Dott. Raffaele Marino, Ph.D.

Dipartimento di Fisica
Università di Roma "La Sapienza"
Piazzale Aldo Moro 5
Roma, 00165 ROMA

Current position

Researcher, Dipartimento di Fisica, Università di Roma "La Sapienza"

Areas of specialisation

Physics; Statistical Mechanics; PDEs; Numerical Methods; Optimization; Heuristic and learning algorithms

Appointments held

2021-present Senior Researcher (post-doc) at Università di Roma "La Sapienza", Dipartimento di Fisica.
Research project: an investigation of sparse neural networks for understanding and developing explainability of deep learning methodology.
Advisor: Prof. Dr. Federico Ricci-Tersenghi

2019-2021 Senior Researcher (post-doc) at EPFL, School of Computer and Communication Science, Lausanne, Switzerland.
Research project: an investigation of high dimensional statistics, modern inference, and machine learning. This interdisciplinary project aimed to benefit from recent learning theory developments to solve high-dimensional partial differential equations using deep learning methodology. In this project, we built deep neural networks for approximating high-dimensional Kolmogorov equation solutions in polynomial time, avoiding, therefore, the curse of dimensionality. Moreover, a comparison of the performance of variants of the deep neural network, derived by using different discretization schemes of the stochastic differential equations, was investigated. Advisor: Prof. Dr. Nicolas Macris

2017-2019 Postdoctoral Fellow at HUJI, School of Computer Science and Engineering, Jerusalem, Israel.
Research project: an investigation of stochastic optimization, computational complexity, and graph theory. The project aimed to develop new greedy and message passing algorithms for overcoming the limits of existing algorithms for graphical models. Empirical comparisons of the developed algorithms with the existing ones showed strong evidence that an exhaustive search over a small number of variables of the problem improves greedy algorithms' performance without presenting the curse of dimensionality. The algorithms developed in this project, e.g., the hidden clique problem, are the best practical methods at the moment.

Advisor: Prof. Dr. Scott Kirkpatrick

2013-2017   Ph.D. student at NORDITA (KTH and SU), Stockholm, Sweden.

Research project: an investigation of stochastic thermodynamics and statistical mechanics out of equilibrium. The project was centered around the theory of transport processes in nonequilibrium systems, where thermal noise typically plays a dominant role. Apart from studying idealizedstochasticmodels,theresearchfocusedondevelopingconcreterealizationsofsuchtransport phenomena and developing thermodynamics analysis.

Supervisor: Prof. Dr. Erik Aurell

2012-2013   Master thesis student at Dipartimento di Fisica, Università di Roma "La Sapienza"

Research project: this research, in the realm of the theory of computational complexity, was centered on the K-SAT Problem. The aim was developing a new message-passing algorithm based on the cavity-method equations. The result was an algorithm for solving K-SAT problems, published in Nature Communications .

Supervisor: Prof. Dr. Giorgio Parisi (Nobel Laureate 2021)

Education

2017   Ph.D. in Theoretical Physics, Royal Institute of Technology (KTH) Stockholm, Sweden

2013   M.Sc. in Theoretical Physics, Università di Roma "La Sapienza", Rome, Italy

2010   B.Sc. in Physics, Università di Roma "La Sapienza", Rome, Italy

Grants, scholarships, honours & awards

2021   3-year post-doc contract at Sapienza Università di Roma. (Prof. Girogio Parisi's Lab) 2021
Member of the Advisory Board AI Transparency Institute (Switzerland).

2020   IOP trusted reviewer (recognition of the exceptionally high level of peer review competency).

2020   Winner of International calling for Research Fellowships at Leonardo Labs (not accepted).

2020   Winner of a PIML travel grant (2000 $).

2020   Winner of International calling for programs at NORDITA (600K SEK).

2019   2-year post-doc contract at EPFL.

2017   2-year post-doc fellowship at the Hebrew University of Jerusalem.

2013   4-year Ph.D. student contract at NORDITA and KTH.

2006   Winner of national competition for admission to Military School "Nunziatella" in Naples, Italian Ministry of Defence (2003).

Supervising and mentoring activities

2021 I am co-supervising a bachelor student for a B. Sc. thesis.

2021 I am teaching assistant to Computational Physics Lab.

2020 I supervised two bachelor students at EPFL for a semester project.

2020 I supervised a master student at KTH for a three months project.

Organization of conferences

2020 Nordita Program "Hard Problems: Beyond Equilibrium Methods" (Summer 2021, delayed cause Covid-19), NORDITA, Stockholm, Sweden.

Skills

Professional skills: solid knowledge of physics, math, algorithms, and hard combinatorial problems.

Technical skills: advanced C++ programming for scientific computation, Python programming, TensorFlow, Deep Learning, Machine Learning, Linux, IOS, Windows, Mathematica.

Personal skills: Leadership, Team building, Problem-solving oriented.

Languages: Italian (mother tongue), English (fluent-C1), French (beginner-A1/A2)

Publications & talks

Number of papers: **11**

Number of Ph.D. thesis: **1**

Number of talks: **12**

Number of posters: **2** h-

index Google Scholar: **4**

Overall citations according to Google Scholar: **74**

Overall citations according to Scopus: **40**

Journal articles

2016 R. M., G. Parisi, F. Ricci-Tersenghi. The backtracking survey propagation algorithm for solving K-SAT problems. Nature Communications 7.

2016 R. M., R. Eichhorn, E. Aurell. Entropy production of a Brownian ellipsoid in the overdamped limit. Phys. Rev. E 93, 012132.

2016 E. Aurell, S. Bo, M. Dias, R. Eichhorn, R. M. Diffusion of Brownian ellipsoid in a force field. EPL (Europhysics Letters) 114 (3), 30005.

2016 R. M., E. Aurell. Advective-diffusive motion on large scale from small scale dynamics with an internal symmetry. Phys. Rev. E 93, 062147.

2017 R. M., R. Eichhorn, Brownian motion of an ellipsoidal particle in a tilted periodic potential: long
term velocity and diffusion. 2017, DOI:10.13140/RG.2.2. 29995.05926.

2018 R. M., S. Kirkpatrick. Revisiting the Challenges of MaxClique. [arxiv:1807.09091].

2020 R.M.,S.Kirkpatrick. Largeindependentsetonrandomd-regulargraphswithdsmall. [arxiv:2003.12293].

2020 R. M., N. Macris. Solving non-linear Kolmogorov equations by using deep learning: a numerical comparison of discretization schemes. [arxiv:2012.07747].

2021 S. Caracciolo, R. Fabbricatore, R. M., G. Parisi, G. Sicuro. Criticality and conformality in the random dimer problem. PRE 103, 042127.

2021 R. M. Learning from Survey Propagation: a Neural Network for MAX-E-3-SAT. Machine Learning: Science and Technology 2 035032.

2021 M. Mohseni, D. Eppens, J. Strumpfer, R. M., V. Denchev, A. K. Ho, S. V. Isakov, S. Boixo, F. Ricci-Tersenghi, H. Neven Nonequilibrium Monte Carlo for unfreezing variables in hard combinatorial optimization. [arxiv:2111.13628]

Books

2017 R.M., *DynamicsandThermodynamicsofTranslationalandRotationalDiffusionProcessesDriven out of equilibrium*. KTH, School of Computer Science and Communications.

Oral contributions and posters to International Conferences

2020 *Contributed talk*: Solving non-linear Kolmogorov equations by using deep learning: a numerical comparison of discretization schemes. Santa Fe 3rd Physics Informed Machine Learning. 13/01/2020, Santa Fe, USA (NM)

2020 *Contributedtalk*: A greedy story of Max-Clique. Mathematical and computational aspects of machine learning. 9/10/2019, Scuola Normale di Pisa, Pisa, Italy.

2018 *Invited talk*: Message passing algorithms & greedy algorithms: two different approaches for solving constraint satisfaction problems. PostDoc Mini-Symposium. 13/12/2018 The Hebrew University of Jerusalem, Faculty of Science, Jerusalem, Israel.

2015 *Invited talk*: Entropy production of a Brownian ellipsoid in the overdamped limit. NORDITA Day-Winter 2015. 20/11/2015 NORDITA, Stockholm, Sweden.

2018 *Poster*: Revisiting the challenges of MaxClique. Statistical physics and machine learning back together. 24/8/2018 Cargese, France.

2016 *Poster*: Diffusion of a Brownian ellipsoid in a force field. Statistical mechanics of quantum dynamics. 5/2016 Mariehamn, Sweden.

Oral contributions to International Seminars

2020   *Invitedtalk*: Solving non-linear Kolmogorov equations by using deep learning: a numerical comparison of discretization schemes. Complex systems and Biological physics seminar. 08/10/2020 NORDITA, Stockholm, Sweden.

2020   *Invitedtalk*: Solving non-linear Kolmogorov equations by using deep learning: a numerical comparison of discretization schemes. Los Alamos National Laboratories Seminar. 23/01/2020 Los Alamos National Laboratories, USA (NM).

2018   *Invited talk*: Revisiting the challenges of MaxClique. IPG Seminar. 17/10/2018 EPFL, School of Computer and Comm. Science, Lausanne, Switzerland.

2017   *Invited talk*: Dynamics and thermodynamics of translational and rotational diffusion processes driven out of equilibrium. Ph.D. Thesis public defence. 15/6/2017 Royal Institute of Technology (KTH), Stockholm, Sweden.

2016   *Invited talk*: The Backtracking Survey Propagation algorithm for solving random K-SAT problems. Complex systems and Biological physics seminar. 20/9/2016 NORDITA, Stockholm, Sweden.

2016   *Invited talk*: Diffusion of a Brownian ellipsoid in a force field. Complex systems and Biological physics seminar. 23/8/2016 NORDITA, Stockholm, Sweden.

2014   s *Invitedtalk*: Anomalous entropy production of a Brownian particle: the general case. Complex systems and Biological physics seminar. 09/12/2014 NORDITA, Stockholm, Sweden.

2013   *Invited talk*: Optimization algorithms for K-SAT problems. Complex systems and Biological physics seminar. 23/10/2013 NORDITA, Stockholm, Sweden.

SOURCE CODES (https://github.com/RaffaeleMarino)

2020   Deep learning neural networks for MAX-E-3-SAT (C++, mlpack libraries)

2019   A greedy algorithm for finding a large independent set on random regular graphs (C++)

2019   Deep learning neural networks for different PDEs (Python and TensorFlow)

2018   The backtracking survey propagation algorithm (C++)

2018   Survey inspired decimation algorithm (C++)

2018   Greedy algorithm SM1-ES (C++)

2018   Greedy algorithm SM2-ES (C++)

2018   Message passing algorithm for Hidden Clique (C++)

2018   E-R graph builder (C++)

2018   Well Random Number Generator (C++)

2016   Effective Diffusion Simulations (C/C++)

2016   Class Quaternion (C++)

References Under Request