

Pedro E. Harunari

POSTDOCTORAL RESEARCHER · STATISTICAL PHYSICS

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Personal Profile

Currently, I hold a postdoctoral researcher position at the University of Luxembourg, working under the supervision of Prof. Massimiliano Esposito. My Ph.D. in physics was obtained in 2022 from the University of São Paulo, Brazil, where I engaged in extensive research and teaching activities. As an active researcher in statistical physics, my focus is on understanding and taming fluctuations in systems outside thermal equilibrium, alongside their thermodynamic properties. I am particularly interested in extending the description of stochastic thermodynamics in the presence of hidden degrees of freedom by pinpointing the relevant quantities, devising model-free estimators, and bridging theoretical results to realistic applications, particularly in biophysics, chemical reaction networks, complex systems, and electronics.

Education

University of Luxembourg

Luxembourg, Luxembourg

Postdoctoral researcher

Dec 2022 - Current

- Member of the group Complex Systems and Statistical Mechanics
- Supervised by Prof. Massimiliano Esposito

University of São Paulo

São Paulo, Brazil

Doctorate in Physics

Mar 2018 - Nov 2022

- 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

University of São Paulo

São Paulo, Brazil

Bachelor in Physics

Feb 2014 - Nov 2017

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

List of Publications

15 articles published in internationally renowned journals and 2 preprints.

From Google Scholar: 261 citations, h-index 9.

- M Polettini, **PE Harunari**, S Dal Cengio, V Lecomte, "Coplanarity of rooted spanning-tree vectors"
arXiv:2407.16093 (preprint) 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"
arXiv:2406.12792 (accepted in Physical Review E) 2024
- **PE Harunari**, S Dal Cengio, V Lecomte, M Polettini, "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 Polettini, "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 Polettini, A Raghu, P Raux, K Sekimoto, A Soret, "Methods and Conversations in (Post)Modern Thermodynamics"
SciPost Phys. Lect. Notes 80 2024
- F Hawthorne, **PE Harunari**, MJ de Oliveira, CE Fiore, "Nonequilibrium thermodynamics of the majority vote model"
Entropy **25**, 1230 (Feature Paper) 2023
- **PE Harunari**, A Garilli, and M Polettini, "The beat of a current"

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)

Trieste, Italy

Visiting researcher

Jul 2021 – Sep 2021

- Visitor at Édgar Roldán’s group.

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.

- 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)**, teacher, 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

Events attended

Dissipative Processes in Molecular Systems

Padova, Italy

University of Padova

2024

- Poster: “Inferring dissipation by monitoring reservoirs”

Journées de Physique Statistique, 42nd edition

Paris, France

École Normale Supérieure de Paris

2024

- Talk: “Unveiling nonequilibrium from multifilar events”

XXVII Sitges Conference on Statistical Mechanics

Sitges, Spain

Universitat de Barcelona

2023

- Talk: “Thermodynamics at the beat of transitions”

Workshop on Stochastic Thermodynamics - WOST IV

online

The Abdus Salam International Centre for Theoretical Physics (ICTP)

2023

- Talk: “Fluctuation relation at the beat of a current”

Physics of Life: Students and Postdocs Edition

New York, United States of America

The Center for the Physics of Biological Function, CUNY/Princeton

2023

- Talk: “Thermodynamics through the lens of transitions”

Fluctuations and First Passage Problems

Stockholm, Sweden

NORDITA

2023

- Talk: “Thermodynamics at the beat of transitions”

Journées de Physique Statistique, 42nd edition

Paris, France

École Normale Supérieure de Paris

2023

- Talk: “Transition-based coarse-graining”

The 47th Conference of the Middle European Cooperation in Statistical Physics

Erice, Italy

MECO 47

2022

- Poster: “Inferences from Statistics of a Few Observable Transitions”

Autumn meeting Brazilian Physical Society • Poster : “Inferences from Statistics of a Few Observable Transitions”	<i>São Paulo, Brazil</i> 2022
National Statistical Physics Meeting Universidade Federal de São João del-Rei (UFSJ) • Talk : “Inferences from Statistics of a Few Observable Transitions”	<i>online</i> 2021
Statistical Physics of Complex Systems The Abdus Salam International Centre for Theoretical Physics (ICTP) • Poster : “Entropy production fluctuation in phase transitions”	<i>Trieste, Italy</i> 2021
Bangalore School on Statistical Physics XII International Center for Theoretical Sciences (ICTS)	<i>online</i> 2021
Autumn meeting Brazilian Physical Society • Talk : “Entropy Production fluctuations in nonequilibrium transitions”	<i>online</i> 2021
Workshop on Stochastic Thermodynamics - WOST II Santa Fe Institute	<i>online</i> 2021
APS March Meeting American Physical Society • Talk : “Quantitative comparison of different time-periodic Thermodynamic Uncertainty Relations”	<i>online</i> 2021
Quantum Thermodynamics of Non-equilibrium systems Donostia International Physics Center	<i>online</i> 2020
Statistical Physics Seminar Series University of São Paulo • Talk : “Stochastic Thermodynamics: Schnakenberg, FT and TUR”	<i>online</i> 2020
Autumn meeting Brazilian Physical Society • Talk : “Stochastic pump as a model to study nonequilibrium properties”	<i>online</i> 2020
Quantum Thermodynamics for Young Scientists Wilhelm and Else Heraeus-Foundation • Poster : “Time asymmetric reciprocity relations for an arbitrarily long single-particle stochastic pump and its exact solution”	<i>Bad Honnef, Germany</i> 2020
“Coloquínho” series of talks organized by IFT-UNESP, ICTP-SAIFR students • Invited talk : “Stochastic Thermodynamics: basics and some modern aspects”	<i>São Paulo, Brazil</i> 2019
Physics Giants: Einstein Week series of talks organized by USP students • Invited talk : “Einstein’s contributions to Statistical Mechanics”	<i>São Paulo, Brazil</i> 2019

Languages ---

English	Full professional proficiency
Portuguese	Native proficiency
Spanish	Limited working proficiency

Peer-review contributions ---

PRL, PRX, PRX Quantum, PRE, PRA, JPhysA, JPhyComm

References available upon request.