Marco Letizia
Resume

Personal details

Date of Birth: February 16, 1987
Place of birth: Tarquinia, VT, Italy
Nationality: Italian
Email: marco.letizia@edu.unige.it
Personal webpage: https://mletizia.github.io/

Research interests

Machine learning for the natural sciences; signal-agnostic new physics searches; efficient machine learning; hypothesis testing; generative models; theoretical physics.

Work experience

Machine Learning Genoa Center (MaLGa), University of Genova — Jan 2020 – Present
Postdoctoral Researcher — *Genova, Italy*

Dept. of Applied Mathematics, University of Waterloo &
Perimeter Institute for Thoretical Physics — Jan 2018 – Dec 2019
Postdoctoral Researcher — *Waterloo, ON, Canada*

Education

International School for Advanced Studies (SISSA) — 2013 – 2017
PhD cum laude in Astroparticle Physics — *Trieste, Italy*
Thesis: Probing the spacetime fabric: from fundamental discreteness to quantum geometries
Supervisor: Prof. Stefano LIberati

Sapienza, University of Rome — 2010 – 2013
Laurea magistrale cum Laude in Fisica (M.Sc.) - Theoretical Physics curriculum — *Rome, Italy*
Thesis: Aspects of Localization in Polymer Quantum Field Theory
Supervisors: Prof. Giovanni Amelino-Camelia and Dr. Michele Arzano

Sapienza, University of Rome — 2006 – 2010
Laurea triennale in Fisica (B.Sc.) — *Rome, Italy*
Thesis: Polymer quantization and the discrete nature of space
Supervisors: Prof. Giovanni Montani and Dr. Francesco Cianfrani

Research activity summary

As a postdoc at the Machine Learning Genoa Center in the group of Computational and Statistical Learning led by Prof. Lorenzo Rosasco, I work on the development of machine learning models for high energy physics. In particular, my research is focused on the development of efficient data-driven approaches to hypothesis testing and, more recently, on generative models and fast simulations. I also contribute to other research themes in our group.

Efficient nonparametric methods for hypothesis testing. We developed a hypothesis testing strategy, powered by machine learning, which is signal-agnostic, multivariate, statistically sound, and efficient [1]. Crucially, our approach based on kernel methods is faster than neural network implementations while maintaining comparable performances. This approach can also be effectively deployed for monitoring particle detectors in real time [2]. Conceptual and technical aspects are further clarified in [3].

Fast generation of calorimeter showers and the manifold hypothesis. In [4], we propose modelling calorimeter showers by first learning their manifold structure, and then estimating the density of data across this manifold. This enables faster training and generation when compared with competing methods.

Testing normalizing flows in high dimensions. We propose in [5] an in-depth comparison of coupling and autoregressive flows, with data of increasing complexity and dimensionality. The performances are discussed in terms of different figures of merit.

Efficient unsupervised learning for the clustering of plankton images. We propose [6] an efficient unsupervised learning pipeline to provide accurate classification of plankton microorganisms. The proposed pipeline outperforms the benchmark algorithms for all the plankton datasets included in our analysis, providing better image embedding properties.

During the first part of my career, which includes my master degree, my Ph.D. training and most of my first postdoc, I have worked in theoretical physics. My research was focused on the study of quantum fields in discrete Lorentzian geometries [7, 8]. These works included both formal and numerical aspects. I also worked on models inspired by different quantum gravity scenarios and modified gravity [9, 10, 11, 12].

I have presented my work in several conferences and workshops (see the list of Selected Presentations).

Publications and Preprints

[1] M. Letizia, G. Losapio, M. Rando, G. Grosso, A. Wulzer, M. Pierini, M. Zanetti, and L. Rosasco, "Learning new physics efficiently with nonparametric methods," *Eur. Phys. J. C* **82** no. 10, (2022) 879, arXiv:2204.02317 [hep-ph].

[2] G. Grosso, N. Lai, M. Letizia, J. Pazzini, M. Rando, L. Rosasco, A. Wulzer, and M. Zanetti, "Fast kernel methods for Data Quality Monitoring as a goodness-of-fit test," *Machine Learning: Science and Technology* **4** no. 3, (2023) 035029, arXiv:2303.05413 [hep-ex].

[3] G. Grosso, M. Letizia, M. Pierini, and A. Wulzer, "Goodness of fit by Neyman-Pearson testing," arXiv:2305.14137 [hep-ph].

[4] J. C. Cresswell, B. L. Ross, G. Loaiza-Ganem, H. Reyes-Gonzalez, M. Letizia, and A. L. Caterini, "CaloMan: Fast generation of calorimeter showers with density estimation on learned manifolds," in *36th Conference on Neural Information Processing Systems*. 11, 2022. arXiv:2211.15380 [hep-ph].

[5] A. Coccaro, M. Letizia, H. Reyes-Gonzalez, and R. Torre, "On the curse of dimensionality for Normalizing Flows," arXiv:2302.12024 [stat.ML].

[6] P. D. Alfano, M. Rando, M. Letizia, F. Odone, L. Rosasco, and V. P. Pastore, "Efficient unsupervised learning for plankton images," in *2022 26th International Conference on Pattern Recognition (ICPR)*, pp. 1314–1321, IEEE. 2022. arXiv:2209.06726 [cs.CV].

[7] A. Belenchia, D. M. T. Benincasa, M. Letizia, and S. Liberati, "On the Entanglement Entropy of Quantum Fields in Causal Sets," *Class. Quant. Grav.* **35** no. 7, (2018) 074002, arXiv:1712.04227 [gr-qc].

[8] Y. K. Yazdi, M. Letizia, and A. Kempf, "Lorentzian Spectral Geometry with Causal Sets," *Class. Quant. Grav.* **38** no. 1, (2021) 015011, arXiv:2008.02291 [hep-th].

[9] M. Arzano and M. Letizia, "Localization and diffusion in polymer quantum field theory," *Phys. Rev.* **D90** no. 10, (2014) 104036, arXiv:1408.2959 [gr-qc].

[10] R. G. Torromé, M. Letizia, and S. Liberati, "Phenomenology of effective geometries from quantum gravity," *Phys. Rev.* **D92** no. 12, (2015) 124021, arXiv:1507.03205 [gr-qc].

[11] A. Belenchia, M. Letizia, S. Liberati, and E. D. Casola, "Higher-order theories of gravity: diagnosis, extraction and reformulation via non-metric extra degrees of freedom–a review," *Rept. Prog. Phys.* **81** no. 3, (2018) 036001, arXiv:1612.07749 [gr-qc].

[12] M. Arzano, L. Brocki, J. Kowalski-Glikman, M. Letizia, and J. Unger, "Quantum ergosphere and brick wall entropy," *Phys. Lett. B* **797** (2019) 134887, arXiv:1901.09599 [gr-qc].

Conference Papers

- G. Grosso, N. Lai, M. Letizia, J. Pazzini, M. Rando, A. Wulzer, and M. Zanetti, ”Fast kernel methods for Data Quality Monitoring as a goodness-of-fit test," *Machine Learning and the Physical Sciences, NeurIPS 2022*, https://ml4physicalsciences.github.io/2022/files/NeurIPS_ML4PS_2022_7.pdf, arXiv:2301.08917 [hep-ex].
- Jesse C Cresswell, Brendan Leigh Ross, Gabriel Loaiza-Ganem, Humberto Reyes-Gonzalez, Marco Letizia, Anthony L Caterini, ”CaloMan: Fast generation of calorimeter showers with density estimation on learned manifolds," *Machine Learning and the Physical Sciences, NeurIPS 2022*, https://ml4physicalsciences.github.io/2022/files/NeurIPS_ML4PS_2022_24.pdf.
- M. Letizia, G. Losapio, M. Rando, G. Grosso, L. Rosasco, ”Efficient kernel methods for model-independent new physics searches," *Machine Learning and the Physical Sciences, NeurIPS 2021*, https://ml4physicalsciences.github.io/2021/files/NeurIPS_ML4PS_2021_146.pdf.

Frequent Collaborators

Prof. Marco Zanetti (Università di Padova, Italy); Prof. Andrea Wulzer (IFAE, Barcelona, Spain); Dr. Maurizio Pierini (CERN, Geneva, Switzerland); Dr. Gaia Grosso (IAIFI, MIT, Boston, MA, USA); Dr. Riccardo Torre (INFN, Sez. di Genova, Italy); Dr. Humberto Reyes-Gonzalez (Università di Genova, Italy).

Selected Presentations

Efficient kernel methods for statistical hypothesis testing — Sept 20–22, 2023
PRIMO Workshop 2023 (talk) — *University of Bari, Bari, Italy*

Kernel methods for goodness of fit and data quality monitoring — Apr 18, 2023
Experimental seminar - Goodness of fit with a learning machine (talk) — *IFAE, Barcelona, Spain*

Modern kernel methods for two-sample testing — Feb 23, 2023
Artificial Intelligence and Complexity - Seminar (remote talk) — *CEA, Paris-Saclay*

A flexible and efficient machine learning approach for data quality monitoring — Sept 5-9 2022
Second MODE Workshop on Differentiable Programming for Experimental Design (poster) — *Crete, Greece*

Efficient nonparametric methods for statistical anomaly detection — Aug 22 - Sep 30 2022
Machine Learning at GGI — *Florence, Italy*

Efficient kernel methods for model-independent new physics searches — Dec 13 2021
Machine Learning and the Physical Sciences, NeurIPS (poster) — *Virtual only*

Efficient kernel methods for large scale problems in HEP — Nov 29 - Dec 3, 2021
International Workshop on Advanced Computing and Analysis Techniques in Physics Research (poster) — *Virtual only*

Causal Sets and Scalar Fields — Sept 9-13, 2019
Quantum gravity and matter (talk). — *IWH Heidelberg*

Algebraic aspects of quantum fields in causal sets and entanglement entropy — Sept 24-27, 2018
Relativistic Quantum Information North 2018 (talk) — *University of Vienna*

Quantum fields on causal sets and entanglement entropy — July 23-28, 2018
International Congress on Mathematical Physics (talk) — *Montreal, QC, Canada*

Deformed relativity symmetries and Finsler geometry — May 12-13, 2017
UCSS Workshop on Finsler Geometry and Lorentz Violation (invited talk) — *Indiana University, Bloomington*

Phenomenology of effective geometries from quantum gravity — July 4-7, 2016
XXXVII Max Born Symposium (talk) — *Faculty of Physics and Astronomy - Wroclaw, Poland*

Funding

Project grant from *Banca Intesa Sanpaolo* 2023
Italian National Recovery and Resilience Plan initiative via the University of Padua
on the development of machine learning-based techniques for the detection of fraudolent activities.

Comprehensive Multiboson Experiment-Theory Action (COMETA) - COST Action 2023
Contributor to the machine learning sections.

Grants from the *Fondazione Angelo Della Riccia* and *The Foundation Blanceflor* 2018, 2019
Ph.D. fellowship from the International School for Advanced Studies (Trieste) 2013 – 2017

Teaching activities

Information theory and Inference 2022,2023
TA - B.Sc. in Informatics, with Prof. Alessandro Verri and Prof. Lorenzo Rosasco *DIBRIS, Università di Genova, Italy*

Advanced Machine Learning 2020,2021
TA - M.Sc. in Informatics, with Prof. Lorenzo Rosasco *DIBRIS, Università di Genova, Italy*

Introduction to Deep Learning for Applied Mathematicians Fall 2019
Instructor *Applied Math., University of Waterloo - Waterloo, Canada*

Summer School on General Relativity July 24 - Aug 2, 2016
Lecturer (7 h) *Petnica Science Center - Valjevo, Serbia*

Mentoring and supervisions

Gabriele Bortolai (M.Sc. in Physics) 2023
A study on neural network embedding of jets with transformer-based models.
Co-supervision with Prof. S. Marzani *Università di Genova, Italy*

Alireza Molla Ali Hosseini (M.Sc. in Physics) 2023
A fast classifier-based approach to credit card fraud detection. Co-supervision with Prof. M. Zanetti *Università di Padova, Italy*

Marco Rando (Ph.D. in Computer Science) 2020-2023
Co-supervision with Prof. L. Rosasco *Università di Genova, Italy*

Gianvito Losapio (M.Sc. in Informatics) 2022
Efficient Machine Learning for new physics discoveries. Co-supervision with Prof. L. Rosasco *Università di Genova, Italy*

Filippo Labate (B.Sc. in Informatics) 2022
Normalizing flow models in unsupervised learning. Co-supervision with Prof. L. Rosasco *Università di Genova, Italy*

Technical Skills

OS: Windows, MacOS, Linux
Programming Languages: Python
Libraries: Numpy, Pandas, Scikit-learn, SciPy, Tensorflow, PyTorch, Python Optimal Transport
Softwares: Wolfram Mathematica
Version Control: Git
Writing: LaTeX, Office
Languages: Italian (native), English (fluent)

Organizational Responsibilities

Co-organizer of the LCSL annual workshop 2020-2023
Laboratory for Computational and Statistical Learning (MaLGa) *Genova, Italy*

Co-organizer of group meetings and seminars 2020-2022
Laboratory for Computational and Statistical Learning (MaLGa) *Genova, Italy*

Probing the spacetime fabric: from concepts to phenomenology July 4-7, 2017
Member of the Local Organizing Committee (SISSA) *Trieste, Italy*

Co-organizer of the gravity group Journal Club 2015, 2017
SISSA *Trieste, Italy*

Reviewer experience

Journals: Machine Learning: Science and Technology, Classical and Quantum Gravity, Physical Review D.
Conferences: Machine Learning and the Physical Sciences (NeurIPS).

Outreach Activities

Educational seminars for high school students 2016-2018, 2023
Liceo Scientifico P. Ruffini *Viterbo, Italy*