# Giorgio Nicoletti

## Contacts


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ICTP, Trieste, Italy
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giorgionicoletti


## Skills

### Programming

Advanced Knowledge

Python | Wolfram Mathematica

Basic Knowledge

C++ | Matlab | Julia | R | Bash

Tools

LaTeX | PowerPoint & MS Office | HTML | CSS | Inkscape

### Languages

**native:** Italian
**fluent:** English
**intermediate:** French
**beginner:** German, Japanese

## Research experience

**International Center for Theoretical Physics** — *Trieste, Italy*
Postdoctoral researcher — 2024 - present
Quantitative Life Sciences section, with prof. Antonio Celani

**École Polytechnique Fédérale de Lausanne** — *Lausanne, Switzerland*
Postdoctoral researcher — 2023 - 2024
Laboratory of Ecohydrology, with prof. Andrea Rinaldo

**Tübingen University** — *Tübingen, Germany*
Visiting Ph.D. student — Sept 2022 - Dec 2022
"Self-organization of neuronal networks" group, with prof. Anna Levina

**Max Planck Institute for the Physics of Complex Systems** — *Dresden, Germany*
Visiting Ph.D. student — June 2022 - July 2022
Division of Biological Physics, with Dr. Daniel M. Busiello

## Education

**Ph.D. in Physics *cum laude*** — *University of Padova*
Thesis: *Information and Criticality in Complex Stochastic Systems* — 2019 - 2023
Supervisors: prof. Amos Maritan and prof. Samir Suweis

**Master's Degree in Physics *cum laude*** — *University of Padova*
Thesis: *Scaling and Renormalization Group for models of neural activity* — 2017 - 2019
Final grade: 110/110 *cum laude*, GPA: 29.93/30

**Erasmus+ scholarship** — *Paris-Sud University*
International Master in Physics of Complex Systems, ECTS GPA: A/A — 2018 - 2019

**Bachelor's Degree in Physics *cum laude*** — *University of Padova*
Thesis: *A Bayesian interpretation of quantum probability* — 2014 - 2017
Final grade: 110/110 *cum laude*, GPA: 29.19/30

## Invited talks and seminars

**Sensing hidden signals: information, dissipation, and adaptation** — *Dresden, Germany*
Max Planck Institute for the Physics of Complex Systems — *28th Oct 2026*

**From timescales to information processing in stochastic biological systems** — *Lecce, Italy*
IV International Summer School of the Italian Statistical Physics Society — *18th Sept 2026*

**Spatial ecological communities on dispersal networks: from metapopulation capacity to coexistence through disorder** — *Parma, Italy*
V Conference of the Italian Society of Statistical Physics — *25th June 2026*

**Information processing in multiscale biological systems: from transduction mechanisms to decision-making processes** — *Tokyo, Japan*
University of Tokyo — *27th Mar 2026*

**Decoding behavior: inference of decision-making processes with interpretable agent models** — *Padova, Italy*
Padova Neuroscience Center — *14th Nov 2025*

**Information propagation across timescales** — *Trieste, Italy*
International Center for Theoretical Physics — *4th Apr 2024*

**Tuning transduction from hidden observables to optimize information harvesting** — *Trieste, Italy*
"Information processing and decision-making in biology" workshop, ICTP — *11th Mar 2024*

**Survival and coexistence in spatially explicit metapopulation models** — *Padova, Italy*
"Emergent dynamical patterns of disordered systems with applications to natural communities" workshop — *18th Dec 2023*

**Information theory in stochastic processes and complex systems** — *Dresden, Germany*
Max Planck Institute for the Physics of Complex Systems — *13th July 2022*

**What can phase transitions and criticality teach us about brain dynamics?** — *Stockholm, Sweden*
BrainNet workshop, KTH Royal Institute of Technology — *23rd - 24th May 2022*

**Unfolding complex systems with information theory** — *Online*
Young Seminars of the Italian Society of Statistical Physics — *10th Mar 2022*

# Publications

**Dispersal diversity buffers species vulnerability to local extinction**
D. Bernardi, **G. Nicoletti**, P. Padmanabha, S. Suweis, S. Azaele, S. A. Levin, A. Rinaldo, A. Maritan
*Nature Eco. Evo.* *10, 2060–2073 (2026)*

**Higher-order assembly and emergent persistence in biology**
B. Vidiella, **G. Nicoletti**, R. Fernández, A. Spiridonov, A. Sanchez, S. T. Hussain, S. Valverde
*Curr. Opin. Sys. Bio.* *100608 (2026)*

**Balancing information and dissipation with partially observed fluctuating signals**
**G. Nicoletti**, I. Di Terlizzi, D. M. Busiello
Featured on the cover of Physical Review Letters, Editors' Suggestion, and viewpoint in the APS "Physics" magazine
*Phys. Rev. Lett.* *137, 127101 (2026)*

**Decoding behavior with minimal and interpretable agent models**
**G. Nicoletti**, A. Celani
*PLOS Comp. Bio.* *22 (8), e1014585 (2026)*

**Habitat heterogeneity and dispersal network structure as drivers of metacommunity dynamics**
D. Bernardi*, A. Doimo*, **G. Nicoletti***, P. Padmanabha*, A. Rinaldo, S. Suweis, S. Azaele, A. Maritan (* equal contribution)
*J. Stat. Mech.* *084003 (2026)*

**Generalized scaling of blue metabolism in river basins**
**G. Nicoletti**, E. Bertuzzo, P. Padmanabha, F. Bassani, S. Bonetti, A. Maritan, A. Rinaldo
*Water Res. Research* *62, e2025WR041131 (2026)*

**Unveiling gene perturbation effects through gene regulatory networks inference from single-cell transcriptomic data**
C. Corridori, M. Romeike, **G. Nicoletti**, C. Buecker, S. Suweis, S. Azaele, G. Martello
*PLOS Comp. Bio.* *22 (4), e1014067 (2026)*

**Information-directed sampling for bandits: a primer**
A. Hirling, **G. Nicoletti**, A. Celani
*J. Stat. Mech.* *4, 043402 (2026)*

**Stochastic processes with multiple temporal scales: timescale separation and information**
**G. Nicoletti**, D. M. Busiello
*J. Stat. Mech.* *12, 124004 (2025)*

**Fast nonlinear integration drives accurate encoding of input information in large multiscale systems**
**G. Nicoletti**, D. M. Busiello
*Comm. Physics* *8, 437 (2025)*

**Optimal information gain at the onset of habituation to repeated stimuli**
**G. Nicoletti**, M. Bruzzone, S. Suweis, M. Dal Maschio, D. M. Busiello
*eLife* *13:RP99767 (2025)*

**Finite size scaling of survival statistics in metapopulation models**
A. Doimo, **G. Nicoletti**, D. Bernardi, P. Padmanabha
*Phys. Rev. E* *111 (6), 064415 (2025)*

**Excitation-inhibition balance controls information encoding in neural populations**
G. Barzon, D. M. Busiello, **G. Nicoletti**
*Phys. Rev. Lett.* *134 (6), 068403 (2025)*

**Information interference driven by environmental activity**
**G. Nicoletti**, D. M. Busiello
*Phys. Rev. Research* *6 (4), 043275 (2024)*

**Landscape and environmental heterogeneity support coexistence in competitive metacommunities**
P. Padmanabha*, **G. Nicoletti***, D. Bernardi*, S. Suweis, S. Azaele, A. Rinaldo, A. Maritan (*equal contribution)
*PNAS* *121 (44), e2410932121 (2024)*

**Information propagation in Gaussian processes on multilayer networks**
**G. Nicoletti**, D. M. Busiello
*J. Phys. Complex.* *5, 045004 (2024)*

**Tuning transduction from hidden observables to optimize information harvesting**
**G. Nicoletti**, D. M. Busiello
Physical Review Letters Editors' Suggestion and viewpoint in the APS "Physics" magazine
*Phys. Rev. Lett.* *133, 158401 (2024)*

**Information propagation in multilayer systems with higher-order interactions across timescales**
**G. Nicoletti**, D. M. Busiello
*Phys. Rev. X* *14 (2) 021007 (2024)*

**Prenatal experience with language shapes the brain**
B. Mariani, **G. Nicoletti**, G. Barzon, M. C. O. Barajas, M. Shukla, R. Guevara, S. Suweis, J. Gervain
*Science Advances* *9 (47), eadj3524 (2023)*

**Emergent encoding of dispersal network topologies in spatial metapopulation models**
**G. Nicoletti***, P. Padmanabha*, S. Azaele, S. Suweis, A. Rinaldo, A. Maritan (*equal contribution)
*PNAS* *120 (46), e2311548120 (2023)*

**The emergence of scale-free fires in Australia**
**G. Nicoletti**, L. Saravia, F. Momo, A. Maritan, S. Suweis
Best poster award at the conference "Stochastic Models and Experiments in Ecology and Biology 2021" Venice, Italy
*iScience* *26 (3) 106181 (2023)*

**Mutual information in changing environments: Nonlinear interactions, out-of-equilibrium systems, and continuously varying diffusivities**
**G. Nicoletti**, D. M. Busiello
*Phys. Rev. E* *106, 014153 (2022)*

**Information-driven transitions in projections of underdamped dynamics**
**G. Nicoletti**, A. Maritan, D. M. Busiello
*Phys. Rev. E* *106, 014118 (2022)*

**Criticality and network structure drive emergent oscillations in a stochastic whole-brain model**
**G. Nicoletti***, G. Barzon*, B. Mariani, M. Formentin, S. Suweis (*equal contribution)
*J. Phys. Complex.* *3, 025010 (2022)*

**Disentangling the critical signatures of neural activity**
B. Mariani, **G. Nicoletti**, M. Bisio, M. Maschietto, S. Vassanelli, S. Suweis
*Sci. Rep.* *12, 10770 (2022)*

Featured in the "Top 100 papers in Neuroscience" published by Scientific Reports in 2022

**Mutual information disentangles interactions from changing environments** — PHYS. REV. LETT.
G. NICOLETTI, D. M. BUSIELLO — *127, 228301 (2021)*
Physical Review Letters Editors' Suggestion, viewpoint in the APS "Physics" magazine and highlight in PRL's weekly tip sheet for reporters

**Neuronal avalanches across the rat somatosensory barrel cortex and the effect of single whisker stimulation** — FRONT. SYST. NEUR. *15:709677 (2021)*
B. MARIANI, G. NICOLETTI, M. BISIO, M. MASCHIETTO, R. OBOE, A. LEPARULO, S. SUWEIS, S. VASSANELLI

**Scaling and criticality in a phenomenological renormalization group** — PHYS. REV. RESEARCH *2, 023144 (2020)*
G. NICOLETTI, S. SUWEIS, A. MARITAN

## PREPRINTS

**Resolving the backbone of multiscale interactions through mutual information rates** — ARXIV *2611.12554 (2026)*
A. RAIOLA, G. NICOLETTI*, D. M. BUSIELLO* (* EQUAL CONTRIBUTION)

**Universal thermokinetic decomposition of short-time information fluctuations** — ARXIV *2605.29957 (2026)*
G. NICOLETTI, D. M. BUSIELLO

**Emergence of information interference in stochastic systems with non-diagonal noise and switching environments** — ARXIV *2605.13556 (2026)*
A. MARCHETTI, D. M. BUSIELLO*, G. NICOLETTI* (* EQUAL CONTRIBUTION)

**Pulse desynchronization of neural populations by targeting the centroid of the limit cycle in phase space** — ARXIV *2603.12878 (2026)*
R. GUEVARA, M. ZENARI, G. NICOLETTI, E. MARINI, S. SUWEIS, S. AZAELE, M. FORMENTIN

**Plasticity-induced multistability on fast and slow timescales enables optimal information encoding and spontaneous sequence discrimination** — ARXIV *2509.13867 (2025)*
G. BARZON, D. M. BUSIELLO*, G. NICOLETTI* (* EQUAL CONTRIBUTION)

**The somatosensory barrel cortex controls the spindle thalamocortical oscillation by frequency locking** — BIORXIV *2025.07.09.662963 (2025)*
R. GUEVARA, M. TAMBARO, M. MASCHIETTO, A. LEPARULO, C. CHECCHETTO, G. NICOLETTI, B. MARIANI, S. SUWEIS, S. VASSANELLI

**A novel metric for species vulnerability and coexistence in spatially-extended ecosystems** — ARXIV *2503.10288 (2025)*
D. BERNARDI, G. NICOLETTI, P. PADMANABHA, S. SUWEIS, S. AZAELE, A. RINALDO, A. MARITAN

**A network-based method for extracting the organization of brain-wide circuits from reconstructed connectome datasets** — BIORXIV *2023.05.21.541471 (2023)*
K. K. H. MANJUNATHA*, M. BRUZZONE*, G. NICOLETTI, S. SUWEIS*, M. DAL MASCHIO* (* EQUAL CONTRIBUTION)

## CONTRIBUTED TALKS AND POSTERS

**From Biological Complexity to Evolutionary Principles (EPIC Assembly Symposium 2026)** — *Tokyo, Japan* — *14th - 16th Mar 2026*
POSTER: PROCESSING INFORMATION FROM PARTIALLY OBSERVED SIGNALS IN BIOLOGICAL SYSTEMS WITH ENERGETIC CONSTRAINTS

**Neurophysics of Active Sensing, KITP** — *Santa Barbara, USA* — *10th - 16th Aug 2025*
TALK: INFERENCE OF DECISION-MAKING STRATEGIES WITH FINITE MEMORY STATES

**International Physics of Living Systems (iPoLS) Annual Meeting** — *Urbana-Champaign, USA* — *28th July - 1st Aug 2025*
TALK: OPTIMIZING TRANSDUCTION OF INFORMATION FROM HIDDEN OBSERVABLES IN BIOLOGICAL SYSTEMS WITH A LIMITED ENERGY BUDGET

**29th International Conference on Statistical Physics** — *Firenze, Italy* — *13th - 18th July 2025*
TALK: TUNING TRANSDUCTION FROM HIDDEN OBSERVABLES TO OPTIMIZE INFORMATION HARVESTING WITH A LIMITED ENERGY BUDGET

**ENAC Research Day 2024** — *Lausanne, Switzerland* — *9th Sept 2024*
POSTER: LANDSCAPE AND HABITAT HETEROGENEITY DRIVE NICHE COEXISTENCE IN DISPERSING ECOLOGICAL METACOMMUNITIES

**Stochastic Models and Experiments in Ecology and Biology 2024** — *L'Aquila, Italy* — *28th - 31st May 2024*
TALK: SPATIALLY DISORDERED ENVIRONMENTS STABILIZE COMPETITIVE METACOMMUNITIES

**SIGNAL24: Information Processing, Noise, and Adaptation in Living Systems** — *Dresden, Germany* — *15th - 19th Apr 2024*
TALK: INFORMATION PROPAGATION ACROSS TIMESCALES IN MULTISCALE SYSTEMS

**Italian Conference on Complex Systems 2023** — *Naples, Italy* — *9th - 11th Oct 2023*
POSTER: EMERGENT ENCODING OF DISPERSAL NETWORK TOPOLOGIES IN SPATIAL METAPOPULATION MODELS

**28th International Conference on Statistical Physics** — *Tokyo, Japan* — *7th - 11th Aug 2023*
TALK: THE ARCHITECTURE OF INFORMATION PROCESSING IN BIOLOGICAL SYSTEMS

**Brain Criticality Meeting 2022** — *Online* — *7th - 9th Nov 2022*
POSTER: CRITICALITY AND NETWORK STRUCTURE DRIVE EMERGENT OSCILLATIONS IN A STOCHASTIC WHOLE-BRAIN MODEL

**Conference on Complex Systems 2022** — *Palma de Mallorca, Spain*, *17th - 21st Oct 2022*
Talk: Criticality and network structure drive emergent oscillations in a stochastic whole-brain model
Talk: Information-driven transitions in optimal projections of underdamped dynamics

**Bernstein Conference 2022** — *Berlin, Germany*, *14th - 16th Sept 2022*
Poster: Disentangling the critical signatures of neural activity: avalanches, spatial correlations and information

**Conference on Complex Systems 2021** — *Lyon, France*, *25th - 29th Oct 2021*
Talk: Disentangling the role of external and intrinsic dynamics on the critical signatures of neural activity
Talk: Modeling the emergence of scale-free fire outbreaks in Australia
Poster: Disentangling internal interactions from noisy environments through mutual information

**Stochastic Models and Experiments in Ecology and Biology 2021** — *Venice, Italy*, *22nd - 25th June 2021*
Poster: Modeling the emergence of scale-free fire outbreaks in Australia

**Brain Criticality Virtual Meeting** — *Online*, *6th - 9th Oct 2020*
Poster: What can a phenomenological Renormalization Group teach us about criticality in a network of neurons?

**Bernstein Conference 2020** — *Online*, *29th Sept - 1st Oct 2020*
Poster: Scaling and criticality in a phenomenological renormalization group

**Italian Conference on Complex Systems** — *Trento, Italy*, *1st - 3rd July 2019*
Poster: Scaling and Renormalization Group for the activity of neurons

## Attended Schools and Workshops

**Brains, Minds and Machines** — *Woods Hole, USA*, *7th Aug - 28th Aug 2026*
School

**Emergence of Information in Molecular Systems (MOLINFO)** — *Munich, Germany*, *22nd July - 2nd Aug 2024*
Workshop

**Winter Workshop on Complex Systems 2022** — *Arc-et-Senans, France*, *24th - 28th Jan 2022*
Workshop

**Beg Rohu Summer School on "Statistical Mechanics and Emergent Phenomena in Biology"** — *St. P. Quiberon, France*, *30th May - 12th June 2021*
School

**Computational and Theoretical Models in Neuroscience** — *Venice, Italy*, *9th - 16th Sept 2019*
School

## Organized Conferences

**Information and Decisions Across Scales: Constraints and Optimality in Neural and Biological Networks (IDEAS)** — *Dresden, Germany*, *18th - 22nd May 2026*
Main organizer
Conference at the Max Planck Institute for the Physics of Complex Systems

**Robustness, Adaptability and Critical Transitions in Living Systems** — *Lyon, France*, *27th Oct 2021*
Main organizer
Satellite of the Conference on Complex Systems 2021

## Teaching Experience and Supervision

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|---|---|---|
| 2026 | **Reinforcement Learning**, ICTP Diploma Program and University of Trieste | *Main lecturer* |
| 2025 | **Ecology and Evolution**, ICTP Diploma Program, SISSA, and University of Trieste | *Invited lecturer* |
| 2025 | **An Introduction to Information Theory for Stochastic Biological Systems**, PhD course in Physics, University of Padova | *Main lecturer* |
| 2025 | **Co-supervision of one Master's thesis**, EPFL-ICTP | *Co-supervision* |
| 2023 | **Fundamentals of Information Systems**, Master's Degree in Data Science, University of Padova | *Teaching assistant* |
| 2022 - 23 | **Advanced Statistical Mechanics**, PhD course in Physics, University of Padova | *Invited lecturer* |
| 2022 - 23 | **Physics with applications to biological systems**, Bachelor's Degree in Biology of Human and Environmental Health, University of Padova | *Teaching assistant* |
| 2021 - 23 | **Co-supervision of two Master's theses and two Bachelor's theses**, Department of Physics and Astronomy, University of Padova | *Co-supervision* |
| 2021 - 22 | **Models of Theoretical Physics**, Master's Degree in Physics of Data, University of Padova | *Teaching assistant* |
| 2020 - 22 | **IT and Bioinformatics**, Bachelor's Degree in Biology and Molecular Biology, University of Padova | *Teaching assistant* |

## AWARDS, HONORS AND MEDIA COVERAGE

9th Oct 2026 **Press release by the University of Padova and coverage by Italian news outlets (ANSA, la Repubblica, Le Scienze)** for the paper *Dispersal diversity buffers species vulnerability to local extinction*, Nature Ecology & Evolution 10, 2060–2073 (2026)

18th Sept 2026 **Featuring on the cover of Physical Review Letters (issue 12, volume 137)** for the paper *Balancing information and dissipation with partially observed fluctuating signals*, Phys. Rev. Lett. 137, 127101 (2026)

14th Sept 2026 **Physical Review Letters Editors' Suggestion, viewpoint in the magazine "Physics", and Phys.org feature article** for the paper *Balancing information and dissipation with partially observed fluctuating signals*, Phys. Rev. Lett. 137, 127101 (2026)

13th July 2025 **"Giovanni Paladin" prize** for the best PhD thesis on topics in statistical physics and complex systems for the years 2022-2024. Awarded at the inaugural ceremony of the 29th International Conference on Statistical Physics by the Italian Society of Statistical Physics (SIFS)

3rd Apr 2025 ***Entropy* Outstanding Reviewer Award** awarded to five outstanding reviewers of the journal *Entropy* in 2024

9th Mar 2025 **Phys.org feature article** for the paper *Excitation-Inhibition balance controls information encoding in neural populations*, Phys. Rev. Lett. 134, 068403 (2025)

7th Oct 2024 **Physical Review Letters Editors' Suggestion, viewpoint in the magazine "Physics", and Phys.org feature article** for the paper *Tuning transduction from hidden observables to optimize information harvesting*, Phys. Rev. Lett. 133, 158401 (2024)

22nd Nov 2023 **Press release by the American Association for the Advancement of Science, coverage by international news outlets (The Times, Daily Mail, El País, Le Figaro, Corriere della Sera, and more), and popular science publications (New Scientist, Nature Italy, PsyPost, Science Alert, and more)** for the paper *Prenatal experience with language shapes the brain*, Science Advances 9 (47), eadj3524 (2023)

12th Mar 2023 **Featuring in the "Top 100 papers in Neuroscience" published by Scientific Reports in 2022** for the paper *Disentangling the critical signatures of neural activity*, Sci. Rep. 12, 10770 (2022)

29th Nov 2022 **Graduate Alumni Award** awarded to the best graduate student of the School of Science of the University of Padova

22nd Nov 2021 **Physical Review Letters Editors' Suggestion, viewpoint in "Physics" magazine and highlight in PRL's weekly tip sheet for reporters** for the paper *Mutual information disentangles interactions from changing environments*, Phys. Rev. Lett. 127, 228301 (2021)

25th June 2021 **Best Poster Award** for "Modeling the emergence of scale-free fire outbreaks in Australia" at *Stochastic Models and Experiments in Ecology and Biology 2021*, ECLT, Venice, Italy. Sponsored by MDPI

Feb 2017 **Student grant** for the best students enrolled in scientific degrees, granted by University of Padova

10th Oct 2014 **Best student award** for the best high school students in Italy, awarded by the Italian Ministry for Education

## SERVICE AND MEMBERSHIPS

Reviewer for **Nature Reviews Physics**, **Nature Communications**, **PNAS**, **Physical Review X**, **Physical Review Letters**, **PRX Life**, **Communications Physics**, **Physical Review Research**, **Physical Review E**, **Journal of Statistical Mechanics**, **New Journal of Physics**, **iScience**, **Entropy**, and **PLOS Computational Biology**.

2021 - 2024 Member of the **Complex Systems Society**

2021 - 2023 Member of the **Italian Society of Physics**

2021 - 2023 **Elected representative** in the PhD Program Committee and the Academic Board of the PhD program, Department of Physics and Astronomy, University of Padova