

ENRICO M. MALATESTA

PERSONAL DATA

AFFILIATION: Department of Computing Sciences, 3-E3-02, Bocconi University
Via Roentgen 1, 20136, Milano, Italy
PLACE AND DATE OF BIRTH: Rome, Italy | 23 September 1991
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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: Prof. Sergio Caracciolo and Prof. 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: Prof. Giorgio Parisi and Prof. Tommaso Rizzo

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

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

AWARDS AND PROJECTS

- 2020 | PhD thesis Special Mention - INFN Fubini prize.
- 2015-2018 | Participant of PRIN (research project of national interest) 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

- 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).
- 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).
- 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).
- 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.
- 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).
- 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).
- E. M. Malatesta, G. Parisi, G. Sicuro, *Fluctuations in the random-link matching problem*, Phys. Rev. E **100**, 032102, (2019).
- S. Caracciolo, A. Di Gioacchino, E. M. Malatesta, *Selberg integrals in 1D random Euclidean optimization problems*, J. Stat. Mech. (2019) 063401.
- 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.
- 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).
- 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.
- 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).
- C. Lucibello, E. M. Malatesta, G. Parisi, G. Sicuro, *The random fractional matching problem*, J. Stat. Mech. (2018), 053301.
- 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.
- 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

- MAY 2022 | *Phase transitions in the landscape of solutions of overparametrized neural networks*, invited group seminar, SPASS - Probability, Stochastic Analysis and Statistics, Pisa university.
- NOV 2021 | *Generalization and local entropy: from the under to the over-parametrized regime*, University of Oxford, Department of Experimental Psychology and UCL university, London.
- DEC 2019 | *On the role of wide flat minima and activation functions in two-layer neural networks*, Sapienza University of Rome, Italy.
- JUL 2019 | *On the role of wide flat minima in multi-layer neural networks*, Buenos Aires, Argentina, StatPhys 27.
- SEP 2017 | *Finite-size corrections in matching and other combinatorial optimization problems*, University of Milan, Italy.
- JUN 2017 | *Finite-size corrections in the random assignment problem*, University of Parma, XXII Convegno Nazionale di Fisica Statistica e dei Sistemi Complessi.

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

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