themes: (i) mathematical foundations of machine learning, and (ii) translating that understanding into principled tools. On the theoretical side, I approach learning problems in flow-based models (neural ODEs, transformers, state-space) through the lens of controllability, to approximate dynamical systems and generate probability distributions. I have used mathematical tools from mean-field analysis, information geometry and approximation theory. On the applied side, I have developed data-driven modeling and decision-making methods for time-series in digital health, combining flow-based models with kernel methods.

### Education

- Oct 2022–Present **PhD in Mathematics**, Universidad Autónoma de Madrid (UAM), Spain.  
(Expected June 2026)  
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.

### Research stays (at least two weeks)

- Aug–Nov 2025 **National University of Singapore**, (Singapore). Host: Qianxiao Li.
- May–July 2025 **Sorbonne Université, Laboratoire Jacques-Louis Lions**, (Paris, France). Host: Borjan Geshkovski.
- 2022–2026 **Friedrich-Alexander-Universität**, (Erlangen, Germany, 2 months per year). 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 Rigolet and Borjan Geshkovski.
- Feb–March 2023 **Imperial College London, Department of Mathematics**, (London, UK). Host: Domènec Ruiz-Balet.

### Scholarships

- 2025–2026 **FPU Mobility Supplement**, Ministerio de Universidades, Ranked #1 in Spain.
- 2022–2026 **FPU Predoctoral Fellowship**, Ministerio de Universidades, Ranked #6 in Spain.
- June–July 2021 **Machine Learning Research Intern**, Advisor: Paulo F. 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 (*Citation counts from Google Scholar (GS), as of 24 Dec 2025.*)

**Interplay between depth and width for interpolation in neural ODEs**, with Arselane Hadj Slimane and Enrique Zuazua, Neural Networks (JCR JIF 2024: 6.3; Q1), Vol. 180, 106640, 2024.  
<https://doi.org/10.1016/j.neunet.2024.106640>. (GS: 23)

**Cluster-based classification with neural ODEs via control**, with Rafael Orive-Illera and Enrique Zuazua, Journal of Machine Learning (Global Science Press; OA; JCR JIF: n/a), Vol. 4(2), 128–156, 2025.  
<https://doi.org/10.4208/jml.241114>. (GS: 6)

**Constructive approximate transport maps with normalizing flows**, with Borjan Geshkovski and Domènec Ruiz-Balet, Applied Mathematics and Optimization (JCR JIF 2024: 1.7), Vol. 92, 33, 2025.  
<https://doi.org/10.1007/s00245-025-10299-7>. (GS: 5)

## Preprints (submitted)

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

**Convergence, design and training of continuous-time dropout as a random batch method**, with Martín Hernández.  
<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. **FAU-DCN**.
- 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). **Univs. 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 Break the curse of dimensionality with Barron Spaces. *Applied PDEs Seminar*. **Imperial College London**.
- Nov 14, 2022 Break 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**.

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## Participation in scientific events

- Dec 2025 **Conference**, *International Conference on Statistics and Data Science*, Universidad de Sevilla, Spain.  
Contributed talk: Continuous-time learning of probability distributions via neural ODEs with applications in continuous glucose monitoring data (**Student Travel Award**).
- 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**, *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, 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**, *Degree in Data Science and Engineering*, UAM.
- Jan–May 2025 **Probability and Statistical Inference**, *Degree in Computer Science*, UAM.
- Feb–May 2024 **Numerical Calculus**, *Double degree in Mathematics and Computer Science*, UAM.
- Feb–May 2023 **Data Analysis**, *Degree in Biology*, UAM.

## Organization

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

## Awards

- 2025 **Student Travel Award**, *2025 IMS International Conference on Statistics and Data Science (ICSDS)*.  
For my paper <https://arxiv.org/abs/2505.08698>
- 2024 **Best Poster Award**, *Workshop Dynamics, Data and Deep Learning, Bristol*.
- 2021 **Research Fellowship “JAE Intro SOMdM 2021”**, *ICMAT, Madrid*.  
Awarded to 7 students 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 **Mathematics Olympiad Awards**, (Regional) Honorable Mention.
- 2016 **Physics Olympiad Awards**, (Regional) Third Place.
- 2014 **National Award for Academic Achievement**, *Spanish Lower Secondary Education*.  
Awarded to 25 students nationwide.

## Others

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