PH4040 - Nuclear and Particle Physics (Extended)

Credits:	15.0	**Semester:**	1
Number of Lectures:			
Available:	All	**Lecturer:**	Dr Antje Kohnle and Dr Bruce Sinclair

Overview

This module is for students on certain joint degrees.

The first aim of this module is to describe in terms of appropriate models, the structure and properties of the atomic nucleus, the classification of fundamental particles and the means by which they interact. The syllabus includes: nuclear sizes, binding energy, spin dependence of the strong nuclear force; radioactivity, the semi-empirical mass formula; nuclear stability, the shell model, magic numbers; spin-orbit coupling; energetics of betadecay, alpha-decay and spontaneous fission; nuclear reactions, resonances; fission; electroweak and colour interactions, classification of particles as intermediate bosons, leptons or hadrons. Standard model of leptons and quarks, and ideas that go beyond the standard model.

The second aim of this module is to develop research skills, and oral and written communication skills in science. Participants will be given training in the use of bibliographic databases, use of the scientific literature, oral and written communication skills, and will develop these skills through structured assignments.

Aims & Objectives

To present an account of nuclear physics and elementary particle physics, including - observational aspects of nuclei, including their binding energy, size, spin and parity - nuclear models: Fermi gas, liquid drop and shell models
- the semi-empirical mass formula and deductions from it concerning nuclear stability
- the classification of fundamental particles and their interactions according to the Standard Model - quark structure of mesons and baryons
- properties of the strong and weak interactions
- scattering Theory

To develop advanced skills in scientific information retrieval, analysis, and communication.

Learning Outcomes

By the end of the module, students should have a comprehensive knowledge of the topics covered in the lectures and should be able to

- describe the nucleus in the context of the liquid drop model, the Fermi gas model and the shell model and apply these models to determine nuclear properties such as binding energy, spin and parity.
- use the liquid drop model and the law of radioactive decay to describe alpha-decay, beta-decay, fission and fusion, predict decay reactions and calculate the energy release in nuclear decays.
- understand the concepts of relativistic kinematics, cross section, luminosity, resonances and interaction rates via FermiÕs second golden rule and apply them to scattering processes.
- apply basic principles of quantum scattering theory to electron-nucleus scattering and high energy particle reactions. Explain how nuclear charge densities can be determined with elastic electron nucleon scattering and use the Fermi distribution to characterize the density of heavy nuclei.
- illustrate scattering processes with Feynman diagrams and apply conservation laws to predict the type of interaction of an elementary particle reaction.
- explain the experimental evidence for quarks, gluons and colour, understand the concepts of quark confinement, asymptotic freedom, sea quarks, the running coupling constant and colour charge.
- know important current particle accelerators and their centre-of-mass energies.
- understand and apply the concepts of quark generation mixing, helicity and parity violation to weak

interaction.

Students should also be able to search the scientific literature in an effective way, and find and analyse relevatn information. They should be able to communicate complicated scientific topics in oral and written formats.

Synopsis

- Binding energy of nuclei, liquid drop model of the nucleus - Stability of nuclei, alpha-decay, beta-decay, fission, fusion - Fermi gas model of the nucleus, nuclear shell model
- Scattering, relativistic kinematics, cross section, luminosity, mean free path, Fermi's second golden rule, resonances
- The four fundamental interactions and Feynman diagrams - The shapes of nuclei
- The standard model of particle physics: Quarks, gluons and hadrons
- The standard model of particle physics: Phenomenology of the weak interaction
- The Scientific Literature and Publishing
- Web of Science and Information Retrieval
- Critical Analysis of Scientific Writing
- Oral and Written Communication Skills

Prerequisites

PH3061, PH3062, Entry to BSc honours in either Logic and Philosophy of Science and Physics or Computer Science and Physics

Antirequisites

PH4022

Assessment

Coursework = 40%, 2-hour Written Examination = 60%

Additional information on continuous assessment etc

Please note that the definitive comments on continuous assessment will be communicated within the module. This section is intended to give an indication of the likely breakdown and timing of the continuous assessment.

The continuous assessment is made up of 33% from the PH3014 component, and 7% from the PH4022 component. Thus the breakdown is

Nuclear and Particle Physics web quizzes that are due in in weeks 4, 6, 7, 10, and 11 -- 3.5%
Nuclear and Particle Physics active participation in lecture Q&A 3.5%

TSfP Compare two papers submission	5.5%
TSfP Compare two papers discussion	1.4%
TSfP talk	6.9%
TSfP input to peer review of article plan	2.0%
TSfP review article	17.2%

Recommended Books

Please view University online record:

http://resourcelists.st-andrews.ac.uk/modules/ph4040.html

General Information

Please also read the general information in the School's honours handbook.