



TONY BONNAIRE

PSL Artificial Intelligence Fellow @ENS

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tbonnair

Machine learning

Statistics

Cosmology

Statistical physics

EDUCATION

Ph.D. in Astronomy and Astrophysics

Université Paris-Saclay

Oct. 2018 – Nov. 2021

Orsay, France

CentraleSupélec Engineer

CentraleSupélec, track: Applied mathematics

Sept. 2014 – Sept. 2017

Gif-sur-Yvette, France

EXPERIENCE

PSL AI Fellow, PRAIRIE Institute

Machine learning

Statistical physics

Cosmology

– Python

PyTorch

École Normale Supérieure – Physics department and Center for Data Sciences

Jan. 2023 – Ongoing

Paris, France

- Theoretical prescriptions for ML models through statistical physics.
- Statistical methods for the analysis of cosmological data and simulations.
- Teaching AI and ML to master students of PSL University (150 hours/year).

Postdoctoral researcher, PRAIRIE Institute

Machine learning theory

Statistical physics

– Python

PyTorch

École Normale Supérieure – Physics department and Center for Data Sciences

Nov. 2021 – Jan. 2023

Paris, France

- Statistical physics and theoretical machine learning – Reference: Giulio Biroli.

Ph.D. Student

Cosmology

Statistics

Pattern extraction

– Python

Université Paris-Saclay – Institut d'Astrophysique Spatiale

Oct. 2018 – Sept. 2021

Orsay, France

- The cosmic web: identification, characterisation and quantification of cosmological information.
- Pattern extraction from cosmological data and simulations.
- Statistical analysis of the cosmic web to improve cosmological models.
- Supervision: Nabila Aghanim, Aurélien Decelle.

Research engineer

Algorithmics

Pattern extraction

– C

Matlab

Open-CL

Thales Systèmes Aéroportés – Algorithmic department

Sept. 2017 – Sept. 2018

Élancourt, France

- Unsupervised classification and characterisation of radar pulses.
- Design and development of algorithms for electronic warfare problematics.

LANGUAGES

French



English



Italian



PROGRAMMING

Python

PyTorch

C

Matlab

Open-CL

Objective-C

REFERENCES

Prof. Giulio Biroli

@ LPENS

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Laboratoire de Physique de l'École normale supérieure, ENS, Paris, France.

Dr. Nabila Aghanim

@ IAS

✉ nabila.aghanim@universite-paris-saclay.fr

Institut d'Astrophysique Spatiale, Université Paris-Saclay, Orsay, France.

Dr. Aurélien Decelle

@ UCM

✉ adecelle@ucm.es

Departamento de Física Teórica I, Universidad Complutense, Madrid, Spain.

TEACHING

Machine Learning

École Normale Supérieure, Jan. 2025 – Ongoing Co-instructor

36 hours – Co-supervision of the hands-on sessions of the Machine Learning course from Prof. Marc Lelarge given to M2 students of the the International Centre For Fundamental Physics (ICFP).

Machine Learning Principles with Applications in Physics

École Normale Supérieure, Sept. 2023 – Ongoing Co-advisor Co-instructor

32 hours – Machine learning introduction to master students of the International Centre For Fundamental Physics (ICFP) and supervision of tutored projects.

Artificial Intelligence and Chemistry

École Normale Supérieure, Sept. 2023 – Ongoing Advisor Instructor

32 hours – Introduction to the basics of machine learning to master students of the Chemistry Department at ENS and supervision of tutored projects.

PSL AI Hackathons

PSL University, Jan. 2023 – Ongoing Advisor Co-instructor

50 hours – Preparation, organisation, supervision and participation to final juries of the PSL AI hackathons for master students.

ENS Data Challenges

École Normale Supérieure and MVA master, Nov. 2022 – Ongoing

Organisation and beta-testing of the data science challenges for the web platform "Challenge Data ENS".

Evaluation of the M2 students from the MVA Master course of Prof. Stéphane Mallat.

SUPERVISION

- Mehdi Noor – Co-supervision of M2 internship Mar. 2024 – Sep. 2024
Generation of Cosmological Simulations via Diffusion-based Models
- Mehdi Noor – Co-supervision of Ph.D. Sep. 2024 – Ongoing
Emulating the cosmic web with generative AI: methods and applications

PROJECTS

- 2024: Membership to the Euclid consortium (Galaxy/AGN Evolution Working Group).
- 2024: Collaborator of an ERC Proof Of Concept (PoC) for the transfer of methodologies developed during my Ph.D. in cosmology to health science with Dr. N. Aghanim and Dr. A. Decelle.

PRIZES AND GRANTS

- 2023: 5-year fellowship at PSL University and ENS Paris for research and teaching in Artificial Intelligence.
- 2022: Prix de la Chancellerie des Université de Paris, catégorie Sciences.

COMMUNITY SERVICES AND SHARING

- T-ReX: Tree-based Ridge eXtractor**
A publicly-available Python implementation of the filament-finder method T-ReX.
- Reviewing activities**
In: Monthly Notices of Royal Astronomical Society (MNRAS), NeurIPS 2024 Scientific Methods for Understanding Deep Learning workshop.

ONGOING PUBLICATIONS AND PREPRINTS

- [1] **Tony Bonnaire** and Giulio Biroli. "A replica analysis of the asymptotic fluctuations of extreme eigenvalues in non-white Wishart matrices". 2025.
- [2] Euclid Collaboration. "The connectivity of Galaxy Clusters with Euclid Q1 first data". 2025.
- [3] **Tony Bonnaire**, Catania Giovanni, Decelle Aurélien, and Seoane Beatriz. "Bipartite generative neural network: the role of the non-linear latent features". 2025.
- [4] **Tony Bonnaire**, Giulio Biroli, and Chiara Cammarotta. "From Zero to Hero: How local curvature at artless initial conditions leads away from bad minima". Mar. 2024. arXiv: 2403.02418 [cs.LG].

REFEREED PUBLICATIONS

- [1] Stefano Gallo et al. "Tracing gaseous filaments connected to galaxy clusters: The case study of Abell 2744". In: *Astron. Astrophys.* 692 (Dec. 2024), A200.
- [2] Giulio Biroli, **Tony Bonnaire**, Valentin De Bortoli, and Marc Mézard. "Dynamical regimes of diffusion models". In: *Nature Communications* 15.1 (Nov. 2024), p. 9957.
- [3] **Tony Bonnaire** et al. "High-dimensional non-convex landscapes and gradient descent dynamics". In: *Journal of Statistical Mechanics: Theory and Experiment* 2024.10 (Oct. 2024), p. 104004. DOI: 10.1088/1742-5468/ad2929.
- [4] Nabila Aghanim et al. "Dissecting a miniature universe: A multi-wavelength view of galaxy quenching in the Shapley supercluster". In: *Astron. Astrophys.* 689 (Sept. 2024), A332. DOI: 10.1051/0004-6361/202348672.
- [5] Victor Bonjean et al. "Self-supervised component separation for the extragalactic submillimetre sky". In: *Astron. Astrophys.* 686, A91 (June 2024), A91. DOI: 10.1051/0004-6361/202245624.
- [6] **Tony Bonnaire**, Joseph Kuruvilla, Nabila Aghanim, and Aurélien Decelle. "Cosmology with cosmic web environments II. Redshift-space and cross power spectra". In: *Astron. Astrophys.* 674 (June 2023), A150. DOI: 10.1051/0004-6361/202245626.
- [7] **Tony Bonnaire**, Nabila Aghanim, Joseph Kuruvilla, and Aurélien Decelle. "Cosmology with cosmic web environments I. Real-space power spectra". In: *Astron. Astrophys.* 651 (May 2022), A146. DOI: 10.1051/0004-6361/202142852.
- [8] **Tony Bonnaire**, Aurélien Decelle, and Nabila Aghanim. "Regularisation of Mixture Models for Robust Principal Graph Learning". In: *IEEE Trans. Pattern Anal.* 44 (Dec. 2021), pp. 9119–9130. DOI: 10.1109/TPAMI.2021.3124973.
- [9] C. Gouin, **Tony Bonnaire**, and N. Aghanim. "Shape and connectivity of groups and clusters: Effect of the dynamical state and accretion history". In: *Astron. Astrophys.* 651 (July 2021), A56. DOI: 10.1051/0004-6361/202140327.
- [10] **Tony Bonnaire**, Aurélien Decelle, and Nabila Aghanim. "Cascade of phase transitions for multiscale clustering". In: *Phys. Rev. E* 103 (Jan. 2021), p. 012105. DOI: 10.1103/PhysRevE.103.012105.
- [11] **Tony Bonnaire**, N. Aghanim, A. Decelle, and M. Douspis. "T-ReX: a graph-based filament detection method". In: *Astron. Astrophys.* 637 (Sept. 2020), A18. DOI: 10.1051/0004-6361/201936859.

INVITED SEMINARS

- **LISN, Paris-Saclay University** Orsay, France, Dec. 2024
The Generative Dynamics of Optimally-Trained Diffusion Models in Large Dimensions
- **Department of Astrophysics, École Normale Supérieure** Paris, France, Apr. 2024
Dynamical Regimes of Diffusion Models
- **Department of Astrophysics, École Normale Supérieure** Paris, France, Feb. 2024
The cosmological information of the cosmic web
- **Centre de Recherche en Informatique, Signal, et Automatique de Lille** Lille, France, Jun. 2023
The cosmic web: from identification to cosmological parameters
- **Institut de Physique Théorique, cosmology group** Saclay, France, Jun. 2022
Identifying and quantifying information of the cosmic web
- **University of Geneva, cosmology group** Geneva, Switzerland, Dec. 2021
Cosmic web environments: from identification to cosmological parameters
- **Laboratoire d'Astrophysique de Marseille** Orsay, France, Dec. 2021
The cosmic web: filaments identification and quantification of the cosmological information
- **Institut Elie Cartan, Dept. of Probability and Statistics** Nancy, France, Dec. 2021
Pattern extraction from point-cloud datasets and cosmological applications
- **Madrid University, Dept. of Theoretical Physics** Madrid, Spain, Nov. 2021
The principal graph of the cosmic web: learning patterns in point-cloud datasets
- **Laboratoire interdisciplinaire des Sciences du Numérique** Orsay, France, Oct. 2021
Learning patterns from point-cloud datasets and applications to cosmology

CONFERENCES & WORKSHOPS

Invited talks

- **Workshop on Generative Models** Paris, France, Feb. 2025
The High-Dimensional Generative Dynamics of Diffusion Models
- **AstroParticle workshop** Orsay, France, Nov. 2024
Cosmology with cosmic web environments

- **Physics Informed Machine Learning workshop** Los Alamos, USA, Oct. 2024
The Generative Dynamics of Diffusion Models in Large Dimensions

Contributed Talks

- **New Strategies For Extracting Cosmology From Future Galaxy Surveys** Sexten, Italy, Jul. 2023
Improving cosmological constraints using comic web environments
- **Cosmic cartography 2022** (Virtual) Kashiwa, Japan, Mar. 2022
Cosmology with cosmic web environments
- **Sixteenth Marcel Grossmann Meeting** Virtual, Jul. 2021
Constraining cosmological parameters with cosmic environments
- **Elbereth conference** (Virtual) Paris, France, Feb. 2021
Learning the principal graph of the galaxy distribution
- **COSPAR 2021 Workshop on Machine Learning for Space Sciences** Sydney, Australia, Jan. 2021
Learning the principal graph of the galaxy distribution
- **Workshop Orsay-Tartu** Virtual, Jun. 2020
Detection of cosmic filaments using galaxy distribution
- **Workshop "The Cosmic Web in the Local Universe"** Leiden, Netherlands, Jan. 2020
Detecting cosmic filaments from halo distribution
- **Workshop ByoPiC ERC** Hossegor, France, Jun. 2019
Automatic detection of Cosmic Web elements, a review
- **Elbereth conference** Paris, France, Jan. 2019
Uncovering cosmic filaments from galaxy distribution

Posters

- **Les Houches Summer School on Statistical Physics and Machine Learning** Jul. 2022
Successes of gradient descent in high-dimensional and non-convex landscapes: the phase retrieval case
- **SF2A conference** Virtual, Jun. 2021
The principal graph of the cosmic web
- **Latin American Workshop on Observational Cosmology** (Virtual) São Paulo, Brazil, Dec. 2020
Learning the principal graph of the galaxy distribution
- **Ph.D. day of the Institut d'Astrophysique Spatiale** Orsay, France, Nov. 2020
Automatic filamentary structure detection from galaxy distribution