UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

# SYLLABUS DEL CORSO

# Esperimentazioni di Plasmi

**2021-3-E3001Q062**

## Aims

The 2020/2021 Plasma Laboratory is divided into two PARTS

PART 1: Laboratory of nuclear diagnostics of fusion plasmas

PART 2: Laboratory on vacuum machines and cold plasmas

## Contents

## Detailed program

### PART 1

The purpose of PART 1 of the laboratory is to give the student a basic knowledge of the main diagnostics used to measure nuclear radiation emitted by fusion plasmas. The nuclear radiation emitted by controlled thermonuclear fusion plasmas consists mainly of neutrons, gamma rays and X-rays. Through a series of introductory theoretical lessons, the concepts underlying the emission of these radiations from the plasma will be provided and their diagnostic importance will be explained in determining the plasma configurations to achieve nuclear fusion.

In particular, the lessons will include the following topics

1) Introduction to nuclear fusion. Why are nuclear measurements from fusion plasmas performed? Why are they important for tokamaks like ITER and DEMO? What information do you get?

2) Neutron spectroscopy from thermonuclear plasmas. What does it mean? What diagnostics are used? How do they work? Description of proven diagnostics (eg. MPR, TOFOR, Liquid Scintillators, ...) and of innovative diagnostics (Synthetic Diamonds, SiC, ...)

3) Gamma spectroscopy from thermonuclear plasmas What does it mean? What diagnostics are used? How do they work? Description of proven diagnostics (eg. Scintillators + PMT) and innovative diagnostics (SiPM, ..)

4) Soft X-ray measurements from thermonuclear plasmas. Description of radiation components and underlying physical processes. What diagnostics are used? How do they work? Description of proven diagnostics (eg. Silicon detectors) and of innovative diagnostics (GEM, ...)

Each introductory lesson will also contain a part of description of the operation of detectors.

The laboratory experiences (E1, E2, E3, E4) that each student will attend are the following (short description)

E1: Determination of absolute efficiency of a LaBr + PMT and measurement of activity of an unknown source

E2: Gamma spectroscopy measurements using scintillators coupled to PMT or SiPM

E3: Measurement of energy resolution and charge collection in diamond and SiC detectors using alpha source

E4: Study of the response of a Silicon X-ray detector (calibration, energy resolution ...)

For some of these experiments a detector emulator will also be used to simulate the response to a (simulated) plasma pulse for some diagnostics during fusion experiments.

For each experience, an introductory lesson will be held in which both the equipment to be used and the different steps of the experience will be explained.

Students will be divided into groups of 4.

Due to the COVID-19 emergency, a maximum of two students are admitted to the laboratory at the same time.

The introductory lessons will take place remotely on the zoom platform (connection link provided in the notices on the e-learning page of the course)

A detailed schedule of both lessons and laboratory shifts will be provided.

The activities are held in room 1001 of Building U9 - Prometeo Plasma Laboratories of the Physics Department.

The purpose of the laboratory activities related to part 2 is to introduce some phenomenological aspects of plasma physics in an experimental way, giving some basic training tools that will also be useful for future university activities and for the physicist profession.

**PART 2**

The activities are accompanied by a brief introduction to the plasma state and to the vacuum and diagnostic techniques used for the production and characterization of plasmas.

The topics of the introductory lessons that will take place remotely:

1) Classification of plasmas in nature and in the laboratory

2) Main characteristics of plasmas: neutrality, collective effects, e.m. properties

3) Diagnostics for plasmas: the Langmuir probe

4) Introduction to vacuum technologies

5) Introduction to experiments

The experiments will take place as part of the main activities:

- Magnetic field mapping of a linear plasma machine

- Preparation and assembly of the vacuum chamber that contains the linear plasma

- Preparation of Langmuir diagnostics

- Linear plasma generation and measurement of the discharge characteristics

- Plasma characterization: measurement of macroscopic plasma profiles (density, potential, temperature)

Students will participate in the experimental activities in pairs according to the calendar that will be prepared in the first days of March 2021.

Due to the COVID-19 emergency, the activities are organized with a maximum simultaneous presence of 4 students.

The introductory lessons will take place remotely on the WebEx Meeting platform (connection link provided in the notices on the e-learning page of the course).

The activities are held in the 2025 room of the U2 Building - Department of Physics.

## Prerequisites

Fisica 2

## Teaching form

Lessons ans laboratory sessions

## Textbook and teaching resource

Some slides will be written on the introductory topics and the cards of the experiments.

We recommend the text

F.F. CHEN Introduction to Plasma Physics and Controlled Fusion, Springer International Publishing

DOI 10.1007 / 978-3-319-22309-4, 2016, for a phenomenological description of the plasma state.

For the diagnostics part, the text Glenn F. Knoll Radiation detection and measurement is recommended

## Semester

Second

## Assessment method

To be admitted to the exam it is necessary to prepare a report on all laboratory experiences. The oral exam will focus both on the discussion of the report itself and on general questions on the theoretical topics covered

## Office hours