Universidad de Costa Rica
Facultad de Ciencias
Escuela de Física
Curso FS-0622: Tópicos de Física II
(Basic Plasma Physics I)

Carta al Estudiante
Ciclo II-2014

Créditos: 3
Horas de teoría: 3
Requisitos: FS-0408, FS-0409, MA-1005, FS-0527
Profesor: Dr. Celso Ribeiro

08 Agosto 2014

1- Background

Plasma is medium frequently referred as the fourth state of matter and appear in nature but can also be created artificially.

It accounts for the most abundant medium in the universe (95-98%). Stars such as the sun, earth ionosphere plasmas, and nebulas are good examples of natural plasmas.

There is an increasing use and variety of man-made plasmas being used in different areas of research and day-to-day life.

Plasma applications are limitless area. It varies from potential clear and limitless source of energy (nuclear fusion) to environment (e.g. plasma torches to waste destruction, potential water purifier), medicine (e.g. sterilisers, skin and wound treatment), sources of light (fluorescent lamps, neon signs, TV screens), space rocket thrusters, creation of new material by “functionalize” organic (e.g. medical implants, hydrophobic wood) and inorganic surfaces (plasma nitriding metals), microelectronics (e.g. plasma etching), nanotechnology (e.g. nano powders).

Historically, plasma research and applications in Costa Rica started with the foundation of the branch of AdAstra Rocket Company in Guanacaste, which is dedicated to develop an electromagnetic thruster for spacecraft propulsion called VASIMIR (Variable Specific Impulse Magnetoplasma Rocket). Among several uses, this device is envisaged to be used in translunar and interplanetary (e.g. Mars) transportation as well as propulsion within Earth orbit.

There are also plasma activities in the Costa Rica Institute of Technology (“TEC”) with a low temperature plasma chamber and the design of the stellarator SCR-1.

A modern Spherical Tokamak (ST) device called MEDUSA-CR (Madison EDUcational Small Aspect-ratio de Costa Rica) has been donated from the University of Wisconsin at Madison to Costa Rica, and is currently being requested to move from TEC to the University of Costa Rica (“UCR”).

There is also at UCR the development of a small electromagnetic thruster. Two different modes of plasma formation will be tested, i.e., via with electron-cyclotron resonant using 2.45GHz frequency magnetron with ~2kW microwave power (SMART- Small Magnetoplasma Resonant Thurster) and via a helicon antenna coupled to 13.56MHz, ~1kW RF source (SMAPT-Small Magneto-Plasma Thruster).

2- Highlights of the Course

The present course aims to initiate undergraduate students and teachers from multidisciplinary fields (physics, engineering, or mathematics, etc) to the world of plasma, its occurrence in nature and laboratory, phenomenology and dynamics, methods of study and description (e.g. particle, fluid, statistical), measurements, as well as, to introduce them to the major research lines of plasma physics locally and worldwide.

This course is intended to be the followed by another semester course named Basic Plasma Physics II.

With the accomplishment of both courses any student is expected to acquire the broad knowledge for understanding the basic literature related to those topics, either in theory or experiments. It is also expected that any student to be fully prepared for having sufficient independence and confidence to conduct his/her research work as advanced researcher assistant and also to pursue a MSc or initiate PhD programme abroad in plasma physics or to work in related subjects in the private sector anywhere.

3- Didactic

The course is a theoretical type although both theory and experimental results (normally to back up theory) are presented. It has 3 credits assigned, 16 weeks duration, and fully conducted in English which helps the student to familiarize with the terms used internationally and also to understand the literature in plasma physics.

The course may use blackboard as an auxiliary tool, although the major presentation would be electronic via power point with didactic sequence as if were written.

4- Approval Criteria

FG = Final Grade, E = Exams, S= seminar, L = list of exercises

$$FG = \frac{1}{6}\left[3\ \frac{E1 + E2 + E3}{3} + 2\,S + 1\ \frac{L1 + L2 + L3}{3}\right]$$

Approval: FG > 67.5

E4 for those with FG= 57.5 - 67.5 or those who want to increase FG: E4 substitute the lowest previous exams (E1, E2, or E3). In this case if E4 < E1, E2, E3, the original FG stands.

5- Structure and Contents

The course is divided in units and variable levels of subunits and depth. A proposal is below

WEEK	DATES	UNITS	CONTENTS / OTHER ACTIVITIES
1	10 – 16 Aug	1	**1. Introduction** 1.1 - Occurrence of Plasmas in Nature 1.2 - Definition of Plasma
2	17 – 23 Aug	1	1.3 - Concept of Temperature 1.3.1- Measuring Temperature: an overview
3	24 – 30 Aug	1	1.4 - Debye Shielding 1.5 - The Plasma Parameter 1.6 - Criteria for Plasmas
4	31Aug – 6Sep	1	1.7 - Plasma Frequency Hand out1st list of exercises/seminars selection[1]
5	7 - 13Sep	1	**Exam 1, hand in the 1st list of exercises**
6	14 – 20Sep	2	**2. Single Particle Motions** 2.1 - Introduction 2.2 - Uniform E and B Fields
7	21 – 27Sep	2	2.3 - Non-uniform B Field 2.4 - Non-uniform E Field
8	28Sep – 4Oct	2	2.5 - Time-varying E Field 2.6 - Time-varying B Field
9	5 – 11Oct	2	2.7 - Summary of Guiding Center Drifts 2.8 - Adiabatic Invariants Hand out 2nd list of exercises
10	12 – 18Oct	2	**Exam 2, hand in the 2nd list of exercises**
11	19 – 25 Oct	3	**3. Plasmas as Fluids** 3.1- Introduction 3.2 - Relation of Plasma Physics to Ordinary Electromagnetics
12	26Oct – 1Nov	3	Contingency/(delays, absence due to conference, etc)
13	2 – 8 Nov	3	3.3 - The Fluid Equation of Motion
14	9 - 15Nov	3	3.4 - Fluid Drifts Perpendicular to B 3.5 - Fluid Drifts Parallel to B 3.6 - The Plasma Approximation Hand out 3rd list of exercises
	16 – 22Nov	3	**Exam 3, hand in the 3rd list of exercises**
	23-29Nov		**Seminars**
	30Nov – 6Dez		**Seminars**
	7-13Dec		**Exam 4 (for those in need or to increase the final grade)**

[1] **The seminar will be one topic about Applications of Plasma Physics**.

6- Bibliography

1. Chen F. F. (1984). Introduction to plasmas physics and controlled fusion, Plenum Press, 2nd edition. (The major text book. Free pdf copy might be available at internet).

2. Dolan, T. (1982), Fusion Research: Principles, Experiments and Technology, Pergamon Press (free pdf copy is available under request).

3. Krall, N. A. and Trivelpiece A. W. (1973), Principle of Plasma Physics, McGraw-Hill (free pdf copy might be available at internet)

4. Hutchinson I. (2005), Principles of Plasma Diagnostics (2nd Ed), Cambridge University Press (free pdf copy might be available at internet).