

ENRICO M. MALATESTA

PERSONAL DATA

AFFILIATION: Department of Computing Sciences, 3-E3-02, Bocconi University
Via Röntgen 1, 20136, Milano, Italy
PLACE AND DATE OF BIRTH: Rome, Italy | 23 September 1991
EMAIL: enrico.malatesta@unibocconi.it

RESEARCH INTERESTS

My research lies at the interface of **theoretical physics and computer science**.

Broadly speaking, I am interested in analytically characterizing the typical landscape of **optimization, inference and machine learning** problems in high-dimensions, using physics-inspired techniques borrowed from the **statistical mechanics of disordered system**, as long as advanced methods in **probability and random matrix theory**.

I am also interested in exploiting this knowledge to theoretically explain the **dynamics of simple algorithms** and to design new high-performance algorithms.

In the case of **deep neural networks**, where an exact analytical treatment is hard, I am interested in developing **simple effective models** that can explain the interplay of the learning algorithm, the **data structure** and of **overparameterization** during the training process.

PRESENT POSITION

from SEPT 2021 | Assistant Professor, [Department of Computing Sciences](#) BOCCONI UNIVERSITY.

PREVIOUS POSITIONS

2021-2021 | Academic Fellow, BOCCONI UNIVERSITY.

2019-2021 | PostDoctoral researcher, BOCCONI UNIVERSITY, [Artificial Intelligence Lab](#).

EDUCATION

2015-2018 | Phd Student in Theoretical Physics, Milan University
Thesis: *Random Combinatorial Optimization Problems: Mean Field and Finite-Dimensional Results*
Supervisors: Sergio Caracciolo and Giorgio Parisi

2013-2015 | Master Degree in Theoretical Physics, Sapienza, Rome
Thesis: *Two-Loop Corrections to the Large Perturbative Order of a φ^4 Theory*
Supervisors: Giorgio Parisi and Tommaso Rizzo

2010-2013 | Bachelor Degree in Physics, Sapienza, Rome
Thesis: *Feynman's Quantum Statistical Mechanics Formulation*
Supervisor: Sara Bonella

2005-2010 | Classic High School "L. MANARA", Rome.

AWARDS AND PROJECTS

- 2023 | PI of the PRIN project “Statistical Mechanics of Learning Machines: from algorithmic and information-theoretical limits to new biologically inspired paradigms”
- 2021 & 2023 | Bocconi Research Excellence Award. Bocconi University.
- 2020 | PhD thesis Special Mention - INFN Fubini prize.
- 2015-2018 | Participant of PRIN on “Statistical Mechanics and Complexity”.
- 2013 | Scholarship “Ernesto e Iole de Maggi”.
- 2012-2013 | During my Bachelor, I took part to the Excellence Track (“Percorso di Eccellenza”) of the department of physics, reserved to students with high merits.

PUBLICATIONS AND PREPRINTS

20. E. Demyanenko, C. Feinauer, E. M. Malatesta, L. Saglietti, *The twin peaks of learning neural networks*, To appear on Machine Learning Science and Technology (2024).
19. E. M. Malatesta, *High-dimensional manifold of solutions in neural networks: insights from statistical physics*, (2023).
18. B. L. Annesi, C. Lauditi, C. Lucibello, E. M. Malatesta, G. Perugini, F. Pittorino, L. Saglietti, *The star-shaped space of solutions of the spherical negative perceptron*, Phys. Rev. Lett. **131**, 227301 (2023), Editors’ suggestion.
17. M. Negri, C. Lauditi, G. Perugini, C. Lucibello, E. M. Malatesta, *Storage and Learning phase transitions in the Random-Features Hopfield Model*, Phys. Rev. Lett. **131**, 257301 (2023).
16. C. Baldassi, E. M. Malatesta, G. Perugini, R. Zecchina, *Typical and atypical solutions in non-convex neural networks with discrete and continuous weights*, Phys. Rev. E **108**, 024310 (2023).
15. C. Baldassi, C. Lauditi, E. M. Malatesta, R. Pacelli, G. Perugini, R. Zecchina, *Learning through atypical “phase transitions” in overparameterized neural networks*, Phys. Rev. E **106**, 014116 (2022).
14. L. T. Giorgini, U. D. Jentschura, E. M. Malatesta, G. Parisi, T. Rizzo, J. Zinn-Justin, *Correlation Functions of the Anharmonic Oscillator: Numerical Verification of Two-Loop Corrections to the Large-Order Behavior*, Phys. Rev. D **105**, 105012 (2022).
13. C. Baldassi, C. Lauditi, E. M. Malatesta, G. Perugini, R. Zecchina, *Unveiling the structure of wide flat minima in neural networks*, Phys. Rev. Lett. **127**, 278301 (2021).
12. C. Baldassi, E. M. Malatesta, M. Negri, R. Zecchina, *Wide flat minima and optimal generalization in classifying high-dimensional Gaussian mixtures*, J. Stat. Mech. (2020) 124012.
11. L. T. Giorgini, U. D. Jentschura, E. M. Malatesta, G. Parisi, T. Rizzo, J. Zinn-Justin, *Two-loop corrections to the large-order behavior of correlation functions in the one-dimensional N -vector model*, Phys. Rev. D **101**, 125001 (2020).
10. C. Baldassi, E. M. Malatesta, R. Zecchina, *Properties of the geometry of solutions and capacity of multilayer neural networks with rectified linear unit activations*, Phys. Rev. Lett. **123**, 170602, (2019).
9. E. M. Malatesta, G. Parisi, G. Sicuro, *Fluctuations in the random-link matching problem*, Phys. Rev. E **100**, 032102, (2019).
8. S. Caracciolo, A. Di Gioacchino, E. M. Malatesta, *Selberg integrals in 1D random Euclidean optimization problems*, J. Stat. Mech. (2019) 063401.
7. S. Caracciolo, A. Di Gioacchino, E. M. Malatesta, C. Vanoni, *Average optimal cost for the Euclidean TSP in one dimension*, J. Phys. A: Math. Theor. **52** (2019) 264003.
6. R. Capelli, S. Caracciolo, A. Di Gioacchino, E. M. Malatesta, *Exact value for the average optimal cost of the bipartite traveling salesman and two-factor problems in two dimensions*, Phys. Rev. E **98**, 030101(R) (2018).
5. S. Caracciolo, A. Di Gioacchino, E. M. Malatesta, *Plastic number and optimal solutions for an Euclidean 2-matching in one dimension*, J. Stat. Mech. (2018) 083402.

4. S. Caracciolo, A. Di Gioacchino, M. Gherardi, E. M. Malatesta, *Solution for a bipartite Euclidean traveling-salesman problem in one dimension*, Phys. Rev. E. **97**, 052109, (2018).
3. C. Lucibello, E. M. Malatesta, G. Parisi, G. Sicuro, *The random fractional matching problem*, J. Stat. Mech. (2018), 053301.
2. E. M. Malatesta, G. Parisi, T. Rizzo, *Two-Loop Corrections to Large Order Behavior of φ^4 Theory*, Nucl. Phys. B, **922**, (2017), 293–318.
1. S. Caracciolo, M.P. D’Achille, E. M. Malatesta, G. Sicuro, *Finite-size corrections in the random assignment problem*, Phys. Rev. E **95**, 052129, (2017).

SELECTED TALKS, SEMINARS AND LECTURES

- SEPT 2023 | *Statistical mechanics of artificial neural networks*, 4 lectures, 2nd School of the Italian Society of Statistical Physics, IMT School for Advanced Studies Lucca, Italy.
- JUL/AUG 2023 | SigmaPhi, Chania, Crete and StatPhys28, Tokyo, Japan.
- MAR 2023 | Laboratoire de Physique Théorique et Modèles Statistiques, Paris, France.
- MAY 2022 | Invited group seminar, SPASS - Probability, Stochastic Analysis and Statistics, Pisa university.
- NOV 2021 | Invited group seminar, University of Oxford, Department of Experimental Psychology and UCL university, London.
- DEC 2019 | Invited group seminar, Sapienza University of Rome, Italy.
- JUL 2019 | StatPhys 27, Buenos Aires, Argentina.
- SEP 2017 | Group seminar, University of Milan, Italy.
- JUN 2017 | XXII Convegno Nazionale di Fisica Statistica e dei Sistemi Complessi, University of Parma.

POSTERS

- 2022 | *Phase transitions of the landscape of solutions of overparametrized neural networks*, 47th Middle European Cooperation in Statistical Physics, Erice, Italy.
- 2019 | *On the geometry of solutions and capacity of multi-layer neural networks with ReLU activations*, 40th years of RSB, Sapienza University of Rome, Italy.
- 2018 | *New Results on the Random Euclidean Traveling Salesman Problem*, Sapienza University of Rome, Italy.
- 2017 | *Finite-size corrections in the random assignment problem*, Sapienza University of Rome, Italy.

TEACHING EXPERIENCE

2021-	Lecturer of “ <i>Foundation of Physics II</i> ”, Bachelor degree in Mathematical and Computing Sciences for Artificial Intelligence, Bocconi.
2021-	Lecturer of “ <i>Foundation of Physics I</i> ”, Bachelor degree in Mathematical and Computing Sciences for Artificial Intelligence, Bocconi.
2020-2022	Lecturer of “ <i>Computer Science - Module 1 (Introduction to computer science and programming)</i> ”, Bachelor degree in Mathematical and Computing Sciences for Artificial Intelligence, Bocconi.
2019-2021	Lecturer of “ <i>Methods and data analytics for risk assessment</i> ”, Master degree in Cyber Risk Strategy and Governance, Bocconi.
2018-2021	Teaching Assistant of “ <i>Machine Learning</i> ”, Bachelor of Science in Economics, Management and Computer Science, Bocconi.
2018-2021	Teaching Assistant of “ <i>Fundamentals of Computer Science</i> ”, Bachelor of Science in Economics, Management and Computer Science, Bocconi.
2016-2018	Lecturer of “ <i>Modern Physics and Quantum Mechanics</i> ”, Bachelor degree in Physics, University of Milan.
2016-2017	Teaching Assistant of “ <i>Numerical treatment of experimental data</i> ”, Bachelor degree in Physics, University of Milan.

SUPERVISION OF STUDENTS

- Clarissa Lauditi, PhD, (ongoing).
- Clarissa Lauditi, Master Thesis, “Statistical physics of learning in a neural network with positive weights”, 2020.
- Andrea Riva, Master Thesis, “The random Minimum Spanning Tree Problem”, 2019.
- Vittorio Erba, Master Thesis, “Random Euclidean Bipartite Matching with concave cost functions in 1d”, 2018.
- Carlo Vanoni, Bachelor Thesis, “Monopartite traveling salesman problem in one dimension”, 2018.
- Co-supervision of Francesco Borra, Master Thesis: “Generalization from correlated inputs in a simple model of supervised neural network”, 2018.
- Giuseppe Del Vecchio Del Vecchio, Bachelor Thesis: “On The Random Euclidean Assignment Problem in one dimension”, 2017.

REVIEWING ACTIVITIES

Reviewer for Journal of Statistical Mechanics: Theory and Experiment, Journal of Physics A: Mathematical and Theoretical, Neural Computation, Physical Review Research, Physical Review E, Physical Review Applied. Referee for 1 PhD Thesis.

ORGANIZATION OF CONFERENCES

2024 MAY 20-24	“ Conceptual Challenges in AI: from ML to Average-Case Computation and Cryptography ”, Bocconi, Milan, Italy.
2022 OCT 17-19	“ The many facets of Statistical Field Theory ”, SISSA, Trieste, Italy.

OTHER ACADEMIC ACTIVITIES

2023	Admission board member of the Ph.D. in Statistics and Computer Science. Bocconi University
2021-PRESENT	Member of Teachers-Students Joint Commission

LANGUAGES

ITALIAN: Mother tongue
ENGLISH: Fluent

COMPUTER SKILLS

SYSTEMS: Unix/Linux, Windows
LANGUAGES: C/C++, Julia, Python, Mathematica, Bash
MARKUP: \LaTeX , Beamer
PACKETS: gnuplot, Tikz, pgfplots, feynMP
LIBRARIES: GSL, Eigen, Lemon, GLPK, Concorde