

Marco Letizia

Resume

Personal details

Nationality: Italian

Email: marco.letizia@edu.unige.it

Personal webpage: <https://mletizia.github.io/>

Research interests

Machine learning for high energy physics; statistical hypothesis testing; efficient machine learning; generative models; simulations; theoretical physics.

Work experience

Machine Learning Genoa Center (MaLGA), University of Genova

Postdoctoral Researcher

Jan 2020 – Present

Genova, Italy

**Dept. of Applied Mathematics, University of Waterloo &
Perimeter Institute for Theoretical Physics**

Postdoctoral Researcher

Jan 2018 – Dec 2019

Waterloo, ON, Canada

Education

International School for Advanced Studies (SISSA)

PhD cum laude in Astroparticle Physics

2013 – 2017

Trieste, Italy

Thesis: Probing the spacetime fabric: from fundamental discreteness to quantum geometries

Supervisor: Prof. Stefano Liberati

Sapienza, University of Rome

Laurea magistrale cum Laude in Fisica (M.Sc.) - Theoretical Physics curriculum

2010 – 2013

Rome, Italy

Thesis: Aspects of Localization in Polymer Quantum Field Theory

Supervisors: Prof. Giovanni Amelino-Camelia and Dr. Michele Arzano

Sapienza, University of Rome

Laurea triennale in Fisica (B.Sc.)

2006 – 2010

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 two directions. The first one is the development of efficient machine learning approaches to hypothesis testing with application to model-independent searches of new physics [1, 2, 3]. At the moment, I am working on improving the algorithm as well as on alternative approaches based on kernel mean embedding and optimal transport. Secondly, I have been working on density estimation and sampling. This research direction include principled approaches to density estimation based on the manifold hypothesis, with applications to the simulation of calorimeter showers[4, 5]. Moreover, I am currently interested in developing techniques for the evaluation and selection of generative models in high energy physics [6, 7]. I also contributed to other research themes in my current group [8].

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 [9, 10]. These works included both formal and numerical aspects. I also worked on models inspired by different quantum gravity scenarios and modified gravity [11, 12, 13, 14].

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

- [1] G. Grosso and M. Letizia, “Multiple testing for signal-agnostic searches of new physics with machine learning,” [arXiv:2408.12296](#) [hep-ph].
- [2] G. Grosso, M. Letizia, M. Pierini, and A. Wulzer, “Goodness of fit by Neyman-Pearson testing,” *SciPost Phys.* **16** (2024) 123, [arXiv:2305.14137](#) [hep-ph].
- [3] 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].
- [4] C. Krause *et al.*, “CaloChallenge 2022: A Community Challenge for Fast Calorimeter Simulation,” [arXiv:2410.21611](#) [cs.LG].
- [5] 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: Workshop on Machine Learning and the Physical Sciences*. 11, 2022. [arXiv:2211.15380](#) [hep-ph].
- [6] S. Grossi, M. Letizia, and R. Torre, “Refereeing the Referees: Evaluating Two-Sample Tests for Validating Generators in Precision Sciences,” [arXiv:2409.16336](#) [stat.ML].
- [7] A. Coccaro, M. Letizia, H. Reyes-Gonzalez, and R. Torre, “Comparative Study of Coupling and Autoregressive Flows through Robust Statistical Tests,” [arXiv:2302.12024](#) [stat.ML].
- [8] 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].
- [9] 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].
- [10] 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].
- [11] 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].
- [12] 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].
- [13] 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].
- [14] 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].

Frequent Collaborators

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

Selected Presentations

Machine learning in high energy physics: from theory to discovery <i>Workshop on High Luminosity LHC and Hadron Colliders (invited talk)</i>	Oct 1–4, 2024 Frascati, Italy
Efficient machine learning for model-independent tests <i>BOOST 2024 (talk)</i>	Jul 29–Aug 4, 2024 Genova, Italy
Learning new physics with a (kernel) machine <i>AISSAI - Anomaly Detection workshop (talk)</i>	March 4–7, 2024 Clermont-Ferrand, France
Learning new physics with a (kernel) machine <i>EuCAIFCon (poster)</i>	Apr 30–May 3, 2024 Amsterdam, The Netherlands
Learning new physics with a (kernel) machine <i>AISSAI - Anomaly Detection workshop (talk)</i>	March 4–7, 2024 Clermont-Ferrand, France
The New Physics Learning Machine <i>ML4Jets2023 (talk)</i>	Nov 6–10, 2023 DESY, Hamburg, Germany
Efficient kernel methods for statistical hypothesis testing <i>PRIMO Workshop 2023 (talk)</i>	Sept 20–22, 2023 University of Bari, Bari, Italy
Kernel methods for goodness of fit and data quality monitoring <i>Experimental seminar - Goodness of fit with a learning machine (talk)</i>	Apr 18, 2023 IFAE, Barcelona, Spain
Modern kernel methods for two-sample testing <i>Artificial Intelligence and Complexity - Seminar (remote talk)</i>	Feb 23, 2023 CEA, Paris-Saclay
A flexible and efficient machine learning approach for data quality monitoring <i>Second MODE Workshop on Differentiable Programming for Experimental Design (poster)</i>	Sept 5-9 2022 Crete, Greece
Efficient nonparametric methods for statistical anomaly detection <i>Machine Learning at GGI</i>	Aug 22 - Sep 30 2022 Florence, Italy
Efficient kernel methods for model-independent new physics searches <i>Machine Learning and the Physical Sciences, NeurIPS (poster)</i>	Dec 13 2021 Virtual only
Efficient kernel methods for large scale problems in HEP <i>International Workshop on Advanced Computing and Analysis Techniques in Physics Research (poster)</i>	Nov 29 - Dec 3, 2021 Virtual only
Causal Sets and Scalar Fields <i>Quantum gravity and matter (talk).</i>	Sept 9-13, 2019 IWH Heidelberg
Algebraic aspects of quantum fields in causal sets and entanglement entropy <i>Relativistic Quantum Information North 2018 (talk)</i>	Sept 24-27, 2018 University of Vienna
Quantum fields on causal sets and entanglement entropy <i>International Congress on Mathematical Physics (talk)</i>	July 23-28, 2018 Montreal, QC, Canada
Deformed relativity symmetries and Finsler geometry <i>UCSS Workshop on Finsler Geometry and Lorentz Violation (invited talk)</i>	May 12-13, 2017 Indiana University, Bloomington
Phenomenology of effective geometries from quantum gravity <i>XXXVII Max Born Symposium (talk)</i>	Jul 4-7, 2016 Faculty of Physics and Astronomy - Wroclaw, Poland

Funding

Project grant from Banca Intesa Sanpaolo <i>Italian National Recovery and Resilience Plan initiative via the University of Padua on the development of machine learning-based techniques for the detection of fraudulent activities.</i>	2023
Comprehensive Multiboson Experiment-Theory Action (COMETA) - COST Action <i>Contributor to the machine learning sections.</i>	2023
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	2022-2024
<i>TA - B.Sc. in Informatics, with Prof. Alessandro Verri and Prof. Lorenzo Rosasco</i>	<i>DIBRIS, Università di Genova, Italy</i>
Advanced Machine Learning	2020,2021
<i>TA - M.Sc. in Informatics, with Prof. Lorenzo Rosasco</i>	<i>DIBRIS, Università di Genova, Italy</i>
Introduction to Deep Learning for Applied Mathematicians	Fall 2019
<i>Instructor</i>	<i>Applied Math., University of Waterloo - Waterloo, Canada</i>
Summer School on General Relativity	July 24 - Aug 2, 2016
<i>Lecturer (7 h)</i>	<i>Petnica Science Center - Valjevo, Serbia</i>

Mentoring and supervisions

Gabriele Bortolai (M.Sc. in Physics)	2023
<i>A study on neural network embedding of jets with transformer-based models.</i>	
<i>Co-supervision with Prof. S. Marzani</i>	<i>Università di Genova, Italy</i>
Alireza Molla Ali Hosseini (M.Sc. in Physics)	2023
<i>A fast classifier-based approach to credit card fraud detection. Co-supervision with Prof. M. Zanetti</i>	<i>Università di Padova, Italy</i>
Marco Rando (Ph.D. in Computer Science)	2020-2023
<i>Co-supervision with Prof. L. Rosasco</i>	<i>Università di Genova, Italy</i>
Gianvito Losapio (M.Sc. in Informatics)	2022
<i>Efficient Machine Learning for new physics discoveries. Co-supervision with Prof. L. Rosasco</i>	<i>Università di Genova, Italy</i>
Filippo Labate (B.Sc. in Informatics)	2022
<i>Normalizing flow models in unsupervised learning. Co-supervision with Prof. L. Rosasco</i>	<i>Università di Genova, Italy</i>

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
<i>Laboratory for Computational and Statistical Learning (MaLGa)</i>	<i>Genova, Italy</i>
Co-organizer of group meetings and seminars	2020-2022
<i>Laboratory for Computational and Statistical Learning (MaLGa)</i>	<i>Genova, Italy</i>
Probing the spacetime fabric: from concepts to phenomenology	July 4-7, 2017
<i>Member of the Local Organizing Committee (SISSA)</i>	<i>Trieste, Italy</i>
Co-organizer of the gravity group Journal Club	2015, 2017
<i>SISSA</i>	<i>Trieste, Italy</i>

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
<i>Liceo Scientifico P. Ruffini</i>	<i>Viterbo, Italy</i>