PHYS 756 Nuclear Physics 2015

Offered:	Semester 2
Credit:	15 points
Pre-/Co-requisites:	None

Description

This course covers topics of interest in the field of nuclear physics, and particle physics as it affects studies in nuclear physics. The advent of ultra-high-energy particle "colliders" has blurred the distinction between nuclear and particle physics. This course examines early but surprisingly effective models of nuclear matter. An introduction to local gauge invariance and the known theory of electromagnetism (QED) leads students to the modern view of strong interactions (QCD). Experiments at the Relativistic Heavy Ion Collider (RHIC) where a new form of strongly interacting nuclear matter (a quark-gluon "plasma") has likely been created, and new results from the Large Hadron Collider (LHC) are presented in detail. Knowledge of quantum mechanics and some particle/nuclear physics at the third year level is assumed.

Aims

This course provides students with the background necessary to start research in experimental high energy physics.

Skills and knowledge to be gained

Students who pass this course should be able to:

- Explain the evolution of ideas that describe strongly interacting nuclear matter;
- Use the MIT Bag model of a nucleon to deduce the conditions necessary to produce deconfined nuclear matter;
- Gain an understanding of the connection between mathematical symmetry and physical forces;
- Describe the experimental techniques used to measure properties of high energy particles produced in nuclear collisions;
- Read and obtain a basic understanding of current research papers.

Syllabus

- Introduction to nuclear matter properties, the liquid drop model, beta decay, neutron and proton separation energies;
- Rare isotopes, Fermi gas model of nuclear matter, relation to liquid drop model; Modern theory of nuclear matter via an introduction to quantum field theory;
- Gauge Transformations, local and global gauge invariance, covariant derivatives; Lagrangian for Dirac equation leading to QED, extension to QCD Lagrangian; U(1), SU(2), SU(3) symmetries, gluons, "colour" quantum number; MIT bag Model of nuclear matter; low and high temperature regions of deconfined nuclear matter;
- Relativistic nuclear collisions, observables and kinematics at the RHIC and the LHC, Bjorken picture of nucleus-nucleus collisions; critical energy density, quark gluon plasma signatures and experimental data; novel electroweak probes of quark gluon plasma.
- The CMS detector at CERN, recent results in p-p, p-A and A-A collisions

Learning activities and teaching methods

Description	Study time
Lectures 20 × 1-hour	20 hours
Assignments X 5	15 hours
Private study (3 hours/lecture)	60 hours (recommended)

Inclusive learning
Students are urged to discuss privately any impairment-related requirements face-to-face and/or in written form with the course convenor/lecturer and/or tutor

Assessment

Form	Weight	Time	When
Assignments	30% (5 × 6%)	4 hours per assignment	weeks 3, 5, 7, 11
Exam	70%	3 hours	exam period

Academic Integrity
The University of Auckland will not tolerate cheating, or assisting others to cheat, and views cheating in coursework as a serious academic offence. The work that a student submits for grading must be the student's own work, reflecting his or her learning. Where work from other sources is used, it must be properly acknowledged and referenced. This requirement also applies to sources on the world-wide web. A student's assessed work may be reviewed against electronic source material using computerised detection mechanisms. Upon reasonable request, students may be required to provide an electronic version of their work for computerised review. Please visit the below link for further information:
https://www.auckland.ac.nz/en/about/learning-and-teaching/policies-guidelines-and-procedures/academic-integrity-info-for-students.html

Resources

Prescribed text:

E. Henley and A. Garcia, "Subatomic Physics", 3rd ed. 2007, GENERAL LIBRARY (539.7 F84 2007)
R. Vogt, "Ultrarelativistic Heavy-Ion Collisions", 2007. e-resource
K. Heyde, "Basic Ideas and Concepts in Nuclear Physics", 2004, e-resource
Das, "Introduction to Nuclear and Particle Physics, 2003, e-resource.
W. Burcham and M. Jobes, "Nucle ar and Particle Ph ysics", 1995, GENERAL LIBRARY (539.7 B94n)
J. Letessier and J. Rafelski, "Hadrons and Quark Gluon Plasma", 2002. e-resource.
D. Griffiths, "Introduction to Elementary Particles" 2008. e-resource

I Aitchison and A. Hey, Gauge theories in Particle Physics: From Relativistic Quantum Mechanics to QED, Vol. 1, 2003, e-resource.
I Aitchison and A. Hey, Gauge theories in Particle Physics: QCD and the Electroweak Theory, Vol. 2, 2003, e-resource. 2013 ed. Available on Short Term Loan Kate Edger Information Commons (Level 1) (539.721 A31g 2013)

Recommended reading: From various books/papers/summer schools

Feedback

Marked script and model solutions to assignments; marked exam script (if requested)

Enrolment

Typical enrolment Semester 2: 5