

PX3A2-10 Quantum Physics of Atoms

26/27

Department

Physics

Level

Undergraduate Level 3

Module leader

Nicholas d'Ambrumenil

Credit value

10

Module duration

10 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 module also covers perturbation theory and variational methods.

[Module web page](#)

Module aims

To develop the ideas of quantum theory

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. Revision of 2nd year quantum theory
2. 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

3. 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
4. Many electron effects-indistinguishability of identical particles. Identical particles and spin; symmetric and anti-symmetric states; discussion of periodic table, ionisation energies
5. Time-dependent perturbation theory. Derivation of Fermi's golden rule. Radiation from atoms; operation of the laser. Two-level driven system near resonance

Learning outcomes

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

- Solve problems using perturbation theory (time-dependent and time-independent) and variational methods
- Characterise the effects of spin-orbit coupling and the Zeeman effect
- Describe the properties of many-electron atoms including the role of exchange symmetry and Hund's rules
- Explain the operation of a laser

Indicative reading list

[Specific reading list for the module](#)

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	20 sessions of 1 hour (20%)
Private study	80 hours (80%)
Total	100 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 do not need to pass all assessment components to pass the module.

Assessment group D2

	Weighting	Study time	Eligible for self-certification
Coursework	15%		No
Tests			
Centrally-timetabled examination (On-campus)	85%		No
Answer 2 questions			

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

Assessment group R2

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

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

Feedback on assessment

Personal tutor, group feedback

[Past exam papers for PX3A2](#)

Availability

Courses

This module is Core for:

- UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
 - Year 3 of FG31 Mathematics and Physics (MMathPhys)
 - Year 3 of FG31 Mathematics and Physics (MMathPhys)
 - Year 3 of FG31 Mathematics and Physics (MMathPhys)
- UPXA-F300 Undergraduate Physics (BSc)
 - Year 3 of F300 Physics
 - Year 3 of F300 Physics
 - Year 3 of F300 Physics
- UPXA-F303 Undergraduate Physics (MPhys)
 - Year 3 of F300 Physics
 - Year 3 of F303 Physics (MPhys)
 - Year 3 of F303 Physics (MPhys)
 - Year 3 of F303 Physics (MPhys)
- Year 4 of UPXA-F301 Undergraduate Physics (with Intercalated Year)
- UPXA-F3F5 Undergraduate Physics with Astrophysics (BSc)
 - Year 3 of F3F5 Physics with Astrophysics
 - Year 3 of F3F5 Physics with Astrophysics
- Year 3 of UPXA-F3FA Undergraduate Physics with Astrophysics (MPhys)

This module is Optional for:

- UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)
 - Year 3 of G105 Mathematics (MMath) with Intercalated Year
 - Year 4 of G105 Mathematics (MMath) with Intercalated Year
 - Year 5 of G105 Mathematics (MMath) with Intercalated Year
- UMAA-G100 Undergraduate Mathematics (BSc)
 - Year 3 of G100 Mathematics
 - Year 3 of G100 Mathematics
 - Year 3 of G100 Mathematics
- UMAA-G103 Undergraduate Mathematics (MMath)
 - Year 3 of G100 Mathematics
 - Year 3 of G103 Mathematics (MMath)
 - Year 3 of G103 Mathematics (MMath)
 - Year 4 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
- UPXA-GF13 Undergraduate Mathematics and Physics (BSc)
 - Year 3 of GF13 Mathematics and Physics

- Year 3 of GF13 Mathematics and Physics
- 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