ELIOT AYACHE

POSTDOCTORAL RESEARCHER IN COMPUTATIONAL ASTROPHYSICS

FOR THE ROLE OF SENIOR DATA SCIENTIST AT NORMATIVE.IO

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PROFESSIONAL EXPERIENCE

Postdoctoral researcher Sept. 2021 - ...

OSKAR KLEIN CENTRE, STOCKHOLM UNIV. (SWEDEN)

Lead of scientific research projects:

- Principal Investigator: Numerical simulations of gamma-ray burst relativistic jets with transverse structure.
  - Designed the research project.
  - Developed solutions for code stability in problematic regions of the parameter space.
  - Was awarded the necessary computer time on National HPC resources.
- Development of original numerical PDE solvers. Implementation as an upgrade to an existing supernova modeling code.

Machine Learning for literature exploration:

- Preliminary work in **NLP** to analyse consensus on scientific questions in the astrophysical literature. Experiments with document pooling, passage extraction and question answering using publicly available transformer models.

EDUCATION

Ph.D., Computational Astrophysics 2017 – 2021

UNIVERSITY OF BATH (UK)

Thesis: "Numerics and Theory of High-Energy Relativistic Astrophysical Transients"

Numerical simulations:

- Developed from scratch a specialized massively parallel moving-mesh finite-volume relativistic hydrodynamics code in C++. This code allows accurate calculation of previously inaccessible regions of the parameter space and is now used by the community.
- Carried out HPC simulations on national facilities.
- 2 first-author publications in a top-level scientific journal.

Machine learning:

- Carried out **unsupervised clustering** of astrophysical time-series data using **variational deep embedding and recurrent neural networks.**

Scientific communication:

- Delivered talks and ML workshops at international conferences.
- Organized and chaired international conference sessions on machine learning.
- Wrote research proposals.
- Supervised multiple Bachelor and Masters theses.
- Teaching and outreach (~120h)

M.Sc., Astronomy, Astrophysics and Space Engineering 2015 – 2017

OBSERVATOIRE DE PARIS, PSL RESEARCH UNIV. (FRANCE)

First of two years carried out in parallel with the last year of Mines ParisTech.
Relevant classes: data analysis, signal/image processing (building of a radio-telescope array imaging pipeline), numerical methods.

Diplôme d'ingénieur (equiv M.Sc. Executive Engineering) 2013 – 2016

MINES PARISTECH, PSL RESEARCH UNIV. (FRANCE)

Applied mathematics and physics geared towards applications in the private sector.

Preparatory classes, Physics and Chemistry 2011 – 2013

LYCÉE SAINT-LOUIS, PARIS (FRANCE)

Two-year intensive undergraduate program in mathematics, physics and chemistry. **Ranked 79th / 3489** (National "Grandes Ecoles" admission competitive exam).

PROFILE

I am an experienced numericist with a proven track record in harnessing complex algorithms for high-level applications in cutting-edge astrophysical research.

I have an extensive experience in machine learning, data analysis and mathematical modeling. Above all, I love learning in order to find new angles to solve the problems I'm tackling. I am excited to apply this mindset to new challenges.

KEY SKILLS

- ML Algorithms
- Data Visualization
- Statistical Modeling
- Clustering & Classification
- Numerical modeling
- Simulations
- High-performance computing
- Model Development

TECHNICAL SKILLS

Languages: Python (Expert), C/C++, Fortran, SQL, Bash, Java, HTML5/CSS.

Packages and services: Scikit-Learn, Tensorflow, PyTorch, Numpy, Pandas, OpenMP, MPI, HDF5, Git...

Mathematical methods: Neural networks, Bayesians statistics (MCMC), Gaussian processes, Numerical modeling (PDEs, finite-volumes, Monte-Carlo methods).

LANGUAGES

- **French:** Native
- **English:** Fluent C2 (TOEFL iBT 112/120)
- **Spanish:** Intermediate B1
- **Swedish:** Beginner A2

RESEARCH INTERNSHIPS

Observatoire de Paris, LUTh (France) Mar-jun 2017
Numerical modeling of the dynamics of stratified AGN jets.
- Implemented a radiation module into legacy numerical hydrodynamics code to compute spatially resolved radiative flux from relativistic jets. Investigated the nature of instabilities at the jet edges.

Observatoire de Genève, Exoplanets Team (Switzerland) May-Aug 2016
Characterization of the density and internal structure of low-mass exoplanets.
- Prediction of improvement in accuracy from observations with upcoming spectrographs on exoplanet internal structure inference using MCMC. Prediction of the number of 'planets of interest'.

NASA Jet Propulsion Laboratory (USA) Jun-Sept 2015
Study of high-redshift galaxy clusters in preparation of the Euclid Mission.
- Investigated feasibility of a new method to confirm galaxy cluster candidates using the radial distribution of cluster members. Came up with innovative solutions to identify and reject cluster members using photometric redshift.

Observatoire de Paris, GEPI (France) Part-time - Sept-Feb 2014
Automatic estimation of galaxy morphology using convolutional neural networks for the EUCLID mission.
- Created synthetic EUCLID images dataset from HST images labelled with Galaxy Zoo.
- Used a **state-of-the-art CNN model** to investigate perspectives for automatic classification of galaxies in future EUCLID observations.

AWARDS AND PROFESSIONAL GRANTS

- SNIC Medium allocation (Dardel), Sweden – Acting PI – **252,000 cpu-hrs /** 2022
- GW4-Isambard Tier-2 HPC Centre, UK – **40,000 node-hrs /** 2020
- **Poster prize 3rd place**, London Mathematical Society - Bath ML symposium / 2020

SELECTED CONTRIBUTED TALKS AND WORKSHOPS

Intl. Conf. on Machine Learning for Astrophysics – ML4Astro (Catania, Italy) Jun. 2022
"An Unsupervised Dive into Gamma-ray Burst Afterglow Classification"

European Astronomical Society annual meeting (remote) Jul. 2021
Workshop: "Introduction to Machine Learning for Astrophysics" (github repository)
Workshop: "Machine Learning Methods for Astrophysics"

Royal Astronomical Society National Astronomy Meeting (remote) Jun. 2020
(Canceled, re-selected and delivered 2021)
Same workshops as above

Royal Astronomical Society specialist meeting: Radiation Hydrodynamics (London, UK) Jan. 2021
"From Dynamics to radiation: Simulating GRB afterglow flares on a moving mesh"

Yamada conference LXXI: GRBs in the gravitational wave era (Yokohama, Japan) Nov. 2020
"Moving-mesh simulations of GRB afterglow flares"

PUBLICATIONS

2 referred, incl. 2 first author, 2 non-referred (Proceedings), 1 in prep., (Google Scholar)

- **Ayache, E. H.**, Van Eerten, H. J., Daigne, F. (2020), MNRAS, 495, 2979-2993
  Late X-ray flares from the interaction of a reverse shock with a stratified ejecta in GRB afterglows: simulations on a moving mesh.
- **Ayache, E. H.**, Van Eerten, H. J., Eardley, R. W. (2022), MNRAS, 510, 1315-1330
  GAMMA: a new method for modelling relativistic hydrodynamics and non-thermal emission on a moving mesh.
- **Ayache, E. H.**, Laskar, T., (in prep.), Machine-learning insights into gamma-ray burst afterglow X-ray emission.

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