PX3A7-15 Statistical Physics

22/23

Department
Physics
Level
Undergraduate Level 3
Module leader
Gareth Alexander
Credit value
15
Assessment
100% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

The collective behaviour of large numbers of interacting particles, or components, in a system can lead to the emergence of novel structures and patterns. Phase transitions, the configurations taken up by polymers, and stock market trends are examples. This module looks at how we classify this behaviour, how the different classes of behaviour come about, and how we model it quantitatively.

We will revise the statistical material from Thermal Physics II, as statistical mechanics is the natural starting point for describing how patterns are nucleated and grow from initial fluctuations. We will then discuss how collective behaviour can be related to order parameters and how these can change across phase transitions.

Module web page

Module aims

The module should illustrate the important concepts of statistical physics using simple examples. It should give an appreciation of the fundamental role played by fluctuations in nature.

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.

Review of the fundamental principles underlying conventional statistical mechanics and thermodynamics.

Phase Transitions: thermodynamic description. PVT system: coexistence lines, triple point, critical point, Gibbs phase rule. First order transitions (latent heat) and continuous phase transitions (no latent heat, divergence of susceptibilities). Mean-field description. Universality, importance of symmetries, concept of order parameter and spontaneous symmetry breaking. Mean field theory, Curie temperature and emergence of spontaneous magnetisation. Critical exponents. Ginzburg-Landau description of phase transitions (continuous and first order). Failure of mean field and concept of critical dimension.

Further topics in Collective Phenomena selected from:

1. Polymers: Motivate a treatment of polymers based on statistical physics emphasising an insensitivity to the chemistry. Ideal and non-ideal chains. Different models for ideal chains - Gaussian chain, lattice chain, freely jointed chain. Master equation and derivation of diffusion equation.
2. Extended quantum systems: Fermi liquids, quantitative modelling through Density Functional Theory. Emergent quantum phase ordering: Superconductivity and/or Superfluidity.
3. Non-equilibrium systems: Turbulence, growth patterns, forest fires, crowd & congestion models

Learning outcomes

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

- Work with equilibrium thermodynamics
- Describe the statistical mechanics of long chain molecules (polymers)
- Work with the Ginzburg-Landau theory of continuous symmetry breaking phase transitions and scaling theory
- Appreciate a range of emergent phenomena including some of quantum phase order and/or the Fermi liquid state, non-equilibrium phenomena such as turbulence, growth patterns, forest fires, crowd & congestion models

Indicative reading list

F. Mandl, Statistical Physics, Wiley David Chandler, Introduction to Modern Statistical Mechanics, OUP P-G de Gennes Scaling Concepts in Polymer Physics, Cornell Univ. Press G Rowlands, Non-Linear Phenomena in Science and Engineering, Ellis Horwood James P. Sethna Statistical mechanics: entropy, order parameters, and complexity OUP 2007

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 (100%)
Total	30 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 Answer 3 questions	100%	

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

Feedback on assessment

Personal tutor, group feedback

Past exam papers for PX3A7

Availability

Courses

This module is Option list B for:

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