PX3A4-15 Plasma Physics and Fusion

22/23

Department
Physics
Level
Undergraduate Level 3
Module leader
Ben McMillan
Credit value
15
Module duration
10 weeks
Assessment
100% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

Plasmas are 'fluids' of charged particles. The motion of these charged particles is controlled by the electromagnetic fields which are imposed from outside and by the fields which the moving charged particles themselves set up. This module will cover the equations which describe such plasmas. It will examine some predictions derived on the basis of these equations and compare these with laboratory observations and with remote observations of astrophysical systems.

The module will also discuss the physics of thermonuclear fusion, which is a candidate solution for the energy demands of our society. Fusion occurs only at temperatures at which all matter is ionized and exists as a plasma. The module discusses the two main approaches: inertial confinement and magnetic confinement, with the emphasis on the latter since it is further developed. The module will deal with both the physics in the plasma as well as with the boundary conditions that must be satisfied for a working reactor.

Module web page

Module aims

The module should discuss particle dynamics in plasmas, and aspects of nuclear fusion and advanced plasma physics relevant to the construction of fusion power stations. The interaction of EM fields with a fully ionised fluid (plasma) should be considered in detail leading to ideas of

magnetohydrodynamics.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

Foundations, Debye shielding, Plasma oscillations, Gyration and drifts; Dielectric description of magnetised plasmas;
Dispersion relations for high-frequency EM waves in a cold plasma;
Elements of plasma kinetics: Landau damping, Bump-on-tail instability; Magnetohydrodynamics: Framework, Equilibria, Waves, Instabilities;

Fusion Foundations, Lawson criterion;
Cylindrical equilibria, including z pinch;
Mirror machines, Tokamaks and stellarators; Laser-plasma interaction and inertial confinement fusion; Transport and turbulence

Learning outcomes

By the end of the module, students should be able to:

- Work with single particle dynamics, guiding centre motion and adiabatic invariants, the plasma approximation and waves in plasmas
- Describe the nature of fluid instabilities and micro-instabilities with application to confinement devices and astrophysics
- Explain the interaction of electromagnetic waves with plasmas
- Appreciate how plasma physics sets the design parameters of fusion power plants
- Explain the physics of fusion power plasma heating, confinement and stability

Indicative reading list

N.A. Krall and A.W. Trivelpiece, Principles of Plasma Physics, San Fransisco Press/McGraw Hill; R. O. Dendy. Plasma Dynamics, OUP 1990.

View reading list on Talis Aspire

Subject specific skills

Knowledge of mathematics and physics. Skills in modelling, reasoning, thinking

Transferable skills

Analytical, communication, problem-solving, self-study

Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (20%)
Private study	120 hours (80%)
Total	150 hours

Private study description

Working through lecture notes, solving problems, wider reading, discussing with others taking the module, revising for exam, practising on past exam papers

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Assessment group B

	Weighting	Study time
In-person Examination	100%	

- Answerbook Pink (12 page)
- Students may use a calculator

Feedback on assessment

Personal tutor, group feedback

Past exam papers for PX3A4

Availability

Courses

This module is Option list A for:

- UPXA-F300 Undergraduate Physics (BSc)

    - Year 3 of F300 Physics
    - Year 3 of F300 Physics
    - Year 3 of F300 Physics
- UPXA-F303 Undergraduate Physics (MPhys)
    - Year 3 of F300 Physics
    - Year 3 of F303 Physics (MPhys)
- UPXA-F3F5 Undergraduate Physics with Astrophysics (BSc)
    - Year 3 of F3F5 Physics with Astrophysics
    - Year 3 of F3F5 Physics with Astrophysics
- Year 3 of UPXA-F3FA Undergraduate Physics with Astrophysics (MPhys)

This module is Option list B for:

- UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)
    - Year 4 of G105 Mathematics (MMath) with Intercalated Year
    - Year 5 of G105 Mathematics (MMath) with Intercalated Year
- UMAA-G100 Undergraduate Mathematics (BSc)
    - Year 3 of G100 Mathematics
    - Year 3 of G100 Mathematics
    - Year 3 of G100 Mathematics
- UMAA-G103 Undergraduate Mathematics (MMath)
    - Year 3 of G100 Mathematics
    - Year 3 of G103 Mathematics (MMath)
    - Year 3 of G103 Mathematics (MMath)
    - Year 4 of G103 Mathematics (MMath)
    - Year 4 of G103 Mathematics (MMath)
- Year 4 of UMAA-G106 Undergraduate Mathematics (MMath) with Study in Europe
- UPXA-GF13 Undergraduate Mathematics and Physics (BSc)
    - Year 3 of GF13 Mathematics and Physics
    - Year 3 of GF13 Mathematics and Physics
- UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
    - Year 3 of FG31 Mathematics and Physics (MMathPhys)
    - Year 3 of FG31 Mathematics and Physics (MMathPhys)
- Year 4 of UMAA-G101 Undergraduate Mathematics with Intercalated Year