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

13 articles published in internationally renowned journals and 4 preprints.

From Google Scholar: 248 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*" arXiv:2407.13707 (accepted in Journal of Statistical Mechanics) *2024*
- **PE Harunari**, CE Fiore, AC Barato, "*Inference of entropy production for periodically driven systems*" arXiv:2406.12792 (preprint) *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 Polettini, and É Roldán, "*What to learn from a few visible transitions' statistics?*"
  Physical Review X **12**, 041026 *2022*
- IN Mamede, **PE Harunari**, BAN Akasaki, K Proesmans, and CE Fiore, "*Obtaining efficient thermal engines from interacting Brownian particles under time-periodic drivings*"
  Physical Review E **105**, 024106 *2022*
- CE Fiore, **PE Harunari**, CEF Noa, and GT Landi, "*Current fluctuations in nonequilibrium discontinuous phase transitions*"
  Physical Review E **104**, 064123 *2021*
- **PE Harunari**, S Fernando Filho, CE Fiore, and A Rosas, "*Maximal power for heat engines: Role of asymmetric interaction times*"
  Physical Review Research **3**, 023194 *2021*
- **PE Harunari**, CE Fiore, and K Proesmans, "*Exact statistics and thermodynamic uncertainty relations for a periodically driven electron pump*"
  Journal of Physics A: Mathematical and Theoretical **53** (37), 374001 *2020*
- CEF Noa, **PE Harunari**, MJ de Oliveira, and CE Fiore, "*Entropy production as a tool for characterizing nonequilibrium phase transitions*"
  Physical Review E **100**, 012104 *2019*
- JM Encinas, **PE Harunari**, MM de Oliveira, and CE Fiore, "*Fundamental ingredients for discontinuous phase transitions in the inertial majority vote model*"
  Scientific reports **8** (1), 1-9 *2018*
- **PE Harunari**, MM de Oliveira, and CE Fiore, "*Partial inertia induces additional phase transition in the majority vote model*"
  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 Polettini, 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 Polettini.

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.

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),** 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 **Intership 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 *São Paulo, Brazil*
Brazilian Physical Society *2022*
- Poster: "Inferences from Statistics of a Few Observable Transitions"

National Statistical Physics Meeting *online*
Universidade Federal de São João del-Rei (UFSJ) *2021*
- Talk: "Inferences from Statistics of a Few Observable Transitions"

Statistical Physics of Complex Systems *Trieste, Italy*
The Abdus Salam International Centre for Theoretical Physics (ICTP) *2021*
- Poster: "Entropy production fluctuation in phase transitions"

Bangalore School on Statistical Physics XII *online*
International Center for Theoretical Sciences (ICTS) *2021*

Autumn meeting *online*
Brazilian Physical Society *2021*
- Talk: "Entropy Production fluctuations in nonequilibrium transitions"

Workshop on Stochastic Thermodynamics - WOST II *online*
Santa Fe Institute *2021*

APS March Meeting *online*
American Physical Society *2021*
- Talk: "Quantitative compartison of different time-periodic Thermodynamic Uncerainty Relations"

Quantum Thermodynamics of Non-equilibrium systems *online*
Donostia International Physics Center *2020*

Statistical Physics Seminar Series *online*
University of São Paulo *2020*
- Talk: "Stochastic Thermodynamics: Schnakenberg, FT and TUR"

Autumn meeting *online*
Brazilian Physical Society *2020*
- Talk: "Stochastic pump as a model to study nonequilibrium properties"

Quantum Thermodynamics for Young Scientists *Bad Honnef, Germany*
Wilhelm and Else Heraeus-Foundation *2020*
- Poster: "Time assymetric reciprocity relations for an arbitrarily long single-particle stochastic pump and its exact solution"

"Coloquinho" *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

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

References available upon request.