

# Francesco D'Amico

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 Website  
 GitHub



## Research interests

- Data structure role in machine learning
- Associative memories and generative models
- Attention-enabled architectures
- RBMs and energy-based models

## Publications

- 2026 **Implicit bias produces neural scaling laws in learning curves, from perceptrons to deep networks**  
D'Amico F., Bocchi D. and Negri M.  
*Accepted at ICLR2026*
- 2025 **Pseudo-likelihood produces associative memories able to generalize, even for asymmetric couplings**  
D'Amico F., Rossi S., Del Bono L. M. and Negri M.  
*New Frontiers in Associative Memories workshop NFAM, ICLR 2025*
- 2025 **Statistical mechanics of vector Hopfield network near and above saturation**  
Nicoletti F., D'Amico F. and Negri M.  
*J. Phys. A: Math. Theor. 58 505005, doi: 10.1088/1751-8121/ae2bd0*
- 2025 **Algorithmic thresholds in combinatorial optimization depend on the time scaling**  
Angelini M.C., Avila-González M., D'Amico F., Machado D., Mulet R. and Ricci-Tersenghi F.  
*Phys. Rev. X, American Physical Society, doi:10.1103/dw9m-95vv*
- 2024 **Self-attention as an attractor network: transient memories without back-propagation**  
D'Amico F. and Negri M.  
*2024 IEEE Workshop on Complexity in Engineering (COMPENG), Florence, Italy, 2024, pp. 1-6, doi: 10.1109/COMPENG60905.2024.10741429.*

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## Education

- 2023 - 2026 **PhD in Physics**, *Sapienza university of Rome*.
- Supervisors: Matteo Negri, Chiara Cammarota
  - Theory of generative AI: attention-enabled models and associative memories (AMs) as a framework for generative abilities
  - Most relevant courses: From Ergodicity breaking to algorithmic phase transitions (M. C. Angelini, G. Gradenigo), Statistical field theory (A. Cavagna), Foundations and Modern Applications of Random Matrix Theory (P. Vivo)
  - Expected defense date: November 2026
- 2021 – 2023 **Master's Degree in theoretical physics**, *Sapienza University of Rome*.
- Supervisors: Chiara Cammarota, Matteo Negri
  - Thesis' title: "Random Features p-Spin Hopfield Model"
  - Final degree mark: 110/110 cum laude
  - Most relevant exams: Statistical mechanics and critical phenomena (E. Marinari), Statistical mechanics of disordered systems (F. Ricci Tersenghi), Statistical physics and machine learning (C. Cammarota), Advanced machine learning for physics (S. Giagu), Mathematical physics (E. Caglioti), Physics of complex systems (V. Loreto, F. Tria)
- 2021 – 2023 **Master's excellence program**, *Sapienza University of Rome*.
- Quantitative analysis of innovation levels in LLM's (CREF, SONY, V. Loreto)
  - Numerical and experimental methods for the study of climate (A. M. Siani)
  - Numerical methods for the study of complex biological systems (A. Giansanti)
- 2018 – 2021 **Bachelor's Degree in physics**, *Sapienza University of Rome*.
- Final mark: 110/110 cum laude
  - Thesis' title: "Topological Vicsek model analyzed with machine learning techniques"
  - Supervisor: S. Giagu
- 2018 – 2021 **Bachelor's excellence program**, *Sapienza University of Rome*.
- Computational Monte Carlo methods for the simulation of Hamiltonian systems (M. C. Angelini)
  - Analytical and computational methods for the analysis of systems solvable by Green's method (D. Barducci)
  - Theoretical study and computational simulation of active matter systems and analysis by machine learning methods (S. Giagu)

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## Other research experience

### Visiting and periods abroad

- 2026 **Visiting PhD student at EPFL - PCSL laboratory**, *Hierarchical model of data for generative AI*, 01/03 - 29/05.  
Supervisor: M. Wyart
- 2025 **Visiting PhD student at Complutense university of Madrid**, *Training of RBMs on power-law distributed random-features dataset*, 01/03 - 31/05.  
Supervisor: B. Seoane

### Talks

- 2026 **Scaling laws, from Perceptrons to Deep networks**, *4th workshop of Unione Matematica Italiana (UMI)*, Roma, 23/01/2026.

- 2025 **Scaling laws, from Perceptrons to Deep networks**, (1) *Chimera journal club, Roma*, 07/10/2025, (2) *Statistical mechanics group, University of Parma*, 23/10/2025.
- 2025 **Statistical mechanics of autoregressive models: towards a theory of Self-Attention**, *PhD talks, Sapienza University, Roma*, 13/10/2025.
- 2024 **Self-attention as an attractor network: transient memories without back-propagation**, *SISSA journal club, Trieste*, 11/10/2024.

## Conferences, workshops and schools

- 01/2026 **4th Workshop of UMI Group, Italian Mathematics Union**, *Sapienza University, Roma, Italy*, contributed talk .
- 09/2025 **Summer school "Mathematical methods for high-dimensional data"**, *Sapienza University, Roma, Italy*, poster .
- 10/2025 **ROccella Conference on INFERENCE and AI**, *Roccella Ionica, Italy*, poster.
- 07/2025 **StatPhys29**, *Firenze, Italy*, poster.
- 07/2025 **Learning and optimization in high dimensions**, *Bocconi university, Milano, Italy*, poster.
- 06/2025 **Beg Rohu Summer school "Learning with machines, physics and minds"**, *Saint Pierre Quiberon, France*, poster.
- 10/2024 **ROccella Conference on INFERENCE and AI**, *Roccella Ionica, Italy*, poster.
- 07/2024 **Workshop on Complexity in Engineering COMPENG**, *Firenze, Italy*, poster.
- 07/2024 **Cargese Summer school "Complex and glassy systems"**, *Cargese, France*, poster.

## Teaching and student supervision

- 2025 Co-supervisor of the Master's Degree thesis "Pseudo-likelihood associative memory on power-law distributed random-features dataset" of Sergio Manfrin, University of Milan
- 2025 Tutor for the course "Calculus 1" at the Department of Physics (Sapienza University) - 40 hours of exercises at the blackboard and Q&A sessions
- 2024 Tutor for the course "Calculus and statistics" at the Department of Biotechnology (Sapienza University) - 40 hours of exercises at the blackboard and Q&A sessions

## Languages

Mother tongue	<b>Italian</b>	
Advanced	<b>English</b>	<i>Level C1</i>
Intermediate	<b>Spanish</b>	<i>Level B1</i>
Basic	<b>French</b>	<i>Level A2</i>

## Digital skills

- Professional **Programming:** Python, C, C++.
- Professional **Scientific packages:** PyTorch, Numpy, Scipy, Matplotlib.
- Professional **Operating systems and HPC schedulers:** Linux, Windows, Slurm, PBS.
- Intermediate **Scientific software:** R, Wolfram Mathematica