PX423-7.5 Kinetic Theory

21/22

Department
Physics
Level
Undergraduate Level 3
Module leader
Nicholas Hine
Credit value
7.5
Module duration
5 weeks
Assessment
100% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

Kinetic Theory is the theory of how distributions change. It is based on Boltzmann's equation (the same Boltzmann who sorted out the equilibrium statistical mechanics you met in Thermal Physics II) and other PDEs. These study the evolution in time of a distribution function, which gives the density of particles in the system's phase space. (Phase space is the space of states which specify particles' position and momenta.) The module establishes relations between conductivity, diffusion constants and viscosity in gases. It looks at molecular simulation and applications to financial modelling (many of the concepts are also the basis for models of the 'motion' of stock and option prices in financial markets).

An additional motivation of this module is to illustrate how some of the mathematics you learnt in second year applied mathematics modules is used in theoretical physics.

Module web page

Module aims

To introduce Maths/Physics students to non-equilibrium statistical physics and to give them an appreciation of mathematical physics as separate sub-discipline

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.

Time dependent distribution functions: Notation, phase space coordinates and volumes. Liouville's theorem. Boltzmann equation and the assumption of molecular chaos.

Collisions: Connection between microscopic particle mechanics and the distribution function. Detailed balance, scattering cross section for a rigid ball and classical binary collision integral. Mean free path.

Equilibrium: Derivation of equilibrium statistical mechanics via phase space distributions. Hamilton's equations as a symplectic transformation.

Transport in gases: Linear transport theory and the Einstein relation between conductivity and diffusion coefficient. Thermal transport, viscosity in gases.

Diffusion: Derivation of the diffusion equation from the Boltzmann equation. Validity of the diffusion approximation. Example boundary problems for the diffusion equation. Mention of Fokker-Plank equation and connection to Langevin dynamics. Applications in molecular simulation and financial modelling.

Non Hamiltonian dynamics: Outline treatment of connection to phase space distributions. Extended 'thermostat' systems obeying the canonical distribution within the particle subspace. Pathogenic failure in the absence of molecular chaos.

Learning outcomes

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

- Derive and solve the Boltzmann equation
- Set up and solve boundary value problems describing the time-development of distributions in phase space
- Apply the theory to model physical systems

Indicative reading list

Physical Kinetics, EM Lifshitz and LP Pitaevskii : Chapters 1-3
Statistical Mechanics: Theory and molecular simulation, ME Tuckerman : Chapters 4, 13 and 15.

[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	15 sessions of 1 hour (20%)
Private study	60 hours (80%)
Total	75 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 B2

	Weighting	Study time
In-person Examination	100%	
Answer 2 questions		

- Answerbook Green (8 page)
- Students may use a calculator

Feedback on assessment

Personal tutor, group feedback

Past exam papers for PX423

Availability

Courses

This module is Core for:

- Year 3 of UPXA-FG33 Undergraduate Mathematics and Physics (BSc MMathPhys)
- UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
  - Year 3 of FG31 Mathematics and Physics (MMathPhys)
  - Year 3 of FG31 Mathematics and Physics (MMathPhys)

This module is Option list B for:

- UPXA-GF13 Undergraduate Mathematics and Physics (BSc)
  - Year 3 of GF13 Mathematics and Physics
  - Year 3 of GF13 Mathematics and Physics
- Year 4 of UPXA-GF14 Undergraduate Mathematics and Physics (with Intercalated Year)