

# Pedro E. Harunari

POSTDOCTORAL RESEARCHER · STATISTICAL PHYSICS

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## Personal Profile

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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

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### Aix Marseille Université

Postdoctoral researcher

Marseille, France

Oct 2025 - Current

- Supervised by Dr. Pierre Ronceray

### University of Luxembourg

Postdoctoral researcher

Luxembourg, Luxembourg

Dec 2022 - Sep 2025

- Supervised by Prof. Massimiliano Esposito

### University of São Paulo

Doctorate in Physics

São Paulo, Brazil

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

Bachelor in Physics

São Paulo, Brazil

Feb 2014 - Nov 2017

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

## List of Publications

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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 Polettini, “*Mutual Multilinearity of Nonequilibrium Network Currents*”  
SciPost Physics 19, 111 2025
- M Polettini, **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 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*”

- 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*”

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

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### (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-passage 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)

Visiting researcher

- Visitor at Édgar Roldán's group.

Trieste, Italy

Jul 2021 – Sep 2021

## Statistical Physics seminar series

Organizer

- 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.

online

2020

## University of São Paulo

Undergraduate researcher

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

São Paulo, Brazil

2015 - 2017

## Teaching Experience

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- 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

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**Programming** Python, Mathematica, C.

**Miscellaneous** Usage of clusters,  $\text{\LaTeX}$ , Ubuntu Linux, teaching.

## Prizes and Grants

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- 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

## Invited seminars and colloquiums

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- 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 pratial information of transition statistics*”, University of Aalto, Finland

## Events attended

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### STATPHYS 29

The 29th international conference on statistical physics

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

Florence, Italy

2025

### Stochastic Thermodynamics and Computer Science Theory

Santa Fe Institute

- Invited Talk: “Stochastic Thermodynamics of communication channels”

Santa Fe, USA

2025

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

<b>Autumn meeting</b>	<i>online</i>
Brazilian Physical Society	2020
• <u>Talk:</u> "Stochastic pump as a model to study nonequilibrium properties"	
<b>Quantum Thermodynamics for Young Scientists</b>	<i>Bad Honnef, Germany</i>
Wilhelm and Else Heraeus-Foundation	2020
• <u>Poster:</u> "Time assymetric reciprocity relations for an arbitrarily long single-particle stochastic pump and its exact solution"	
<b>"Coloquinho"</b>	<i>São Paulo, Brazil</i>
series of talks organized by IFT-UNESP, ICTP-SAIFR students	2019
• <u>Invited talk:</u> "Stochastic Thermodynamics: basics and some modern aspects"	
<b>Physics Giants: Einstein Week</b>	<i>São Paulo, Brazil</i>
series of talks organized by USP students	2019
• <u>Invited talk:</u> "Einstein's contributions to Statistical Mechanics"	

## Languages

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<b>English</b>	Full professional proficiency
<b>Portuguese</b>	Native proficiency
<b>Spanish</b>	Limited working proficiency

## Peer-review contributions

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- 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.**