

Aurelio Amerio

PHD CANDIDATE

Valencia, Spain

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Areas of Expertise: Generative AI, LLMs, Diffusion & Flow Models, Multimodal Learning, Bayesian Inference, Computational Physics.

Education

PhD

UNIVERSITY OF VALENCIA, INSTITUTO DE FISICA CORPUSCOLAR

PhD project on theoretical astroparticle physics and machine learning methodologies applied to physics.

Research advisor: Dr Bryan Zaldívar

Valencia, Spain

Feb 2022 – Current

Master's degree

UNIVERSITY OF TORINO

Thesis title: "Machine learning approach to the determination of the gamma-ray source count distribution below the Fermi-LAT detection limit"

Research advisor: Prof. Nicolao Fornengo and Prof. Alessandro Cuoco

Final grade: **110/110**

Turin, Italy

2018 – 2021

Violin diploma

CONSERVATORIO A. VIVALDI

Music diploma, equivalent to a master's degree

Alessandria, Italy

2007 – 2018

Bachelor's degree

UNIVERSITY OF TORINO

Thesis topic: gravitation lensing

Research advisor: Prof. Nicolao Fornengo

Final grade: **108/110**

Turin, Italy

2014 – 2017

Programming experience (4 years)

Core Programming Stack

My core stack is built on **Python** and **Julia**, leveraging their extensive scientific computing ecosystems for high-performance numerical analysis and machine learning. For deep learning, I specialize in the **JAX/Flax/NumPyro** ecosystem and am highly proficient with **PyTorch**, **TensorFlow/TFP**, and **Turing.jl**. I use **C++** for performance-critical tasks and **Wolfram Mathematica** for symbolic computation.

Machine Learning

- **Specialization:** Deep expertise in generative models (Diffusion/Flow Models, Normalizing Flows), probabilistic programming, and Bayesian inference for solving complex inverse problems in physics.
- **Key Contributions:**
 - Authored **GenSBI**, a novel JAX-based library for Generative Simulation-Based Inference.
 - Published a popular implementation of **ConcreteDropout**, which has garnered over 25,000 downloads.
 - Developed a specialized package for mapped convolutions on the HEALPix sphere domain and implemented the Expectation-Maximization (EM) algorithm for generic mixture models.

Numerical computation

- **High-Performance Computing:** Advanced skills in GPU programming, multi-threading, memory management, and code profiling/optimization. Proficient in numerical differential equation solving (SDE/ODE) with modern JAX-based libraries such as **Difffrax**.
- **Julia Ecosystem Leadership:**
 - Developed open-source packages **MultiQuad.jl** (n-dimensional numerical integration) and **FunctionTabulations.jl** (fast function interpolation).
 - Created a highly successful **lecture series on Julia**, recognized as a **top unofficial learning resource** by the official Julia language website and cited in university courses.
 - Served as a subject matter expert and technical reviewer for Julia publications with the **Manning** group.

Funded projects

Center for Computational Astrophysics

FUNDED BY: SIMONS FOUNDATION

This 3-month planned research stay has been granted **15.000\$** in funds to cover accommodation and living expenses.

New York, NY (USA)

Nov. 2025 - Jan 2026

Laboratoire d'Annecy-le-Vieux de Physique Théorique

FUNDED BY: UNIVERSITY OF VALENCIA

This project involved a 1 month research stay under the supervision of prof. Pasquale Serpico and prof. Francesca Calore.

This project was awarded **1800€** in funds.

Annecy, France

28 Apr. - 28 May 2025

Research stay at Fermilab

FUNDED BY: HORIZON EUROPE PROGRAMME (ASYMMETRY GRANT)

This project involved a 2-month research stay at Fermilab (USA), where I had the opportunity to work with the astroparticle theory group under the supervision of Prof. Dan Hooper.

This project was awarded **4600€** in funds.

Chicago, IL (USA)

Mar. - Apr. 2024

Novel methods in Dark Matter searches driven by Artificial Intelligence

FUNDED BY: CONSELLERIA DE EDUCACIÓN, INVESTIGACIÓN, CULTURA Y DEPORTE DE LA COMUNITAT VALENCIANA

This is the scholarship funding my doctoral studies, for a total of **53.000€** over three years.

Valencia, Spain

2022 - Current

Visiting scientist

Flatiron Institute & New York University (approved & funded)

CENTER FOR COMPUTATIONAL ASTROPHYSICS

New York, NY (USA)

Nov. 2025 - Jan. 2026

Flatiron Institute

CENTER FOR COMPUTATIONAL ASTROPHYSICS

New York, NY (USA)

24 Mar. - 9 Apr. 2025

Publications

Search for dark matter subhalos among Fermi-LAT sources in presence of dataset shift

2025

A. AMERIO, D. MALYSHEV, B. ZALDÍVAR, V. GAMMALDI, M.A. SÁNCHEZ-CONDE

Submitted to JCAP, arXiv:**2503.14584**

Dark satellites and dwarf spheroidal galaxies are some of the most compelling targets for dark matter annihilation searches within our galaxy.

In this work, I probe through machine learning techniques the unassociated gamma-ray sources identified by the Fermi Gamma Ray Telescope in search of a population of dark matter subhalos.

Across the Universe: Dark Matter and Galaxy Cross-Correlations with the Cherenkov Telescope Array Observatory

2025

E. PINETTI, V. VODEB, A. AMERIO, A. CUOCO, S. CAMERA, N. FORNENGO, G. ZAHARIJAS

Submitted to PRD, arXiv:**2505.20383**

The Cherenkov Telescope Array (CTA) is one of the most promising next-generation experiments for gamma-ray astrophysics.

In this work, I quantify the prospects of CTA's extragalactic survey for detecting a signal of cross-correlation between the observed gamma-ray emission and a map tracing the standard astrophysical extragalactic sources, such as active galactic nuclei.

Millisecond Pulsars in Globular Clusters and Implications for the Galactic Center Gamma-Ray Excess

2024

A. AMERIO, D. HOOPER, T. LINDEN

Accepted for publication by JCAP, arXiv:**2412.05220**

A bright, statistically significant gamma-ray signal has been detected from the inner region of our galaxy, known as the galactic center excess (GCE).

In this work, I study the gamma-ray luminosity function of millisecond pulsars found inside globular clusters. Finding good agreement with the current measurements of pulsars along the galactic plane, I use our results to better understand the validity of an explanation of the GCE in the form of a population of millisecond pulsars.

A. AMERIO, F. CALORE, P. D. SERPICO AND B. ZALDÍVAR

JCAP03(2024)055 , arXiv:**2306.1648**

I propose a novel statistical method to extend Fermi-LAT catalogs of high-latitude γ -ray sources below their nominal threshold. To do so, I rely on the determination of the differential source-count distribution of sub-threshold sources which only provides the statistical flux distribution of faint sources. By simulating ensembles of synthetic skies, I assess quantitatively the likelihood for pixels in the sky with relatively low test statistics to be due to sources, therefore complementing the source-count distribution with spatial information. Besides being useful to orient efforts towards multi-messenger and multi-wavelength identification of new γ -ray sources, I expect the results to be especially advantageous for statistical applications such as cross-correlation analyses.

A. AMERIO, A. CUOCO AND N. FORNENGO

JCAP09(2023)029, arXiv:**2302.01947**

I reconstruct the extragalactic gamma-ray source-count distribution (dN/dS) of resolved and unresolved sources by adopting machine learning techniques. Specifically, I train a convolutional neural network on synthetic 2-dimensional sky-maps, which are built by varying parameters of underlying source-counts models and incorporate the Fermi-LAT instrumental response functions. The trained neural network is then applied to the Fermi-LAT data, from which I estimate the source count distribution down to flux levels a factor of 50 below the Fermi-LAT threshold. I perform our analysis using 14 years of data collected in the 1-10 GeV energy range. The results I obtain show a source count distribution which, in the resolved regime, is in excellent agreement with the one derived from cataloged sources, and then extends as $dN/dS \propto S^{-2}$ in the unresolved regime, down to fluxes of $5 \cdot 10^{-12} \text{ cm}^{-2} \text{ s}^{-1}$. The neural network architecture and the devised methodology have the flexibility to enable future analyses to study the energy dependence of the source-count distribution.

Invited seminars and conference contributions

Center for Computational Astrophysics FLATIRON INSTITUTE - COSMOLOGY GROUP MEETING Seminar	<i>New York, NY (USA)</i> 26 Mar. 2025
New York University CENTER FOR COSMOLOGY AND PARTICLE PHYSICS Seminar	<i>New York, NY (USA)</i> 31 Mar. 2025
University of Turin PHYSICS DEPARTMENT Seminar	<i>Turin, Italy</i> 22 Jan. 2025
IDM2024 UNIVERSITY OF L'AQUILA, INFN, GSSI Poster	<i>L'Aquila, Italy</i> 8-12 July 2024
Invisibles school 2024 UNIVERSITY OF BOLOGNA, INFN Poster	<i>Bologna, Italy</i> 24-28 June 2024
Fermilab MACHINE LEARNING SEMINAR SESSIONS Chalk talk	<i>Chicago, IL (USA)</i> 26 Apr. 2024
Fermilab ASTROPARTICLE THEORY SEMINAR SESSIONS Invited Seminar	<i>Chicago, IL (USA)</i> 25 Mar. 2024
European Astronomical Society annual meeting 2022 EUROPEAN ASTRONOMICAL SOCIETY (EAS) Parallel session talk	<i>Valencia, Spain</i> June 2022

Workshops and schools

Towards realistic detection forecasts of primordial GWBs

UNIVERSITY OF VALENCIA

Workshop

Valencia, Spain

9-12 Dec. 2024

European Consortium for Astroparticle Theory School

EuCAPT AND UNIVERSITY OF VALENCIA

One-week postgraduate school

Valencia, Spain

Sep. 2023

Theoretical Aspects of Astroparticle Physics, Cosmology and Gravitation

INFN, GGI, AND UNIVERSITY OF FLORENCE

Three-week postgraduate school

Florence, Italy

Apr. 2024

Taller de Altas Energías 2022

CENTRO DE CIENCIAS DE BENASQUE PEDRO PASCUAL

Two-week workshop on high energy physics and astrophysics

Benasque, Spain

Sep. 2022

Reference contacts

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October 27, 2025