MATTEO LULLI

matteo.lulli@gmail.com – lullimat.org, GitHub, LinkedIn, Google Scholar

ACADEMIC EXPERIENCE

November 2023 – December 2025 **The Chinese University of Hong Kong**
Research Associate
Lattice and optimal quadratures in one and higher dimension for the efficient and accurate estimation of multivariate probability distributions and scalar functions with applications to classification and generation as well as CFD for multi-phase flows.

October 2019 – October 2023 **Southern University of Science and Technology**
Research Associate Professor
Surface tension curvature corrections in multi-phase and multi-component systems with application to nucleation, cavitation and jet-breakup dynamics in the context of fluctuating hydrodynamics.

2018 – 2019 **The Hong Kong Polytechnic University**
Postdoc Fellow
Out-of-equilibrium Kovacs' dynamics of structural glasses near the glass transition with the a lattice particle model; Kovacs' Paradox and Kovacs' Memory.

2016 – 2017 **University of Rome "Tor Vergata"**
Postdoc Fellow
Flow and Yield-stress transition in emulsions systems in connection with spin-glasses and in direct comparison to microfluidics experiments.

2015 **University of Twente – Eindhoven University of Technology**
Postdoc Fellow
Diffusive surface nano-droplet growth dynamics in multi-component systems.

EDUCATION

2011 – 2015 **Ph.D. in Physics – University of Rome "Sapienza"**
Thesis Title: "Out-of-equilibrium measure of critical parameters for second order phase transitions"
Advisors: Giorgio Parisi, Andrea Pelissetto, Massimo Bernaschi

2008 – 2010 **M.A. in Physics 110/110 *cum laude* – University of Rome "Sapienza"**
Thesis title: "Hamiltonian analysis of Dirac's formulation of gravity and ADM formalism"
Advisors: Giovanni Montani, Francesco Cianfrani

2005 – 2008 **B.A. in Physics 110/110 *cum laude* – University of Rome "Sapienza"**
Thesis title: "A study of 2D Ising model phase transition performed with an exact decimation algorithm"
Advisors: Federico Ricci-Tersenghi

OPEN-SOURCE PROJECTS

Idea.Deploy : A Unified/Modular Computational Physics Framework; through this project I am ensuring the *reproducibility* of the numerical results of my recent peer-reviewed papers by allowing the scientific community to perform the simulations independently; the framework allows to use the same code-base both on consumer- and on cluster-grade hardware.

GRANTS

January 2021 - December 2022
National Science Foundation of China
"Cavitation Inception and Self-Emulsification in Lattice Boltzmann"
Research Fund for International Young Scientists, Grant no. 12050410244
Total Funds: 250K RMB (Year 1), 300K RMB (Year 2)

PROFESSIONAL ACTIVITIES

- **Schools**: Director of the 18^{th} course for the "International School on Complexity" – Machine Learning Approaches for Complexity
- **Referee for the journals**: Physical Review Research, Physical Review E, Computer Physics Communications, Communications in Computational Physics
- **Member of the organizing committee** for the international conference "Perspectives of GPU computing in Science 2016"

PUBLICATIONS

Selected key publications

- **M. Lulli**, G. Parisi, A. Pelissetto
"Out-of-equilibrium finite-size method for critical behavior analyses"
Phys. Rev. E **93**, 032126 (2016)
- **M. Lulli**, R. Benzi, M. Sbragaglia
"Metastability at the Yield-Stress Transition in Soft Glasses"
Phys. Rev. X **8**, 021031 (2018)
- **M. Lulli**, C.-S. Lee, H.-Y. Deng, C.-T. Yip, C.-H. Lam
"Spatial heterogeneities in structural temperature cause Kovacs expansion gap paradox in aging of glasses"
Phys. Rev. Lett. 124, 095501 (2020)
- A. Marciano, D. Chen, F. Fabrocini, C. Fields, E. Greco, N. Gresnigt, K. Jinklub, **M. Lulli**, K. Terzidis, E. Zappala
"Deep Neural Networks as the Semi-classical Limit of Quantum Neural Networks"
Neural Networks Volume **153**, September 2022, Pages 164-178
- **M. Lulli**, Antonino Marcianò, Emanuele Zappala
"Exact Evaluation of Hexagonal Spin-Networks for Topological Quantum Neural Networks"
Fortschritte der Physik - Progress of Physics, 2025
- **M. Lulli**, E. S. C. Ching
"Higher-order Tuning of Interface Physics in Multiphase Lattice Boltzmann"
Phys. Rev. E – Accepted 4 June, 2025

Book

- F. Cianfrani, O. M. Lecian, **M. Lulli** and G. Montani
"Canonical Quantum Gravity", World Scientific, ISBN: 978-981-4556-64-4

Peer-reviewed publications – **[Google Scholar]**

- **M. Lulli**, A. Marciano, X. Shan
"Stochastic Quantization of General Relativity à la Ricci-Flow"
Fortschritte der Physik - Progress of Physics, 2025
- **M. Lulli**, E. S. C. Ching
"Higher-order Tuning of Interface Physics in Multiphase Lattice Boltzmann"
Phys. Rev. E 112, 035308 (2025)
- F. Pelusi, **M. Lulli**, C. Coreixas, M. Sbragaglia, X. Shan
"A note on the lattice momentum balance in the lattice Boltzmann interaction-framework"
Physics of Fluids 37, 063320 (2025)
- **M. Lulli**, Antonino Marcianò, Emanuele Zappala
"Exact Evaluation of Hexagonal Spin-Networks for Topological Quantum Neural Networks"
Fortschritte der Physik - Progress of Physics, 2025
- **M. Lulli**, Luca Biferale, Giacomo Falcucci, Mauro Sbragaglia, Dong Yang, Xiaowen Shan
"Metastable and unstable hydrodynamics in multiphase lattice Boltzmann"
Phys. Rev. E 109, 045304 (2024)
- A. Marciano, D. Chen, F. Fabrocini, C. Fields, E. Greco, N. Gresnigt, K. Jinklub, **M. Lulli**, K. Terzidis, E. Zappala
"Deep Neural Networks as the Semi-classical Limit of Quantum Neural Networks"
Neural Networks Volume **153**, September 2022, Pages 164-178

- **M. Lulli**, L. Biferale, G. Falcucci, M. Sbragaglia, X. Shan
"Mesoscale Modelling of the Tolman Length in Multi-component Systems"
arXiv:2112.02574 [cond-mat.stat-mech], accepted for publication on **"The Legacy of Carlo Cercignani: from Kinetic Theory to Turbulence Modeling"**
- **M. Lulli**, L. Biferale, G. Falcucci, M. Sbragaglia, and X. Shan
"Mesoscale perspective on the Tolman length"
Phys. Rev. E 105, 015301 (2022)
- F. Pelusi, **M. Lulli**, M. Sbragaglia, M. Bernaschi
"TLBfind: a Thermal Lattice Boltzmann code for concentrated emulsions with FINite-size Droplets"
Computer Physics Communications Volume 273, 108259 (2022)
- **M. Lulli**, C.-S. Lee, L.-H. Zhang, H.-Y. Deng and C.-H. Lam
"Kovacs effect in glass with material memory revealed in non-equilibrium particle interactions"
J. Stat. Mech. 093303 (2021)
- **M. Lulli**, L. Biferale, G. Falcucci, M. Sbragaglia and X. Shan
"Structure and isotropy of lattice pressure tensors for multirange potentials"
Phys. Rev. E 103, 063309 (2021)
- A. Addazi, P. Chen, F. Fabrocini, C. Fields, E. Greco, **M. Lulli**, A. Marcianò and R. Pasechnik
"Generalized Holographic Principle, Gauge Invariance and the Emergence of Gravity à la Wilczek"
Front. Astron. Space Sci., 07 June (2021)
- C.-S. Lee, **M. Lulli**, L.-H. Zhang, H.-Y. Deng and C.-H. Lam
"Fragile Glasses Associated with a Dramatic Drop of Entropy under Supercooling"
Phys. Rev. Lett. 125, 265703 (2020)
- **M. Lulli**, C.-S. Lee, H.-Y. Deng, C.-T. Yip, C.-H. Lam
"Spatial heterogeneities in structural temperature cause Kovacs expansion gap paradox in aging of glasses"
Phys. Rev. Lett. 124, 095501 (2020)
- F. Pelusi, M. Sbragaglia, A. Scagliarini, **M. Lulli**, M. Bernaschi, S. Succi
"On the impact of controlled wall roughness shape on the flow of a soft material"
Europhysics Letters 127 34005 (2019)
- H.-Y. Deng, C.-S. Lee, **M. Lulli**, L.-H. Zhang, C.-H. Lam
"Configuration-tree theoretical calculation of the mean-squared displacement of particles in glass formers"
J. Stat. Mech. 094014 (2019)
- **M. Lulli**, R. Benzi, M. Sbragaglia
"Metastability at the Yield-Stress Transition in Soft Glasses"
Phys. Rev. X **8**, 021031 (2018)
- L. Derzsi, D. Filippi, **M. Lulli**, G. Mistura, M. Bernaschi, P. Garstecki, M. Sbragaglia, M. Pierno
"Wall fluidization in two acts: from stiff to soft roughness"
Soft Matter, **14**, 1088-1093 (2018)
- L. Derszi, D. Filippi, G. Mistura, M. Pierno, **M. Lulli**, M. Sbragaglia, M. Bernaschi, P. Garstecki
"Fluidization and wall slip of soft glassy materials by controlled surface roughness"
Phys. Rev. E **95**, 052602 (2017)
- M. Bernaschi, **M. Lulli**, M. Sbragaglia
"GPU based detection of topological changes in Voronoi diagrams"
Computer Physics Communications **213**, 19-28 (2017)
Detection Library source code
- M. Bernaschi, M. Carrozzo, **M. Lulli**, G. Piperno, D. Vergni
"Parallel Quasi Exhaustive Search of Optimal Asset Allocation for Pension Funds"
American Journal of Operations Research **6**, 387-400 (2016)
- A. Scagliarini, **M. Lulli**, M. Bernaschi, M. Sbragaglia
"Fluidisation and plastic activity in a model soft-glassy material flowing in micro-channels with rough walls"
Europhysics Letters **114**, 6, 64003 (2016)

- **M. Lulli**, G. Parisi, A. Pelissetto
"Out-of-equilibrium finite-size method for critical behavior analyses"
Phys. Rev. E **93**, 032126 (2016)

- **M. Lulli**, M. Bernaschi and G. Parisi
"Highly optimized simulations on single- and multi-GPU systems of 3D Ising spin glass"
Computer Physics Communications **196**, Pages 290-303 (2015)
Single-GPU source code
Multi-GPU source code

- F. Cianfrani, **M. Lulli** and G. Montani
"Solution of the noncanonicity puzzle in General Relativity: a new Hamiltonian formulation"
Physics Letters B, **710**, (4-5), 703-709 (2012)

Preprints

- **M. Lulli**, A. Marcianò, K. Piscicchia
"Stochastic Ricci Flow dynamics of the gravitationally induced wave-function collapse"
arXiv:2307.10136 [gr-qc]

- A. Marcianò, E. Zappala, T. Torda, **M. Lulli**, S. Giagu, C. Fields, D. Chen, F. Fabrocini
"Deep Neural Networks as the Semi-classical Limit of Topological Quantum Neural Networks: The problem of generalisation"
arXiv:2210.13741 [quant-ph]

TALKS IN INTERNATIONAL CONFERENCES

1. "Higher-order Tuning of Interface Physics in Multiphase Lattice Boltzmann"
Discrete Simulation of Fluid Dynamics 2025 (DSFD2025) - 34^{th} International Conference on Discrete Simulations of Fluid Dynamics, Harbin, China
July the 6^{th}, 2025
Awarded: Outstanding Young Scientist Award

2. "Distinguishable Kinetic Ising Model: bridging molecular dynamics and lattice Boltzmann"
Discrete Simulation of Fluid Dynamics 2024 (DSFD2024) - 33^{rd} International Conference on Discrete Simulations of Fluid Dynamics, ETH Zurich, Switzerland
July the 11^{th}, 2024

3. "Cosmological and Astrophysical Implications of the Stochastic Ricci Flow"
at the International Symposium on Cosmology and Particle Astrophysics: CosPA 2023, The Chinese University of Hong Kong, China
November the 13^{th}, 2023

4. "Hydrodynamic Metastability: Fluctuations and Pressure Tensor in Shan-Chen multi-phase lattice Boltzmann"
Invited Talk at Discrete Simulation of Fluid Dynamics 2023 (DSFD2023) - 32^{nd} International Conference on Discrete Simulations of Fluid Dynamics, The University of New Mexico, Albuquerque, NM
July the 20^{th}, 2023

5. "Stochastic Quantization of General Relativity: from multiplicative noise to the cosmological constant"
at Nuclear and Atomic transitions as laboratories for high precision tests of Quantum Gravity inspired models, Trento, Italy
September the 22^{nd}, 2022

6. "Mesoscale Modelling of the Tolman Length in Multi-component Systems"
at Discrete Simulation of Fluid Dynamics 2022 (DSFD2022) - 31^{st} International Conference on Discrete Simulations of Fluid Dynamics, Soochow University, Suzhou, China
August the 24^{th}, 2022

7. "A Mesoscale Perspective on the Tolman Length"
Invited Talk at Discrete Simulation of Fluid Dynamics 2021 (DSFD2021) - 30^{th} International Conference on Discrete Simulations of Fluid Dynamics, Viterbo, Italy
September the 16^{th}, 2021
Recording

8. "Shan-Chen pressure tensor anisotropies: another dimension for reducing spurious currents"
   Contributed Talk at DSFD 2020 - 29^{th} International Conference on Discrete Simulations of Fluid Dynamics, Viterbo, Italy
   July 2020

9. "Yield Transition and Controlled Fluidization of Soft-Glassy Materials"
   Contributed Talk at SM&FT 2017 - The XVII Workshop on Statistical Mechanics and nonperturbative Field Theory, Bari, Italy
   December 2017

10. "Detecting Topological Changes in Dynamic Delaunay Triangulations Using CUDA"
    Contributed talk at GPU Technology Conference 2017, San Jose, California
    May the 10^{th}, 2017
    Slides

11. "Detecting Plastic Events in Emulsion Simulatons" Contributed Talk at APS Meeting Division Fluid Dynamics 2016, Portland, Oregon
    November the 22^{nd}, 2016

12. "GPU Based Detection of Plastic Events in Lattice Boltzmann Emulsions"
    Contributed talk at Perspectives of GPU computing in Science 2016, Rome, Italy
    September the 26^{th}, 2016

13. "Live detection of plastic events in Lattice Boltzmann emulsions"
    Contributed talk at Discrete Simulation of Fluid Dynamics 2016 (DSFD2016), Shenzhen, China
    July the 7^{th}, 2016

14. "Solutions for Efficient Memory Access for Cubic Lattices and Random Number Algorithms"
    Contributed talk at GPU Technology Conference 2015, San Jose, California
    March the 29^{th}, 2015
    Slides

15. "3D Ising spin models: a test ground for wide spectrum optimization"
    Contributed talk at Perspectives of GPU computing in Physics and Astrophysics, Rome
    September the 16^{th}, 2014
    Slides

SEMINARS

1. "Quadratures and Machine Learning"
   Department of Physics, North Dakota State University
   February the 17^{th} 2025

2. **Colloquium** – "Quadratures and Machine Learning"
   Department of Mathematics & Statistics, Idaho State University
   February the 14^{th} 2025

3. "Quadratures and Machine Learning"
   Physics Department, University of Utah
   Invitation by Prof. Wu Yong-Shi – February the 10^{th}, 2025

4. "Fluctuating Multi-phase Hydrodynamics: from Boltzmann to Ising, and back"
   Department of Physics, City University of Hong Kong
   December the 11^{th}, 2023

5. **Colloquium** – "A Mesoscopic Perspective on Fluctuating Hydrodynamics"
   Department of Mathematics & Statistics, Idaho State University
   November the 7^{th} 2023

6. "Stochastic Quantization of General Relativity: Multiplicative Noise and Time-Intermittency at the Event Horizon"
   Physics Department, The Chinese University of Hong Kong
   February the 10^{th}, 2023

7. "Controlling Homogeneous Nucleation in Lattice Boltzmann: Tolman length and fluctuating hydrodynamics"
   Mechanical and Aerospace Engineering Department, The Hong Kong University of Science and Technology
   June the 15^{th}, 2022

8. "Guessing Ice from cooling (not freezing) hot Water: out-of-equilibrium scaling and Renormalization Group"
   Theory Seminar, Physics Department, Fudan University
   November the 1^{st}, 2019
9. "Metastability at the Yield-Stress Transition in Soft Glasses"
   Theory Seminar, Physics Department, Fudan University
   June the 21^{st}, 2019
10. "Out-of-equilibrium determination of critical parameters for continuous phase transitions: theory and computational details"
    Department of Physics Seminar, The Hong Kong University of Science And Technology
    January the 6^{th}, 2017
11. "Live detection of plastic activity in Lattice Boltzmann Emulsions"
    HPC Leap School "High Performance Computing Applications to Turbulence and Complex Flow", University of Rome Tor Vergata
    October the 6^{th}, 2016
12. "Out-of-equilibrium measure of critical parameters for second order phase transitions"
    Physics Of Fluids Group Seminar, University of Twente
    June the 10^{th}, 2015
13. "Non-canonicity in Arnowitt-Deser-Misner Hamiltonian formulation of General Relativity: a first hint of reference frame in the Canonical Quantization"
    Theoretical Seminary, University of Rome "Sapienza", Italy
    April the 20^{th}, 2011

ADVISING

Master Degree:

- Guo Hongying, Physics Dept. Fudan University
- Dr. Francesca Pelusi, former Ph.D. candidate at the University of Rome "Tor Vergata" now postdoc fellow at Helmholtz Institute Erlangen-Nürnberg for Renewable Energy (IEK-11)

Bachelor Degree:

- Yiqiu Zheng, School of Engineering Faculty of Computing and Engineering, Ulster University
- Riccardo Voso, Physics Department University of Rome "Tor Vergata"

Group Advising:

- Lee Chun-Shing, Ph.D. candidate at the Applied Physics department of The Hong Kong Polytechnic University
- Gu Rukai, University of Oxford, Department of Physics

TEACHING EXPERIENCE

I delivered lessons and guided laboratory experiences assisting the main teacher in the following courses

- "Programming in Physics", The Hong Kong Polytechnic University
- "Statistical Mechanics", University of Rome "Tor Vergata"
- "Primordial Cosmology", University of Rome "Sapienza"
- "Physics Laboratory", University of Rome, "Sapienza"

AWARDS

- **July 2025**: *Outstanding Young Scientist Award* at DSFD 2025 for the paper "Higher-order Tuning of Interface Physics in Multiphase Lattice Boltzmann"
  Phys. Rev. E – Accepted 4 June, 2025
- **July 2016**
  Excellent talk of the 25^{th} International Conference on Discrete Simulation of Fluid Dynamics (DSFD2016), Shenzhen, China. An nVidia Tesla K40 GPU has been awarded.

FUNDING AND SCHOLARSHIPS

- **March 2015**: nVidia VIP speaker at GTC 2015.
- **August 2013**: nVidia Academic Partnership Programme funding two GTX Titan GPUs

MULTIMEDIA

- Topological Changes in Delaunay Triangulations (Video)

REFERENCES

Giorgio Parisi

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University of Rome "Sapienza", 00185 Roma, Italy
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Southern University of Science and Technology, Shenzhen, Guangdong 518055, China
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Yong-Shi Wu

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