TONY BONNAIRE

PSL Artificial Intelligence Fellow @ENS

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Machine learning   Statistics   Cosmology   Statistical physics

EXPERIENCE

PSL AI Fellow – ENS Paris, PSL University, PR[AI]RIE

Machine learning   Statistical physics   Cosmology   –   Python   PyTorch

📅 Jan. 2023 – Ongoing 📍 Paris, France

- Machine Learning theory: non-convex optimization, generative models.
- AI for cosmology: segmentation, generative modelling, parameter inference.
- Teaching ML to master students of PSL University (150 hours/year).

Postdoctoral researcher – ENS Paris, PSL University, PR[AI]RIE

Machine learning theory   Statistical physics   –   Python   PyTorch

📅 Nov. 2021 – Jan. 2023 📍 Paris, France

- Machine Learning theory: gradient descent dynamics in high-dimensional non-convex optimization — Reference: Giulio Biroli.

Ph.D. Student – IAS, Paris-Saclay University

Cosmology   Statistics   Pattern extraction   –   Python

📅 Oct. 2018 – Sept. 2021 📍 Orsay, France

- Title: *The cosmic web: identification, characterisation and quantification of cosmological information.*
- 2D/3D Pattern extraction from cosmological data and simulations.
- Statistical analysis of the cosmic web to improve cosmological models.
- Supervision: Nabila Aghanim, Aurélien Decelle.

Research engineer – Thales

Algorithmics   Pattern extraction   –   C   Matlab   Open-CL

📅 Sept. 2017 – Sept. 2018 📍 Élancourt, France

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

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

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

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

Dr. Aurélien Decelle

@ UCM

✉ adecelle@ucm.es

Departamento de Física Téorica 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

64 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 Ph.D.   Sep. 2024 – Ongoing
  Emulating the Cosmic Web with Generative AI: Methods and Applications
- Mehdi Noor – Co-supervision of M2 internship   Mar. 2024 – Sep. 2024
  Generation of Cosmological Simulations via Diffusion-based Models

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

- Codes
  Tree-based Ridge eXtractor (T-ReX): A publicly-available Python implementation of the filament-finder method.
- Reviewing activities
  Machine Learning conferences: NeurIPS 2024 Scientific Methods for Understanding Deep Learning workshop.
  Physics journals: MNRAS, Nature Scientific Report.

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

- **Collège de France, MVA course from Prof. S. Mallat**   Paris, France, Feb. 2025
  Dynamique des modèles de diffusion
- **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