UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Cosmic Structure Formation

2526-1-F5803Q007

Aims

In this course, the students will learn how to investigate the properties and physical origin of the largest baryonic structures in the universe through the study of their radiation. The course spans a large range in the universe's history and radiation spectrum: from X-ray emitting Intra Cluster Medium in the local universe to Cosmic Web UV emission and absorption, to HI radio emission during Reionization. In the final part of the course, the students will investigate how galaxies formed and developed in the context of the large scale structure of the universe. A strong focus will be also put on learning and improving research practice.

Contents

The learning outcomes of the course in terms of knoweledge and understanding (fundamental content; Dublin descriptors 1 and 2), include:

- The students will learn how to investigate and characterise the physical properties of the largest baryonic structures in the universe by studying in detail the mechanisms that produce and modify the electromagnetic radiation detectable with astronomical observing facilities.

- The students will learn that radiation processes are an active agent in shaping the formation and evolution of cosmic structures in the universe from the largest scales associated with intergalactic gas to galaxies.

- The students will learn how to use astronomical observations at different wavelengths to infer physical properties of cosmic structures and their constituents.

Learning outcomes in terms of scientif skills and transverse skills (practice; Dublin descriptors 3-5), include:

- The students will learn how to combine the observational data and theoretical models to formulate meaningful questions and hypotheses on cosmic structure and galaxy formation, as well as strategies to test them.

- Through this course, the students will learn/consolidate the fundamental skills in scientific research practice including: i) asking and refining scientific questions, ii) finding relevant variables in physical problems, iii) making testable predictions, iv) making relevant assumptions, v) reducing complex problems in smaller units, vi) effectively sharing and communicating the results.

These learning outcomes will be reached in the course through a series of activities as described in the section "Detailed program".

Detailed program

In order to achieve the learning goals described above, the course is designed through a series of activities (including both frontal and interactive group activities) which will cover the following topics:

- Inferring the physical properties of the Intra Cluster Medium in Galaxy Clusters (X-ray, high-energy radiation processes)

- Detecting and studying Intergalactic gas in the Cosmic Web in absorption and emission (UV/optical absorption and emission of Hydrogen Ly-alpha radiation, Radiative Transfer)

- The physics of Radiative Cooling and how radiation processes shape cosmic structure and galaxy formation.

- Cosmic Reionization and radio emission from neutral hydrogen in the early universe and the effect of Reionization on galaxy formation and evolution.

Through group activities, facilitated by the teacher but independently guided by the students themselves (guaranteeing the student ownership of learning), the students will develop critical thinking skills (Dublin Descriptor 3) and they will improve their communication skills (Dublin Descriptor 4) through dialogue with their peers and with the teacher. The student ownership of learning, with the help of the teacher facilitation, will help the student to develop their own learning skills and thus to become more autonomous in their learning process beyond the course (Dublin Descriptor 5).

Prerequisites

The course is geared towards students in the physical sciences with no particular prerequisites on previous classes or study background. The only prerequisites necessary for this class are: i) motivation, ii) curiosity, iii) willingness to actively participate.

Teaching form

The course is designed through inquiry activities lead by the students themselves and facilitated by the instructors, in which the students will be able to choose their own investigation path, develop their own material and, finally, share their findings with their peers in a equitable and inclusive environment.
In particular, about one third of the course will consist in plenary activities ("didattica erogativa") and two thirds will focus on interactive activities ("didattica interattiva") based on group works.

Textbook and teaching resource

Class material will include: i) power point and black-board presentations, ii) research papers and reviews, iii) extracts from books (provided during the class when necessary). This material will be made available online and will be complemented by material produced during the classroom activities by the students themselves. For the latter, class attendance and active participation are encouraged for both learning and assessment. For the students that cannot attend, the material developed during the activities will be made available upon request.

Semester

Second Semester.

Assessment method

Final culminating assessment based on oral discussion on the topics and practices of the courses. The exam is structured as a investigation chosen by the student similarly to the investigations practiced during the course. During the exam, both fundational scientific content and scientific practices taught in the course (described in session "contents") will be assessed. In particular, the following scientific practices will be evaluated: i) asking and refining scientific questions, ii) finding relevant variables in physical problems, iii) making testable predictions, iv) making relevant assumptions, v) reducing complex problems in smaller units, vi), translating ideas into mathematical and graphical language, vii) effectively sharing and communicating the results.
The final grade will take into account both the assesment of knowledge (fundamental content; 10 points over 30) and skills (practice; 20 points over 30) acquired using the following rubric: i) knowledge of the main physical properties (e.g., density, temperature) of the cosmic structure studied in the course and how to derive such properties: 5 points; ii) knowledge of the main radiative processes relevant for cosmic structures and their role in their formation and evolution: 5 points; iii) ability to ask relevant scientific questions: 5 points; iv) ability to identify relevant physical variables: 3 points; v) ability to make testable hypotesis: 3 points; vi) ability to make relevant assumptions: 2 points; vii) ability to translate ideas into mathematical and grafical language: 2 points; viii) ability to reduce complex problems into smaller units: 2 points; ix) communication skills and in particular the ability to effectively share and communicate knowledge and how to derive it: 3 points + additional point for "lode".

Office hours

By appointment (via email).

Sustainable Development Goals

QUALITY EDUCATION | GENDER EQUALITY