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Inertial Confinement Fusion

Academic Year: (2019 / 2020) **Review date: 22/04/2018 16:18:22**

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 quantum mechanics and nuclear reactions

OBJECTIVES

Give the elements of Physics and Technology of the Nuclear Fusion option to obtain energy using the idea of Confinement and Heating by Inertial mechanism.

Basic elements of Plasma Dynamics under high pressure will be developed with an enough explicative introduction of main mechanisms of laser- plasma interaction (at different levels of intensity) and ion-plasma.

Fluid-dynamics evolution of matter following the scheme of ablation-implosion central for Inertial Confinement will be explained giving the laws of necessary pressure, speed, for efficient process. Maximum interest will be devoted to the analysis of Hydro instabilities such as Rayleigh- Taylor or Richtmyer-Meskhov that can destroy the necessary stability of the full compression until the desired isentropic and uniform final stage. The thermonuclear processes that will happen when the temperature reach the threshold for nuclear fusion reactions and the feedback effect of progress of heating in the massive fuel will also be explained and will give the input for emerging energy and fractions carried out by the different particles (neutrons, charged particles) and radiation. A particular emphasis will be devoted to the target fabrication techniques (close to micro and advance nano technologies) and ideas to injection and tracking.

The two main lines of research (central and fast) to obtain efficiently energy will be explained using the available computational tools at the Instituto Fusion Nuclear and the known responses from experiments.

We emphasize state-of-art of facilities to obtain and demonstrate ignition such as National Ignition Facililty (NIF/LLNL, USA) and Laser MegaJoule (LMJ/CEA, France), that will be presented extensively using first information from agreement with those institutions, together with large scale in support to those installations such as OMEGA (Univ. Rochester, USA), LIL (ILP/CEA, France), VULCAN (RAL, U.K.) or GEKKO (ILE Osaka, Japan). The new series of facilities for central and fast ignition will be explained such as OMEGA-FI OMEGA (Univ. Rochester, USA), PETAL (ILP/CEA, France), PHELIX (GSI, Germany), FIREX (ILE Osaka, Japan), including the new ideas for developing a common European program for Fast Ignition HiPER.
The ideas of Future Energy reactors (HYLIFE-II, SOMBRERO, KOYO- FI) will be fully developed presenting the key technological necessary developments and necessary research in physics and technology such as Materials, Safety and Environment, Coolant and Breeding, Protection of Wall, Target Injection and Tracking and Auxiliary systems.

The course will provide the student with an appropiate training in high density plasma physics and processes to obtain efficiently energy by nuclear fusion using the approach of inertial confinement.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Introduction: Energy parameters and Alternative Sources of Energy
2. Principles of Nuclear Fusion: Types of Reactions; Cross Sections; concept of <¿v>; dependence with Temperature.
3. Ignition and Efficiency parameters in Nuclear Fusion: Lawson criteria for Magnetic and Inertial Fusion. Development of Ignition for Inertial Fusion using different physics criteria. Hydrodynamics Efficiency.
4. Principles of Inertial Fusion energy: interaction of laser and/or ions ¿ plasma.
5. Hydrodynamics elements to explain targets implosion. Basic equations for high density plasmas. Radiation-Hydrodynamics interaction and modelling of full system.
6. Determination of atomic conditions of high density plasmas: opacities and Equations of State (EOS).
7. Central and Fast Ignition. Volume Ignition. Uses of one or two beams for ignition and burnup. Types of Targets.
8. Demonstration Systems of Ignition and small gain: LaserMegaJoule (LMJ/CEA France) and National Ignition Facility (NIF/LLNL USA).
9. Inertial Fusion Energy Technology for Power Plants: Systems; Materials and irradiation sources for realistic experiments (IFMIF and others); Safety and Environment; options for First Wall / Structural Wall protection.
10. Other complementary Power Plant Syatems: Target fabrication; Auxiliary systems.

LEARNING ACTIVITIES AND METHODOLOGY

* Teaching Methods:

Classroom lectures and classroom problem solving sessions. Homework assignments

* Course Material:

Lecture notes. Virtual facilities (a dedicated web page) will be also provided with the aim of improving the interaction with the lecturers and the learning of the subject.

ASSESSMENT SYSTEM

% end-of-term-examination/test:	70
% of continuous assessment (assigments, laboratory, practicals…):	30

Evaluation shall take into account attendance and class participation, including practical classes and the solution of questionnaries periodically proposed by the lecturers along the course (30% of the final mark). A written-closed book exam will take place at the end of the semester (70% of the final mark).

BASIC BIBLIOGRAPHY

- Eds. W. Hogan, J. Coutant, S. Nakai, V.B. Rozanov, G. Velarde Energy from Inertial Fusion, IAEA Pub., 1995

- J.M. Perlado, O. Cabellos Nuclear Fusion: Principles and technology, Ed. ETSII, 2003

ADDITIONAL BIBLIOGRAPHY

- Eds., G. Velarde, Y. Ronen, J.M. Martínez-Val Nuclear Fusion by Inertial Confinement. A comprehensive Treatise, CRC Press, 1993