

Pedro E. Harunari

POSTDOCTORAL RESEARCHER · STATISTICAL PHYSICS

Aix Marseille Université, CNRS, CINAM, Turing Center for Living Systems, 13288 Marseille, France

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Personal Profile

After obtaining my Ph.D. from the University of São Paulo in 2022, and three years of postdoctoral experience in Massimiliano Esposito's group, I am now working with Pierre Ronceray to understand information-theoretic aspects of inference from stochastic trajectories.

A wide range of natural phenomena can be described by stochastic processes, yet in most cases, only part of their details are accessible. My research focuses on uncovering fundamental relationships between the observable quantities, precising their thermodynamic limits, and developing model-free tools to infer their hidden properties. By bridging theoretical insights with realistic applications, I aim to advance our understanding of the stochastic dynamics governing biophysics, chemical reaction networks, electronics, and other complex systems.

Education and positions

Aix Marseille Université

Postdoctoral researcher

- Supervised by Dr. Pierre Ronceray

Marseille, France

Oct 2025 - Current

University of Luxembourg

Postdoctoral researcher

- Supervised by Prof. Massimiliano Esposito

Luxembourg, Luxembourg

Dec 2022 - Sep 2025

University of São Paulo

Doctorate in Physics

- Thesis: "The role of time in nonequilibrium: transition-based coarse-graining, phase transitions and heat engines"
DOI:10.11606/T.43.2022.tde-14122022-084103
- Advisor: Prof. Dr. Carlos E. Fiore
- Allowed to join the program without a Master's degree
- Approved with the highest grades in every course

São Paulo, Brazil

Mar 2018 - Nov 2022

University of São Paulo

Bachelor in Physics

- 1.5 years of research training activities
- Complementary courses at: IMPA, CBPF and ICTP-SAIFR

São Paulo, Brazil

Feb 2014 - Nov 2017

List of Publications

17 articles published in internationally renowned journals and 3 preprints.

From Google Scholar: 409 citations, h-index 11.

- G Fiusa, **PE Harunari**, AS Hegde, GT Landi, "A framework for fluctuating times and counting observables in stochastic excursions"
arXiv:2506.05160 (preprint) 2025
- G Fiusa, **PE Harunari**, AS Hegde, GT Landi, "Counting observables in stochastic excursions"
arXiv:2505.06208 (preprint) 2025
- S Dal Cengio, **PE Harunari**, V Lecomte, M Poletti, "Mutual Multilinearity of Nonequilibrium Network Currents"
SciPost Physics 19, 111 2025
- M Poletti, **PE Harunari**, S Dal Cengio, V Lecomte, "Coplanarity of rooted spanning-tree vectors"
arXiv:2407.16093 (accepted in Letters in Mathematical Physics) 2024
- Q Yu, **PE Harunari**, "Dissipation at limited resolutions: Power law and detection of hidden dissipative scales"
Journal of Statistical Mechanics 103201 2024
- **PE Harunari**, CE Fiore, AC Barato, "Inference of entropy production for periodically driven systems"
Physical Review E **110**, 064126 2024
- **PE Harunari**, S Dal Cengio, V Lecomte, M Poletti, "Mutual linearity of nonequilibrium network currents"
Physical Review Letters **133**, 047401 (Editors' suggestion) 2024
- **PE Harunari**, "Uncovering Nonequilibrium from Unresolved Events"
Physical Review E **110**, 024122 2024
- A Garilli, **PE Harunari**, M Poletti, "Fluctuation relations for a few observable currents at their own beat"

Journal of Physics A: Mathematical and Theoretical 57 , 455003	2023
• F Avanzini, M Bilancioni, V Cavina, S Dal Cengio, M Esposito, G Falasco, D Forastiere, N Freitas, A Garilli, PE Harunari , V Lecomte, A Lazarescu, SGM Srinivas, C Moslonka, I Neri, E Penocchio, WD Piñeros, M Poletti, A Raghu, P Raux, K Sekimoto, A Soret, “ <i>Methods and Conversations in (Post)Modern Thermodynamics</i> ” SciPost Phys. Lect. Notes 80	2024
• F Hawthorne, PE Harunari , MJ de Oliveira, CE Fiore, “ <i>Nonequilibrium thermodynamics of the majority vote model</i> ” Entropy 25 , 1230 (Feature Paper)	2023
• PE Harunari , A Garilli, and M Poletti, “ <i>The beat of a current</i> ” Physical Review E 107 , L042105	2022
• PE Harunari , A Dutta, M Poletti, and É Roldán, “ <i>What to learn from a few visible transitions’ statistics?</i> ” Physical Review X 12 , 041026	2022
• IN Mamede, PE Harunari , BAN Akasaki, K Proesmans, and CE Fiore, “ <i>Obtaining efficient thermal engines from interacting Brownian particles under time-periodic drivings</i> ” Physical Review E 105 , 024106	2022
• CE Fiore, PE Harunari , CEF Noa, and GT Landi, “ <i>Current fluctuations in nonequilibrium discontinuous phase transitions</i> ” Physical Review E 104 , 064123	2021
• PE Harunari , S Fernando Filho, CE Fiore, and A Rosas, “ <i>Maximal power for heat engines: Role of asymmetric interaction times</i> ” Physical Review Research 3 , 023194	2021
• PE Harunari , CE Fiore, and K Proesmans, “ <i>Exact statistics and thermodynamic uncertainty relations for a periodically driven electron pump</i> ” Journal of Physics A: Mathematical and Theoretical 53 (37), 374001	2020
• CEF Noa, PE Harunari , MJ de Oliveira, and CE Fiore, “ <i>Entropy production as a tool for characterizing nonequilibrium phase transitions</i> ” Physical Review E 100 , 012104	2019
• JM Encinas, PE Harunari , MM de Oliveira, and CE Fiore, “ <i>Fundamental ingredients for discontinuous phase transitions in the inertial majority vote model</i> ” Scientific reports 8 (1), 1-9	2018
• PE Harunari , MM de Oliveira, and CE Fiore, “ <i>Partial inertia induces additional phase transition in the majority vote model</i> ” Physical Review E 96 , 042305	2017

Work Experience

(Post)Modern Thermodynamics - School and workshop

Luxembourg, Luxembourg

Organizer

Dec 2022

- Approximately, 100 participants from abroad and 30 from Luxembourg
- Conference consisting of 10 school lectures, 8 workshop sessions, and one poster session.
- Shared teaching duties of the lecture “*Continuous-time Markov chain: basics, first-passages and thermodynamics*” with Ken Sekimoto.
- Editorial duties on the preparation of lecture notes “*Methods and Conversations in (Post)Modern Thermodynamics*”.
- Co-organizers: Matteo Poletti, Vasco Cavina, William Piñeros.

The Abdus Salam International Centre for Theoretical Physics (ICTP)

Trieste, Italy

Visiting researcher

May 2022 – Jun 2022

- Visitor at Édgar Roldán’s group.

University of Luxembourg

Luxembourg, Luxembourg

Visiting researcher

Apr 2021 – Feb 2022

- Visitor at Massimiliano Esposito’s Complex Systems and Statistical Mechanics group.
- Supervised by Matteo Poletti.

University of Aalto

Helsinki, Finland

Visiting researcher

Dec 2021 – Jan 2022

- Visitor at Jukka Pekola’s PICO group.

The Abdus Salam International Centre for Theoretical Physics (ICTP)

Visiting researcher

- Visitor at Édgar Roldán's group.

Trieste, Italy

Jul 2021 – Sep 2021

Statistical Physics seminar series

online

Organizer

2020

- 21 seminars virtually presented during the COVID lockdown, mostly by professors, for a broad audience of students and researchers across Brazil and other countries. Co-organizer: Carlos E. Fiore.

University of São Paulo

São Paulo, Brazil

Undergraduate researcher

2015 - 2017

- Research training program.
- Supervisors: Mário J. de Oliveira (2015-2016), and Carlos E. Fiore (2016-2017).

Teaching Experience

- 2024 **Classical and Quantum Information Theory (graduate level)**, lecturer, University of Luxembourg
- 2020 **Thermodynamics**, teaching assistant, University of São Paulo
- 2019 **Statistical Mechanics**, teaching assistant, University of São Paulo
- 2018 **Statistical Mechanics (graduate level)**, teaching assistant, University of São Paulo
- 2018 **Statistical Mechanics**, teaching assistant, University of São Paulo

Skills

Programming Python, Mathematica, C.

Miscellaneous Usage of clusters, \LaTeX , Ubuntu Linux, teaching.

Prizes and Grants

- 2023 **Honorable mention for distinguished Ph.D. thesis in Exact and Earth Sciences**, University of São Paulo
- 2023 **Best Ph.D. thesis in Statistical and Computational Physics (national level)**, Brazilian Physical Society
- 2022 **Best Ph.D. thesis prize**, Institute of Physics - University of São Paulo
- 2022 **Honorable mention for distinguished publication**, Institute of Physics - University of São Paulo
- 2021 **Internship grant**, grant for 11 months of internship abroad (BEPE - FAPESP)
- 2018 **Ph.D. fellowship**, FAPESP 4 years grant for the Doctorate without Masters degree program
- 2017 **Undergrad research fellowship**, FAPESP grant for the Undergraduate research program
- 2016 **Undergrad research fellowship**, CNPq grant for the Undergraduate research program

Invited seminars and colloquiums

- 2025 “*Thermodynamic cost of communication channels*”, Universitat Pompeu Fabra
- 2025 “*Thermodynamic limits of nonequilibrium communication across scales*”, Princeton University
- 2025 “*Thermodynamic limits of nonequilibrium communication across scales*”, Massachusetts Institute of Technology (MIT)
- 2024 “**Colloquium:** *Recuperando termodinâmica estocástica com informação limitada*”, Univ. of São Paulo, Brazil
- 2024 “*Mutual Linearity of Nonequilibrium Network Currents*”, Université Paris Cité, France
- 2024 “*Mutual Linearity of Nonequilibrium Network Currents*”, Aix-Marseille Université, France
- 2024 “*Model-free inference of entropy production from partial information*”, Université Grenoble Alpes, France
- 2021 “*Inferences from partial information of transition statistics*”, University of Aalto, Finland

Events attended

STATPHYS 29

Florence, Italy

The 29th international conference on statistical physics

2025

- Poster: “Thermodynamic limits of nonequilibrium communication across scales”

Stochastic Thermodynamics and Computer Science Theory

Santa Fe, USA

Santa Fe Institute

2025

- Invited Talk: “Stochastic Thermodynamics of communication channels”

Workshop on Stochastic Thermodynamics - WOST VI virtual conference • Talk : “Mutual linearity of nonequilibrium network currents”	online 2025
Dissipative Processes in Molecular Systems University of Padova • Poster : “Inferring dissipation by monitoring reservoirs”	Padova, Italy 2024
Journées de Physique Statistique, 42nd edition École Normale Supérieure de Paris • Talk : “Unveiling nonequilibrium from multifilar events”	Paris, France 2024
XXVII Sitges Conference on Statistical Mechanics Universitat de Barcelona • Talk : “Thermodynamics at the beat of transitions”	Sitges, Spain 2023
Workshop on Stochastic Thermodynamics - WOST IV The Abdus Salam International Centre for Theoretical Physics (ICTP) • Talk : “Fluctuation relation at the beat of a current”	online 2023
Physics of Life: Students and Postdocs Edition The Center for the Physics of Biological Function, CUNY/Princeton • Talk : “Thermodynamics through the lens of transitions”	New York, United States of America 2023
Fluctuations and First Passage Problems NORDITA • Talk : “Thermodynamics at the beat of transitions”	Stockholm, Sweden 2023
Journées de Physique Statistique, 42nd edition École Normale Supérieure de Paris • Talk : “Transition-based coarse-graining”	Paris, France 2023
The 47th Conference of the Middle European Cooperation in Statistical Physics MECO 47 • Poster : “Inferences from Statistics of a Few Observable Transitions”	Erice, Italy 2022
Autumn meeting Brazilian Physical Society • Poster : “Inferences from Statistics of a Few Observable Transitions”	São Paulo, Brazil 2022
National Statistical Physics Meeting Universidade Federal de São João del-Rei (UFSJ) • Talk : “Inferences from Statistics of a Few Observable Transitions”	online 2021
Statistical Physics of Complex Systems The Abdus Salam International Centre for Theoretical Physics (ICTP) • Poster : “Entropy production fluctuation in phase transitions”	Trieste, Italy 2021
Bangalore School on Statistical Physics XII International Center for Theoretical Sciences (ICTS)	online 2021
Autumn meeting Brazilian Physical Society • Talk : “Entropy Production fluctuations in nonequilibrium transitions”	online 2021
Workshop on Stochastic Thermodynamics - WOST II Santa Fe Institute	online 2021
APS March Meeting American Physical Society • Talk : “Quantitative comparison of different time-periodic Thermodynamic Uncertainty Relations”	online 2021
Quantum Thermodynamics of Non-equilibrium systems Donostia International Physics Center	online 2020
Statistical Physics Seminar Series University of São Paulo • Talk : “Stochastic Thermodynamics: Schnakenberg, FT and TUR”	online 2020

Autumn meeting

Brazilian Physical Society

- Talk: “Stochastic pump as a model to study nonequilibrium properties”

online

2020

Quantum Thermodynamics for Young Scientists

Bad Honnef, Germany

Wilhelm and Else Heraeus-Foundation

2020

- Poster: “Time assymmetric reciprocity relations for an arbitrarily long single-particle stochastic pump and its exact solution”

“Coloquinhão”

São Paulo, Brazil

series of talks organized by IFT-UNESP, ICTP-SAIFR students

2019

- Invited talk: “Stochastic Thermodynamics: basics and some modern aspects”

Physics Giants: Einstein Week

São Paulo, Brazil

series of talks organized by USP students

2019

- Invited talk: “Einstein’s contributions to Statistical Mechanics”

Languages

English	Full professional proficiency
Portuguese	Native proficiency
Spanish	Limited working proficiency

Peer-review contributions

- Physical Review Letters
- Physical Review X
- Physical Review X Quantum
- Physical Review E
- Physical Review A
- New Journal of Physics
- Journal of Statistical Mechanics: Theory and Experiment
- npj Unconventional Computing
- Journal of Physics A: Mathematical and Theoretical
- Journal of Physics Communications

References available upon request.