UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Astrophysics Laboratory

2324-3-E3001Q058

Aims

1. Introduce instrumentation and techniques for Astrophysics observations;
2. Allow students to get the first experience in observation of astronomical sources and signal calibration;
3. Perform data analysis on observation and learn how to derive physical variables.

Contents

The course is divided into two laboratory modules plus a series of lessons on Python programming. The two laboratory modules will be preceded by a few hours of introductory lessons to the laboratory activity.

- The first module concerns the analysis of photometric images with the Bicocca Optical Telescope (TOBI) on star formation regions in galaxies.
- The second module concerns the spectroscopic observation and analysis of data acquired with the Radio Telescope in the 1.4 GHz band on galactic regions containing atomic hydrogen clouds.
- The programming module covers an introduction to Python and the use of Jupyter Notebooks for scientific computing and data analysis.

Detailed program

The course is divided into two laboratory modules plus a series of lectures on Python programming.

The first part of the teaching will consist of a series of introductory lectures:

1. Python module: 12 hours on scientific computing and data analysis;

2. Optical telescope and Radio telescope modules: approximately 10-15 hours of introduction to the observations and laboratory activities.

Laboratory activities will be divided into two modules.

1. Optical Telescope Module;
2. Radio telescope module.

Students will work in groups; each group consisting of 3 students. Each group will work with both the Optical Telescope and the Radio Telescope. The total commitment is approximately 42 hours for each module. The two modules will be followed in parallel on different days of the week.

- **Programming module**:
  Introduction to Python and the use of Jupyter Notebooks for scientific computing and data analysis. Introduction with examples and exercises to the libraries:

- Numpy (numeric calculation)
- Matplotlib (create figures, plots, animations)
- Simpy (symbolic calculation)
- Scipy (scientific calculation)
- Astropy (astronomical applications)
  This module will be held at the beginning of the course and aims to provide basic knowledge useful for the use of python in laboratory activities and also, more generally, in other scientific applications.

- **Optical Telescope Module**:

The objective of this module is to learn the techniques of acquisition and analysis of photometric images in filters for the study of the morphology, distribution and brightness of star-forming regions in galaxies.

In particular, we will understand the principles of operation of an imaging camera, the techniques of analysis of optical telescope images and the techniques of characterization of the morphology, distribution and brightness of sources.

These techniques will be applied to the study of galaxies, to know and characterize the morphology of galaxies in the local universe, to know the physics of the emission of star-forming regions, to know the main techniques for measuring the star formation rate in galaxies.

- **Radio telescope module**:
  Each group will be proposed a program of observations and a goal. Each group will carry out observations of celestial sources, in the 1.4 GHz band, in particular of galactic regions containing atomic hydrogen clouds. The observations will be spectroscopic and will allow to recognize the emission of atomic hydrogen. The educational objectives will be to learn to:

- Make observations with the telescope
- Analyze the acquired data
- Calibrate the signal with known sources
  Therefore each group will manage an observing program with the radio telescope and will analyze the collected data. The results will be described in a short report, which will be discussed at the exam.
  The specific objectives will be:
- Study of the dynamics of the observed regions
- Study of the rotational speed of the disc

- **Introductory lessons**:
  Some of the astronomical sources to be observed and the astrophysical observables are described. The techniques and instrumentation used in laboratory observations are also introduced.

Prerequisites

Students are requested to know the content of courses of Physics and Laboratories followed in the previous years.

Teaching form

1) Introductory front teaching, including python module: 20-24 hours. Remote connection is not planned during lectures.
2) Laboratory experimental training, in total for the two modules: 72-76 hours. Students presence in laboratory is mandatory.

Textbook and teaching resource

1) Slides and notes of the introductory lectures, provided by the lecturers.

2) Software codes and packages for driving instruments and data analysis.

Semester

Second semester.

Assessment method

Final assessment with the usual score up to 30, including:

1) Written report on the activities carried on in laboratory, incuding experimental measurements and data analysis; one report per group, including both modules.

2) Final interview on the activities carried on in laboratory and discussion of the report presented.

Office hours

On request to the various teachers.

Sustainable Development Goals