Universitat Autònoma de Barcelona

2021/2022

Data Analysis in Astrophysics

Code: 104416
ECTS Credits: 6

Degree	Type	Year	Semester
2503740 Computational Mathematics and Data Analytics	OT	4	2

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

Contact

Name: Manuel Carlos Delfino Reznicek
Email: Manuel.Delfino@uab.cat

Use of Languages

Principal working language: spanish (spa)
Some groups entirely in English: No
Some groups entirely in Catalan: No
Some groups entirely in Spanish: No

Teachers

María del Pilar Casado Lechuga

Prerequisites

There are no formal prerequisites. It is recommended to have completed the core subjects of the first three courses of the Degree.

Objectives and Contextualisation

Humanity's view of the Universe changed radically in the 20th Century. The evolution of detection techniques has increased the number of viewable objects in the sky from a few hundred to many billion. In addition, objects can be viewed through electromagnetic radiation over a wide range of wavelengths, from radio and infrared to the visible band and up to x-rays. Elementary particle physics techniques have been adapted to allow observations of higher energy photons up to Very High Energy gamma rays. These techniques also allow, for the first time, observation of the sky through non-electromagnetic messengers, namely charged particles ("cosmic rays") and, very recently, neutrinos. Finally, very large and precise laser interferometers have recently observed gravitational waves, which bring yet another way to observe objects in the sky.

All of these ways of observing the Universe are producing huge amounts of data that need to be cleaned, calibrated, analyzed and compared to theoretical predictions. This requires the use of large computer clusters optimized for data-intensive applications as well as supercomputers for simulations combined with sophisticated statistical analyses and uncertainty estimations. Big Data and Artificial Intelligence techniques are increasingly being applied in the field. The objective of the course is to explore these techniques in the context of the Degree.

Competences

- Formulate hypotheses and think up strategies to confirm or refute them.
- Make effective use of bibliographical resources and electronic resources to obtain information.

- Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
- Students must be capable of collecting and interpreting relevant data (usually within their area of study) in order to make statements that reflect social, scientific or ethical relevant issues.
- Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
- Students must develop the necessary learning skills to undertake further training with a high degree of autonomy.
- Using criteria of quality, critically evaluate the work carried out.
- Work cooperatively in a multidisciplinary context assuming and respecting the role of the different members of the team.

Learning Outcomes

1. Extract relevant conclusions from applied problems, through the application of advanced statistical methods.
2. Identify the special methodological characteristics of statistical analysis according to the distinct areas of application.
3. Interpret results with advanced methodologies, and extract conclusions.
4. Make effective use of bibliographical resources and electronic resources to obtain information.
5. Prepare technical reports that clearly express the results and conclusions of the study using terminology pertaining to the field of application.
6. Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
7. Students must be capable of collecting and interpreting relevant data (usually within their area of study) in order to make statements that reflect social, scientific or ethical relevant issues.
8. Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
9. Students must develop the necessary learning skills to undertake further training with a high degree of autonomy.
10. Using criteria of quality, critically evaluate the work carried out.
11. Work cooperatively in a multidisciplinary context, taking on and respecting the role of the distinct members in the team.

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

Methodology

The course will be organized in 5 modules of 2-3 week duration. The introduction to each module will be given in Lectures. Afterwards the students will work on understanding a number of Case Studies, taking a critical look at existing solutions and proposing improvements.

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.

Activities

Title	Hours	ECTS	Learning Outcomes

Type: Directed			
Lectures	10	0.4	5, 1, 2, 3, 4
Type: Supervised			
Case Studies	25	1	10, 5, 1, 2, 3, 9, 8, 6, 7, 11, 4
Type: Autonomous			
Development of solutions and programs	50	2	5, 1, 2, 3, 9, 6, 7, 11, 4
Study	45	1.8	5, 1, 2, 3, 9, 6, 7, 4
Tutorials with professors	5	0.2	10, 5, 1, 2, 3

Assessment

The more theoretical aspects will be evaluated through two Continuous Evaluation Assessments of 2 hour duration. The more practical aspects will be evaluated through Presentations and Participation in Debates, each of about 2 hour duration.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Continuous Assessment Tests	25%	5	0.2	5, 1, 2, 3, 6, 7, 4
Presentations and participation in debates	75%	10	0.4	10, 5, 1, 2, 3, 9, 8, 6, 7, 11

Bibliography

Física nuclear y de partículas (3a edición)
Full Text Access:
Unebook Intercambio Científico (UAB) 2020
http://web.b.ebscohost.com/pfi/ExternalLinkOut/PubFinderLinkOut?sid=857a256b-c942-49c2-b16a-ae47c0e484

Author:
Ferrer Soria, Antonio
ISBN:
978-84-370-9645-2
978-84-370-9771-8
Publisher Information:
Publicaciones de la Universidad de Valencia
Resource Type:
Book
Subjects:
Science

Particle Physics Reference Library: Volume 2: Detectors for Particles and Radiation
Full Text Access:
DOAB Directory of Open Access Books 2020
http://web.b.ebscohost.com/pfi/ExternalLinkOut/PubFinderLinkOut?sid=857a256b-c942-49c2-b16a-ae47c0e484

Springer Physics and Astronomy eBooks 2020 English/International 2020
http://web.b.ebscohost.com/pfi/ExternalLinkOut/PubFinderLinkOut?sid=857a256b-c942-49c2-b16a-ae47c0e484

SpringerOpen Books 2020
http://web.b.ebscohost.com/pfi/ExternalLinkOut/PubFinderLinkOut?sid=857a256b-c942-49c2-b16a-ae47c0e484(

Author:
Fabjan
Niko, editor
ISBN:
978-3-030-35317-9
978-3-030-35318-6
Publisher Information:
Springer International Publishing
Resource Type:
Book
Subjects:
English Language

Software

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