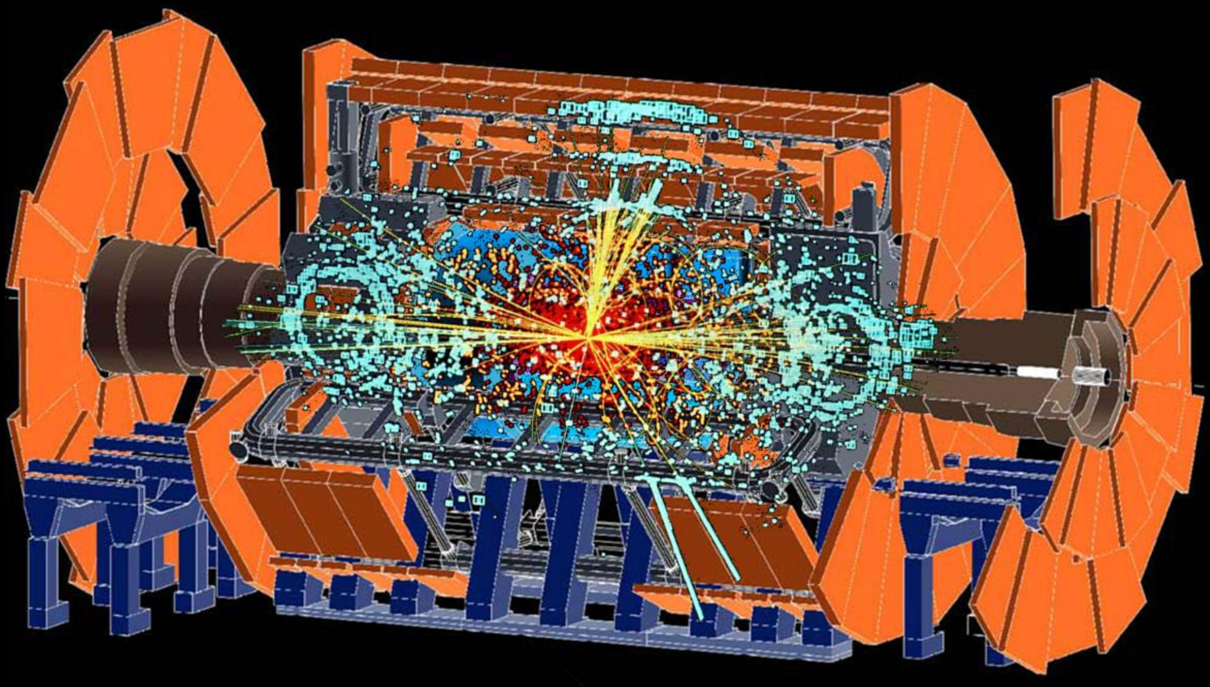
University of Glasgow | School of Physics & Astronomy



PHYS 4018 Particle Physics

Course Information Guide

1 Course Details

PHYS 4018 Particle Physics is a level 4 Physics Honours course. It is an elective course for many physics degree options. It is composed of 18 lectures and 2 full class tutorials, all given in Semester 2.

Lecturer: Prof Tony Doyle
Room 478, Kelvin Building
tony.doyle@glasgow.ac.uk

Recommended Text: Alessandro Bettini, Introduction to Elementary Particle Physics, Cambridge University Press, 1st edition (May 2008) or 2nd edition (February 2014).

Course Notes and Question Sheets are made available on Moodle.

2 Assessment

The course will be assessed via an examination in the April/May diet. It provides 10 H-level credits.

3 Required Knowledge

Students are expected to have completed the Level 4 course PHYS4015 Nuclear & Particle Physics. They should be familiar with the motivations of the Standard Model and its historical development. They should be familiar with the concepts of quantum mechanics and quantum numbers.

4 Intended Learning Outcomes

By the end of the course, students will be able to demonstrate a knowledge and broad understanding of Particle Physics. They should be familiar with the Standard Model (SM) and its breakdown in terms of matter fermions and force-carrying bosons. They should be familiar with how accelerators and detectors work. Students should be able to recognise how the matter and forces are connected in the SM and be able to demonstrate knowledge of their interactions. They should understand the Higgs mechanism. Students should be able to discuss the consequences and applications of these concepts through various experiments. They should also appreciate how particle physics affects and relates to the topics of their other honours level physics courses.

5 Course Outline

Part 1

Section 1 Review, Accelerators & Detectors

Lecture 1 (Bettini 1.9)

Review: Fundamental Forces and Particles

Standard Model fermions and bosons; Standard Model structure

Lecture 2 (Bettini 1.10)

Accelerators and Detectors

Passage of radiation through matter: Ionisation, energy loss

Accelerators: Circular and linear accelerators; RF acceleration; synchrotron radiation; magnets, focussing; cooling; luminosity; Large Hadron Collider

Lecture 3 (Bettini 1.11)

Particle Detectors: fixed target, collider; detector elements: tracking, calorimetry, muons, triggering; Case studies: ATLAS, CMS, LHCb, Neutrino detectors

Section 2 Kinematics

Lecture 4 (Bettini 1.7, 1.3-1.5, 2.5-2.7)

Kinematics, interactions, Feynman Diagrams, cross-sections and decays

Review: Fundamental forces and particles; kinematics; Klein-Gordon and Dirac equations

Lecture 5 (Bettini 5.3-5.4, 1.6)

Feynman diagrams; cross-sections and decays; Relationship of Feynman diagrams to transition probabilities in QM; interaction rate; luminosity and cross-section; decay rates

Section 3 Quantum Electrodynamics

Lecture 6 (Bettini 5.5-5.8)

Basic QED diagrams and running coupling constant; Electron-positron annihilation into a muon pair

Section 4 Quantum Chromodynamics

Lecture 7 (Bettini 6.1-6.2)

Quantum Chromodynamics: first observation of gluons; nucleon structure and parton distribution functions; electron-positron annihilation into jets: measurement of R and number of flavours.

Lecture 8 (Bettini 6.3)

Deep inelastic scattering kinematics and scaling; direct observation of partons; scaling violations

Lecture 9 (Bettini 6.4-6.8)

QCD and the colour charge; evolution of strong coupling constant: asymptotic freedom and anti-screening

Section 5 Weak interactions

Lecture 10 (Bettini 7.1-7.6)

Weak interactions: Low energy lepton processes and the Fermi constant; Charge and neutral currents; Mediators of weak interactions: W and Z; Parity violation in weak interactions; helicity and chirality; C violation in weak interactions; V-A theory of weak interactions

Part 2

Section 6 Electroweak

Lecture 11 (Bettini 9.1-9.5)

Electroweak unification; Weak neutral currents; Weinberg angle; intermediate vector bosons

Lecture 12 (Bettini 9.6-9.10)

Experimental Electroweak

Discovery of W and Z; Z Breit-Wigner Resonance and the number of neutrinos: resonances and partial width, measurement of number of neutrinos at LEP;

e^+e^- -> W^+W^-: ratios of hadronic to semi-leptonic to leptonic decays by counting states.

Section 7 Top & Higgs

Lecture 13: (Bettini 9.11 and ATLAS/CMS discoveries)

Higgs searches; Higgs decays: coupling to mass and decays for different Higgs decays; Higgs searches at LEP; Higgs searches at the LHC; ATLAS/CMS discoveries

Lecture 14: (Bettini 4.10, Bettini 9.8 and other material)

Top Quark generations and anomalies: why do we need top?; Discovery of top

Section 8 Heavy Flavour Physics

Lecture 15: (Bettini 7.7-7.9)

GIM mechanism and the discovery of charm and J/Ψ; Extension of GIM to six quarks and CKM matrix

Section 9 CP Violation

Lecture 16: (Bettini 8.1-8.6)

Particle anti-particle oscillations; CP violation in Standard Model; Neutral kaon system and discovery of CP violation; CP violation in B system

Section 10 Neutrinos & BSM

Lecture 17: (Bettini 10.1-10.5)

Neutrinos: Parity and helicity of neutrinos; Neutrino oscillations and the solar neutrino puzzle; Example Neutrino experiment, SNO; Neutrino masses

Lecture 18: (Bettini 10.6)

Beyond the Standard Model Supersymmetry; Dark Matter; Grand Unified Theories