PX917-15 Computational Plasma Physics

22/23

Department
Physics
Level
Taught Postgraduate Level
Module leader
Tom Goffrey
Credit value
15
Assessment
75% coursework, 25% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

N/A.

Module web page

Module aims

Provide students with an understanding of the key algorithmic choices available for modelling plasma physics relevant to laser-plasma interactions. This will include training in core kinetic and fluid codes and how these might be coupled to complete simulations relevant to inertial fusion energy (IFE).

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.

1. The hierarchy of plasma models from kinetic to fluid and how these interact
2. The basic computational techniques for kinetic plasma simulations:
   a. Particle-in-cell methods, e.g. the EPOCH code
   b. Vlasov-Fokker-Planck models for collisional transport

3. The physics of laser-driven IFE and how this specifies the algorithmic requirements of fluid models
4. Fluid models for IFE compression
   a. Basic Eulerian schemes, their stability and accuracy
   b. Lagrangian models, energy conservation and grid entanglement
   c. Arbitrary Lagrangian-Eulerian schemes
5. Inclusion of advanced physics packages in a fluid code
   a. Thermal conduction
   b. Radiation transport
   c. Multi-material modelling
6. Couple kinetic-fluid models, integrated IFE point design and the importance of UQ in these designs.

Learning outcomes

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

- Comprehension of the most common algorithms used for modelling plasma physics at the kinetic and fluid limits.
- Understanding of the physics of inertial fusion for power generation.
- Ability to setup and solve kinetic plasma physics problems with the commonly used EPOCH code.
- Familiarity with the basic methods of radiation-hydrodynamics and how to run and interpret 1D simulations of laser-driven pellet implosion.
- Appreciate the issues about uncertainty quantification (UQ) relevant for complex coupled kinetic-fluid models of an inertial fusion pellet point design.

Indicative reading list

Core Algorithms and Methods:

● Birdsall, C. K., and Langdon, A.B. (2004). Plasma physics via computer simulation. CRC press.

● Laney, C. B. (1998). Computational gasdynamics. Cambridge University press.

● Colvin, J., and Larsen, J. (2013). Extreme physics: properties and behavior of matter at extreme conditions. Cambridge University press.

Additional background physics:

● Mihalas, D., and Mihalas, B. W. (2013). Foundations of radiation hydrodynamics. Courier Corporation.

● Zel'Dovich, Y. B., and Raizer, Y. P. (2012). Physics of shock waves and high-temperature hydrodynamic phenomena. Courier Corporation.

Subject specific skills

1. Comprehension of the most common algorithms used for modelling plasma physics at the kinetic and fluid limits.
2. Understanding of the physics of inertial fusion for power generation.
3. Ability to setup and solve kinetic plasma physics problems with the commonly used EPOCH code.

4. Familiarity with the basic methods of radiation-hydrodynamics and how to run and interpret 1D simulations of laser-driven pellet implosion
5. Appreciate the issues about uncertainty quantification (UQ) relevant for complex coupled kinetic-fluid models of an inertial fusion pellet point design.

Transferable skills

Mathematics, UQ, simulation software design

Study

Study time

Type	Required
Lectures	20 sessions of 1 hour (40%)
Practical classes	15 sessions of 1 hour (30%)
Other activity	15 hours (30%)
Total	50 hours

Private study description

Further reading, revising notes etc.

Other activity description

Run predefined 1D radiation-hydrodynamics simulations to interpret the results and understand the sensitivity to equations of state (EoS) and the important of UQ in predictive modelling.

Costs

No further costs have been identified for this module.

Assessment

You do not need to pass all assessment components to pass the module.

Assessment group D

	Weighting	Study time
Report (1 of 2)	25%	12 hours

	Weighting	Study time
A report analysing results for accuracy, convergence and implications for IFE.		
Report (2 of 2)	50%	12 hours
A report on 1D radiation-hydrodynamics simulations of pellet implosion.		
Oral Examination	25%	5 hours
On kinetic plasma physics using EPOCH based on viva voce. 30 minutes.		

Feedback on assessment

¿\tVerbal discussion during viva voce exam\r\n¿\tWritten summary of viva performance\r\n¿\tFeedback on reports

Past exam papers for PX917

Availability

Courses

This module is Core optional for:

- Year 1 of TPXA-F344 Postgraduate Taught Modelling of Heterogeneous Systems

This module is Core option list A for:

- Year 2 of TPXA-F345 Postgraduate Taught Modelling of Heterogeneous Systems (PGDip)