Data Analysis in Astrophysics

Code: 104416
ECTS Credits: 6

2025/2026

Degree	Type	Year
Computational Mathematics and Data Analytics	OP	4

Contact

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Teachers

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

There are no formal prerequisites. Recommendations:

- have completed the core subjects of the first three years of the Degree
- basic knowledge of python programming
- Physics studies at least at the high school level

Objectives and Contextualisation

Humanity's vision of the Universe changed radically in the 20th century. The evolution of detection techniques has increased the number of objects visible in the sky from a few hundred to many billions. In addition, objects can be observed through electromagnetic radiation in a wide range of wavelengths, from radio and infrared to the visible band and X-rays. Experimental techniques from elementary particle physics have been adapted to extend observations of celestial objects, for example through higher energy photons (gamma rays). These techniques also allow, for the first time, the observation of the sky through non-electromagnetic messengers, that is, charged particles ("cosmic rays") and, very recently, neutrinos. Finally, gigantic, highly accurate laser interferometers have recently observed gravitational waves, providing another way of observing celestial objects.

All of these ways of looking at the Universe are producing enormous amounts of data that must be filtered, calibrated, analyzed, and compared with theoretical predictions. This requires data reduction in high throughput systems and simulations in high performance systems, combined with sophisticated statistical analysis and uncertainty estimation. Big Data and Artificial Intelligence techniques are being increasingly applied in the field. The objective of the course is to explore these techniques in the context of the Degree.

Learning Outcomes

1. CM32 (Competence) Assess the degree of compliance with the requirements necessary to apply each advanced statistical procedure.
2. CM33 (Competence) Draw relevant conclusions from applied problems by applying advanced statistical methods.
3. KM27 (Knowledge) Recognise the advantages and disadvantages of different statistical methodologies when applied to different disciplines.

Content

1. Observing the sky: Physics, models and simulations, observations and instruments.
2. Case Study: Optical Sky Surveys: Measuring the expansion of the Universe
3. Case Study: Imaging Atmospheric Cherenkov telescopes: Measuring the non-thermal Universe
4. Case Study: The violent Universe: Neutrino astronomy with huge volumes of instrumented ice or water
5. Case Study: The violent Universe: Detecting gravitational waves with laser interferometers

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Lectures	15	0.6	
Type: Supervised			
Case Studies	25	1	
Type: Autonomous			
Development of solutions and programs	50	2	
Study	45	1.8	
Tutorials with professors	5	0.2	

The course will be organized into five modules, each lasting 2-3 weeks. Each module will be introduced in lectures. Students will then work on understanding a series of case studies (officially classified as Laboratory Practices (PLABs), critically analyze existing solutions, and propose improvements. Students will do the PLAB activities using their own personal computers.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Continuous Assessment Tests	14%	2	0.08	CM32, CM33, KM27
Presentations and participation in Case Studies	86%	8	0.32	CM32, CM33, KM27

This subject does not provide for the single assessment system.

The more theoretical aspects will be evaluated through a Continuous Evaluation Assessment of 2 hour duration which contributes 14% to the global grade and is not recoverable.

The more practical aspects will be evaluated through Presentations and Participation in the Laboratory Practices (PLAB) about the Case Studies.

PLAB classes are not recoverable. Attendance to PLAB classes contributes 26% to the global grade.

Students must demostrate their learning results for each Case Study through a Presentation which summarizes their activities. Each Presentation will contribute 15% to the global grade (for a total of 60%).

Bibliography

Física per a la ciència i la tecnologia Electricitat i magnetisme / La llum / Física moderna: mecànica quàntica, relativitat i estructura de la matèria / Paul A. Tipler, Gene Mosca; obra coordina per David Jou i Mirabent i Josep Enric Llebot Rabagliati. 2nd ed. Barcelona: Editorial Reverté, 2010. (versión electrónica disponible a través de la Biblioteca de la UAB).

Statistical Data Analysis, G. Cowan, ISBN: 0198501552, 1998.

Python Pocket Reference, O'Reilly, Mark Lutz, ISBN: 0596158084, 2009.

Fundamental Astronomy, Hannu Karttunen, Pekka Kröger, Heikki Oja, Markku Poutanen, Karl Johan Donner. ISBN: 978-3-662-53045-0, 2016

Particle Physics Reference Library: Volume 2: Detectors for Particles and Radiation / Edited by Christian W. Fabjan, Herwig Schopper. Ed. Christian W. Fabjan and Herwig Schopper. Cham, Switzerland: Springer Nature, 2020. Web.
Full Text Access:
https://bibcercador.uab.cat/permalink/34CSUC_UAB/1eqfv2p/alma991010351516706709

Software

Any type of spreadsheet (LibreOffice Calc, Google Sheets, Microsoft Excel, etc.)
Online pages that generate graphics (desmos.com, geogebra, etc.)
python
Jupyter notebooks

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this link. To consult the language you will need to enter the CODE of the subject.

Name	Group	Language	Semester	Turn
(PLAB) Practical laboratories	1	Catalan/Spanish	second semester	afternoon
(TE) Theory	1	Catalan/Spanish	second semester	afternoon