School of Physics

Course Outline 2020

PHYS3115

Particle Physics and the Early Universe

School of Physics

Faculty of Science

T3, 2020

1. Staff

Position	Name	Email	Consultation times and locations	Contact Details
Course Convenor	Dr Jan Hamann	j.hamann@unsw.edu.au	Consultation times: by arrangement via email	(02) 9385 6172
Lecturer	Dr Michael Schmidt	m.schmidt@unsw.edu.au	Consultation times: by arrangement via email	(02) 9385 6306
Teaching Support Officer	Zofia Krawczyk-Bernotas	z.krawczyk-bernotas@unsw.edu.au	School of Physics office G06, Old Main Building	(02) 9385 5969

2. Course information

Prerequisites: (PHYS2111 or PHYS2110) and (PHYS2114 or PHYS2210) and PHYS2113

Teaching times and locations: online

2.1 Course summary

This course aims to provide an introduction to modern elementary particle physics from both an experimental and theoretical viewpoint, and how particle physics impacts on the structure and chemical composition of the universe. Topics to be covered include: Basic ideas of the standard model. Interaction and fields. Feynman diagrams. Cross section and decay rates. Accelerators and particle detectors. Invariance principle and conservation laws: parity, charge conjugation, time reversal, CPT. Concepts of QCD and asymptotic freedom. Concepts of electroweak theory, Higgs mechanism. CP violation. Neutrino oscillations. FLRW universe: thermal history, particle decoupling. Big bang nucleosynthesis. Boltzmann equation in an FLRW universe: WIMP freezeout, baryogenesis, recombination and photon decoupling. Phase transitions. Inflation: scalar field models, Klein-Gordon equation, inflation fluctuations as seeds for structure formation. Particle physics impact on the cosmic microwave background and structure formation. Particle dark matter models. Dark matter direct and indirect detection. Dark energy and scalar field models.

Graduate Attributes Developed in this Course:

- Research, inquiry and analytical thinking abilities
- Capability and motivation for intellectual development
- Ethical, social and professional understanding
- Communication in a scientific/technical context
- Collaborative and management skills
- Information literacy

2.3 Course learning outcomes (CLO)

This course aims to provide an introduction to modern elementary particle physics from both an experimental and theoretical viewpoint, and how particle physics impacts on the structure and chemical composition of the universe.

Learning outcomes:
1. Describe the fundamental concepts of the standard model of particle physics.
2. Use conservation laws to analyse simple particle interaction problems.
3. Explain how particle physics in the first moments after the big bang impacts on the structure and chemical composition of universe observed today.
4. Describe the principles of modern particle physics experiments and cosmological observations

2.4 Relationship between course and program learning outcomes and assessments

The course learning outcomes are assessed in the 4 assessment tasks. These assessments are largely of a critical-thinking nature designed to determine students' ability to deploy acquired knowledge to new situations, which is a key graduate attribute for successful university graduates.

3. Strategies and approaches to learning

3.1 Learning and teaching activities

Assumed Knowledge
Prerequisites: (PHYS2111 or PHYS2110) and (PHYS2114 or PHYS2210) and PHYS2113

Timetable

Lectures: 1 x 2hr, 2 x 1hr per week (Weeks 1–5, 7–10)
Tutorials: 1hr per week (Weeks 1–5, 7–10)

Lecture Timetable

Day Time Location
Monday (Weeks 1–5, 7–10) 14:00-16:00 Online
Tuesday (Weeks 1–5, 7–10) 09:00-10:00 Online
Thursday (Weeks 1–5, 7–10) 13:00-14:00 Online

Lecture Information
This course is taught by two lecturers teaching 18 hours each.

Tutorial:
Friday (Weeks 1–5, 7–10) 12:00–13:00 Burrows Theatre

3.2 Expectations of students

We believe that effective learning is best supported by a climate of enquiry, in which students are actively engaged in the learning process. To ensure effective learning, students should participate in class. Effective learning is achieved when students attend all classes, have prepared effectively for classes by reading through previous lecture notes, in the case of lectures, and, in the case of tutorials or laboratories, have made a serious attempt at doing the problems or pre-work themselves prior to the class. Furthermore, lectures should be viewed by the student as an opportunity to learn, rather than just copy down lecture notes. Effective learning is achieved when students have a genuine interest in the subject and make a serious effort to master the basic material.

Academic misconduct will not be tolerated in any form in this course. Substantiated instances of cheating, plagiarism or copying answers may result in a failure grade or significant deduction of marks. Please https://student.unsw.edu.au/plagiarism if you are in any way unsure of what constitutes plagiarism. Assignments in this class are to be done independently.

4. Course schedule and structure

Detailed Syllabus

Week 1: Basic ideas of the standard model; review of special relativity; cross section and decay rates

Week 2: Klein-Gordon and Dirac equation

Week 3: Interaction and fields; Feynman diagrams

Week 4: Invariance principle and conservation laws; concepts of gauge theories; Higgs mechanism

Week 5: FLRW universe; distance measures

Week 7: Thermal history, particle decoupling; Big bang nucleosynthesis

Week 8: Boltzmann equation in an FLRW universe; WIMP freeze-out, recombination and photon decoupling

Week 9: Inflation: scalar field models, Klein-Gordon equation,

Week 10: inflaton fluctuations as seeds for structure formation, particle physics impact on cosmic microwave background and structure formation.

5. Assessment

5.1 Assessment tasks

Assessment
Course assessment comprises assignments, in-session test, laboratory and final examination.

Assessment task	Length	Weight	Mark	Due date *(normally midnight on due date)*
Mid-term Test	50 mins	15%		Monday 12th October (Week 5)

Assignment		10%		Monday 9th November (Week 9)
Weekly quizzes		15%		Fridays Weeks 1–5, 7–9
Final Exam	2 hours	60%		See exam schedule (TBA)

Further information

UNSW grading system: student.unsw.edu.au/grades

UNSW assessment policy: student.unsw.edu.au/assessment5.2

Assessment criteria and standards

Please see Moodle for a marking rubric for each assessment task.

5.3 Submission of assessment tasks

Assignment Submissions
Unless otherwise specified, assignments should be submitted online by 5pm on the due date.

A downloadable assignment cover sheet is available from
https://www.physics.unsw.edu.au/current-students/cover-sheet

Marks will be deducted for late assignments, at a rate of 5% of the maximum possible mark for the assignment per day. A weekend will count as two days. An assignment submitted after the solutions have been posted will automatically receive 0%.

5.4. Feedback on assessment

Please see Moodle for details on how feedback will be provided for each assessment task

6. Academic integrity, referencing and plagiarism

Referencing is a way of acknowledging the sources of information that you use to research your assignments. You need to provide a reference whenever you draw on someone else's words, ideas or research. Not referencing other people's work can constitute plagiarism.

Further information about referencing styles can be located at student.unsw.edu.au/referencing

Academic integrity is fundamental to success at university. Academic integrity can be defined as a commitment to six fundamental values in academic pursuits**:** honesty, trust, fairness, respect, responsibility and courage.[1] At UNSW, this means that your work must be your own, and others' ideas should be appropriately acknowledged. If you don't follow these rules, plagiarism may be detected in your work.

Further information about academic integrity and **plagiarism** can be located at:

[1] International Center for Academic Integrity, 'The Fundamental Values of Academic Integrity', T. Fishman (ed), Clemson University, 2013.

- The *Current Students* site student.unsw.edu.au/plagiarism, and
- The *ELISE* training site subjectguides.library.unsw.edu.au/elise

The *Conduct and Integrity Unit* provides further resources to assist you to understand your conduct obligations as a student: student.unsw.edu.au/conduct.

7. Readings and resources

Prescribed Text:
Mark Thomson, Modern Particle Physics
David Griffiths, Introduction to Elementary Particle Physics

Other Resources
Lecture notes will be posted on Moodle

8. Administrative matters

Communications

Students should check their UNSW email account regularly as all official university communication will be sent to that address. Students should use their university email account when writing to UNSW staff and should always include their name and student number.

Health and Safety

The School of Physics is actively committed to the health, safety and welfare of its staff and students. Information on relevant UNSW Occupational Health and Safety policies and expectations is available at: www.ohs.unsw.edu.au and https://www.physics.unsw.edu.au/about/safety

Recommended Internet Sites

The School of Physics website is www.physics.unsw.edu.au. Under the "Current Students" link students will find information about degrees, courses, and assessment.

The University website my.unsw.edu.au provides links to the UNSW Handbook, Timetables, Calendars and other student information.

Student Complaint Procedures

UNSW has procedures for dealing with complaints. These aim to solve grievances as quickly and as close to the source as possible. Information is available here: student.unsw.edu.au/complaints. Staff who can assist include:

School Contacts:

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9. Additional support for students

- The *Current Students* Gateway: student.unsw.edu.au
- Academic Skills and Support: student.unsw.edu.au/skills
- Student Wellbeing, Health and Safety: student.unsw.edu.au/wellbeing
- Disability Support Services: student.unsw.edu.au/disability
- UNSW IT Service Centre: www.it.unsw.edu.au/students