Plasmas in Space and Astrophysics

Academic Year: (2019 / 2020) **Review date: 23/04/2018 00:06:58**

Department assigned to the subject:

Coordinating teacher:

Type: Electives ECTS Credits : 3.0

Year : 2 Semester :

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Basic knowledge of electromagnetic theory (graduate level) and fluid mechanics.

OBJECTIVES

The purpose of this course is to study the peculiarities of plasmas existing in the terrestrial environment and interstellar medium, its orders of magnitude and basic equations. The specific objectives are:

1) Learn the characteristics, physical properties and basic equations of plasmas in the terrestrial and astronomical environment.
2) Introduce the characteristics of interaction between plasma and bodies submerged in it (orbital vehicles, grains of dust, etc.).
3) To become proficient in the usage of some numerical tools to treat and study the radiative output from plasmas.
4) To introduce the physics associated with the generation of collmated outflows from astronomical sources.

The course will provide the student with an appropiate understanding of the space medium and astrophysics plasmas. The result sought is that after the course, the students should have the knowledge and tools to enable them to work with advanced issues within this scientific discipline.

DESCRIPTION OF CONTENTS: PROGRAMME

Part I: Introduction: Plasma in space and astrophysics.

1.- Models and approximations used in the context of plasma in space. Orders of magnitude. Two-temperature plasma fluid equations. Magnetohydrodynamic approximation.

Part II: Terrestrial plasma environment.

2.- Introduction. Solar wind and its interaction with the geomagnetic field, formation of the magnetosphere. General structure of the earth¿s ionosphere and magnetosphere. Physical and chemical properties and basic parameters.

3.- Interaction between the environmental plasma and bodies in high and low orbits. Polar and equatorial orbits. Mesothermal plasma flow around an orbital object. Interaction between orbital vehicles, plasma in the environment and neutral gas. Similarities and differences between the electrical discharges in the laboratory and in space. Discharges at high and low altitudes.

4.- Introduction to dusty plasmas: Plasmas with solid or dust particles (dusty plasmas). Characteristics of electrically charged dust grains in space plasmas (terrestrial environment, comets, interstellar space, etc.). Different types of dusty plasma in space.

5.- Scales of length and time. Effects of the grain charge on Debye length, plasma frequencies and properties of the electrostatic sheath. Forces between particles. Forces on grains of dust, ions and neutral atoms. Fluid equations for dusty plasma. DIA and DA mode acoustic waves in dusty plasma.

Part III: Astrophysical Problems.

6.- Interstellar medium and star formation. Physical properties of the interstellar medium. Astronomical observations. Relevance of magnetic fields, equipartition and virialization. Plasma components: electrons, ions, neutral particles and dust. Scales of ambipolar diffusion. Interaction matter-radiation.

7.- MHD turbulence and characteristic cascades. Observational tests: Chemical anomalies, fractal dimension of clouds, initial function of stellar mass, correlation functions.

8.- Astronomical Engines. Presentation of the astronomical paradigm: from quasars to protostars. General properties: bipolarity, collimation, accretion disks, mechanical efficiency. Relevance of the magnetic field.

9.- Centrifugally driven hydromagnetic winds: from the solar wind to disk winds. Formation and jet collimation.

LEARNING ACTIVITIES AND METHODOLOGY

Classroom lectures and classroom problem solving sessions. Homework assignments.

The course will be taught by two professors for four hours a week. It is divided into three differentiated parts. The first is an introduction where the general characteristics and orders of magnitude are presented and which can be adapted to cover the necessary prior knowledge. The second, taught by Dr. L. Conde, is on plasmas in the near terrestrial environment and its interaction with diverse objects. The third part, on plasmas in astrophysics and the stellar medium, is taught by Dr. A.I. Gómez de Castro and includes an introduction to magnetohydrodynamics addressed to those students who may not have taken that course in this programme.

ASSESSMENT SYSTEM

% end-of-term-examination/test:	0
% of continuous assessment (assigments, laboratory, practicals…):	10

Evaluation shall be based on a report proposed to each student in the course by the professors to measure how much they have learned. The exercise consists of developing in extenso and in writing the content of a recent article in a research journal selected from among subjects closely related to the course contents. After evaluating the reports, the results will be given in a brief oral presentation at the end of the course with a copy for all those attending the course. Evaluation shall be based on:

¿ Level of comprehension of the scientific problem of the task proposed.
¿ Understanding of the subjects taught in the course and the relationship with the subject proposed.
¿ Scientific maturity and expression and communication skills during the presentation.

BASIC BIBLIOGRAPHY

- Edited by M.G. Kivelson and C.T. Russel A.Introduction to Space Physics, Cambridge University Press, New York, 1995

ADDITIONAL BIBLIOGRAPHY

- E.R. Priest Solar Magnetohydrodynamics, Reidel Pub. Company, 1987

- Edited by Ana I. Gomez de Castro et al. Magnetic fields and star formation: theory versus observations, Kluwer Academic Publishers, The Netherlands , 2004

- M.C. Kelley The Earth's Ionosphere: Plasma Physics and Electrodynamics, International Geophysical Series, Academic Press, San Diego CA, USA , 1989

- P.K. Shukla and A.A. Mamun Introduction to Dusty Plasma Physics, IOP, Bristol , 2002