PX382-7.5 Quantum Physics of Atoms

21/22

Department
Physics
Level
Undergraduate Level 3
Module leader
Martin Lees
Credit value
7.5
Module duration
5 weeks
Assessment
Multiple
Study location
University of Warwick main campus, Coventry

Description

Introductory description

The principles of quantum mechanics are applied to a range of phenomena in atomic physics including the operation of a laser. The intrinsic property of spin is described and its relation to the indistinguishability of identical particles in quantum mechanics discussed. Perturbation theory and variational methods are described and illustrated for several examples. The hydrogen and helium atoms are analysed and the ideas that come out from this work are used to obtain a qualitative understanding of the periodic table.

Module web page

Module aims

To develop the ideas of quantum theory and apply these to atomic physics

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.

Revision of 2nd year quantum theory

1. Approximation methods in quantum mechanics. Time-independent perturbation theory, non-degenerate case, ground state of helium atom, degenerate case, Stark effect in hydrogen. Variational methods: Rayleigh - Ritz, ground state of helium atom
2. Spin-orbit coupling and the Zeeman effect. Effects of spin-orbit coupling, and the strong and weak field Zeeman effect using time-independent perturbation theory
3. Many electron effects-indistinguishability of identical particles. Identical particles and spin; symmetric and anti-symmetric states; discussion of periodic table, ionisation energies
4. Time-dependent perturbation theory and the lasers. Derivation of Fermi's golden rule; radiation from atoms.; operation of the laser including stimulated emission and population inversion

Learning outcomes

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

- Use the approximate methods of quantum theory – perturbation theory (time-dependent and time-independent), variational methods
- Explain the role of spin and the Pauli exclusion principle
- Explain atomic spectra and the structure of the periodic table
- Describe the operation of lasers

Indicative reading list

F Mandl, Quantum Mechanics, Wiley;
A.I.M. Rae, Quantum Mechanics, IOP, 2002;
S. Gasiorowicz, Quantum Physics, Wiley, 2003;
S.M. McMurry, Quantum Mechanics, Addison-Wesley 1994

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	13 sessions of 1 hour (17%)
Other activity	2 hours (3%)
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

Other activity description

2 problem classes

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 D2

	Weighting	Study time	Eligible for self-certification
Coursework Tests	15%		No
In-person Examination Answer 2 questions	85%		No

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

Assessment group R1

	Weighting	Study time	Eligible for self-certification
In-person Examination - Resit Answer 2 questions	100%		No

	Weighting	Study time	Eligible for self-certification

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

Feedback on assessment

Personal tutor, group feedback

Past exam papers for PX382

Availability

Courses

This module is Core for:

- Year 3 of UPXA-FG33 Undergraduate Mathematics and Physics (BSc MMathPhys)
- Year 3 of UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
- Year 3 of UPXA-F300 Undergraduate Physics (BSc)
- UPXA-F303 Undergraduate Physics (MPhys)
    - Year 3 of F300 Physics
    - Year 3 of F303 Physics (MPhys)
- Year 4 of UPXA-F301 Undergraduate Physics (with Intercalated Year)

This module is Option list B for:

- UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)
    - Year 3 of G105 Mathematics (MMath) with Intercalated Year
    - Year 5 of G105 Mathematics (MMath) with Intercalated Year
- Year 3 of UMAA-G100 Undergraduate Mathematics (BSc)
- UMAA-G103 Undergraduate Mathematics (MMath)
    - Year 3 of G100 Mathematics
    - Year 3 of G103 Mathematics (MMath)
    - Year 4 of G103 Mathematics (MMath)
- UMAA-G106 Undergraduate Mathematics (MMath) with Study in Europe
    - Year 3 of G106 Mathematics (MMath) with Study in Europe
    - Year 4 of G106 Mathematics (MMath) with Study in Europe
- Year 3 of UPXA-GF13 Undergraduate Mathematics and Physics (BSc)
- Year 3 of UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
- Year 4 of UPXA-GF14 Undergraduate Mathematics and Physics (with Intercalated Year)
- Year 4 of UMAA-G101 Undergraduate Mathematics with Intercalated Year