

# ELIOT AYACHE, Ph.D.

MATHEMATICAL MODELER / DATA SCIENTIST



NATIONALITY: FRENCH (EU CITIZEN)

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## SUMMARY

I am an experienced modeler with a background in astrophysics, harnessing complex algorithms, data and statistics, for applications in research and innovation. I have an executive engineering degree, and 5 years of professional experience in machine learning, data analysis and numerical simulation. I have lead research projects and built, tested and deployed software for “end to end” modelisation and analysis. I thrive in both specialised and interdisciplinary collaborative environments and have strong communication skills with both specialists and non-experts. I am always fascinated with any type of challenging mathematical problem and I find that the tools I have learnt and developed in astrophysics can be applied to nearly every quantitative field.

## PROFESSIONAL EXPERIENCE

**Research Scientist** ————— **Sept. 2021 - ...**  
STOCKHOLM UNIVERSITY (SWEDEN)

- Analysis of scientific literature: built a Natural Language Processing pipeline using publicly available transformer models on a dataset of over 74,000 abstracts.
- Data visualization: Identified sub-structure in a previously unified class of 1200 astrophysical time-series using UMAP for unsupervised learning.
- Research project leader: Numerical hydrodynamics simulations of relativistic jets.
  - o Devised the research project, carrying out over 40 HPC numerical simulations (250,000 cpu.hours). Built data post-processing and visualization pipelines.
  - o Developed solutions for code stability for problematic input parameter values. Reached 100% successful runs.
- Implemented a Fortran implicit PDE solver module as a feature upgrade to an existing Monte-Carlo radiative transfer simulation code. Improved accuracy by 10%.
- Led 1 machine learning conference paper on variational autoencoders applied to time-series.
- Organized weekly seminars delivered by international guest speakers over the course of 6 months.

**Research Scientist** ————— **Oct. 2017 – Aug. 2021**  
UNIVERSITY OF BATH (UK)

- Developed from scratch a specialized massively parallel moving-mesh finite-volume relativistic hydrodynamics code in C++. Improved efficiency by a factor 10, and accuracy by 100%, over legacy codes. Public release and maintenance of the code.
- Carried out unsupervised clustering of astrophysical sparse time-series data using variational deep embedding and recurrent neural networks on a dataset of 1500 samples.
- 2 first-author publications in a top-level scientific journal.
- Organized, chaired and presented at international conferences sessions on machine learning.
- Supervised 5 Bachelor and Masters theses. Teaching (computational astrophysics, programming...) and outreach (~120h).

## SKILLS

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

Analytical thinking  
Problem solving  
Project management  
Public speaking  
Technical writing  
Teaching  
Collaboration  
Communication

## TECHNICAL EXPERTISE

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

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

**Mathematical methods:** Neural networks, self-supervised / unsupervised learning, Bayesian statistics (MCMC), Gaussian processes, PDEs, Monte-Carlo.

## LANGUAGES

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

## OTHER PROJECTS

### **Numerical Simulation Research Intern** OBSERVATOIRE DE PARIS (FRANCE)

Mar-jun 2017

- Implemented a radiation module into a legacy numerical hydrodynamics code in Fortran, to numerically integrate spatially resolved radiative flux from relativistic jets.
- Carried out and post-processed 16 HPC simulations to investigate the nature of magneto-hydrodynamical instabilities.

### **Data Analysis and Modelisation Research Intern** OBSERVATOIRE DE GENÈVE (SWITZERLAND)

May-Aug 2016

- Bayesian analysis of improvement in accuracy from observations with 6 upcoming spectrographs on exoplanet internal structure inference using MCMC.
- Devised follow-up observation strategy for a simulated sample of 1700 exoplanets to maximize information gain with minimal telescope operation time.

### **Data Analysis Research Intern** NASA JET PROPULSION LABORATORY (USA)

Jun-Sept 2015

- Designed an original method to reject X-ray detected galaxy cluster candidates using the radial distribution of their member galaxies in infrared telescope observation images.
- Combined heterogeneous data from 3 different catalogues, and fitted the procedure on a dataset of 249 confirmed galaxy clusters.
- Formulated and incorporated innovative solutions to identify and reject cluster members using photometric redshift.

### **Deep Learning Research Intern** OBSERVATOIRE DE PARIS (FRANCE)

Part-time - Sept-Feb 2014

- Created a dataset of 16,300 simulated images of galaxies from a dataset of 51,524 labelled legacy images.
- Used a state-of-the-art CNN deep learning model for automatic classification of galaxies in future observations.
- Built image data-augmentation pipelines to reduce over-fitting.

## EDUCATION

### **Ph.D., Computational Astrophysics** UNIVERSITY OF BATH (UK)

2017 – 2021

High performance computing for scientific calculus and numerical simulations.

### **M.Sc., Astronomy, Astrophysics, Space Engineering** OBSERVATOIRE DE PARIS, PSL RESEARCH UNIVERSITY (FRANCE)

2015 – 2017

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, Earth dynamics.

### **Diplôme d'ingénieur (equiv M.Sc. Executive Engineering)** MINES PARISTECH, PSL RESEARCH UNIVERSITY (FRANCE)

2013 – 2016

**Top 2 French scientific "Grande Ecole"** (National Graduate Engineering School).

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

**Minor: Earth Science.** Relevant classes: geo-statistics, signal processing, cost assessment and modelling.

### **Preparatory classes, Physics and Chemistry** LYCÉE SAINT-LOUIS, PARIS (FRANCE)

2011 – 2013

Two-year intensive undergraduate program in mathematics, physics and chemistry.

Ranked 79<sup>th</sup> / 3489 (National "Grandes Écoles" admission competitive exam).