PX388-7.5 Magnetic Resonance

20/21

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

Description

Introductory description

You have probably heard about the use of Magnetic Resonance Imaging (MRI) in medical diagnosis. In fact, magnetic resonance in nuclei, Nuclear Magnetic Resonance (NMR), and in electrons, Electron Paramagnetic Resonance (EPR), have existed as powerful tools and been used across science for several decades before being applied in the medical arena. This module describes the physics behind the techniques and shows why these techniques have found numerous applications in diverse fields including chemistry, medicine, and materials science.

Module web page

Module aims

This module should show how the intrinsic spin of nuclei and electrons is probed in Nuclear Magnetic Resonance (NMR) and Electron Paramagnetic Resonance (EPR) experiments. It should explain why magnetic resonance methods are such indispensable analytical tools in science today, in particular how NMR is used to form three-dimensional images (magnetic resonance imaging, MRI), and how molecular-level structure is revealed by the interactions that lead to fine detail in NMR and EPR spectra.

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.

THE NMR AND EPR PHENOMENA spin and angular momentum; inherent magnetism, precession at the Larmor frequency in an external magnetic field; thermal equilibrium and bulk magnetisation; resonance and electromagnetic induction: continuous wave and pulsed experiments

NMR AND EPR HARDWARE NMR and EPR magnets (super-conducting and electro-); radiofrequency (rf) (NMR) and microwave (EPR) equipment

THE BLOCH EQUATIONS classical physics: precession of transverse magnetisation; the rotating frame, resonance offsets and nutation frequency; pulsed NMR: rf Pulses; longitudinal (T1) and transverse (T2) relaxation; continuous-wave MR: the steady-state magnetisation

PULSED MR inversion recovery and T1 relaxation; spin-echoes and T2 relaxation; Fourier transformation and frequency-domain spectra; sensitivity and signal averaging

MAGNETIC RESONANCE IMAGING (MRI) one-dimensional imaging: frequency encoding using magnetic field gradients; two-dimensional imaging: phase encoding; slice selection (3D to 2D); gradient echoes

NMR & EPR SPECTROSCOPY: PROBING CHEMICAL STRUCTURE chemical shielding & the chemical shift (NMR); the g-value (EPR); through-bond J coupling and through-space dipole-dipole coupling (NMR); nuclear hyperfine and exchange interactions (EPR); solid-state NMR: anisotropic interactions and magic-angle spinning; quadrupolar interaction (nuclear spin I > 1/2)

Learning outcomes

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

- Explain the physics of the NMR and EPR
- Describe how pulsed MR experiments work
- Explain how three-dimensional images are formed in the MRI technique
- Describe how fine structure in NMR and EPR spectra can reveal structural detail on the atomic scale

Indicative reading list

MH Levitt, Spin Dynamics: Basic principles of Nuclear Magnetic Resonance Spectroscopy, Wiley

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 B1

Assessment component	Weighting	Study time	Eligible for self-certification
Online Examination Answer 2 questions from 3	100%		No

- Online examination: No Answerbook required

Reassessment component is the same

Feedback on assessment

Personal tutor, group feedback

Past exam papers for PX388

Availability

Courses

This module is Option list A for:

- Year 3 of UPXA-F300 Undergraduate Physics (BSc)
- Year 3 of UPXA-F303 Undergraduate Physics (MPhys)
- Year 4 of UPXA-F301 Undergraduate Physics (with Intercalated Year)

This module is Option list B for:

- Year 4 of UPXA-GF14 Undergraduate Mathematics and Physics (with Intercalated Year)
- Year 3 of UPXA-F303 Undergraduate Physics (MPhys)