ASTR708

Introduction to Particle Physics and Cosmology

S2 Day 2018

Dept of Physics and Astronomy

Contents

General Information

Unit convenor and teaching staff
Unit Convenor
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Co-lecturer
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Credit points
4

Prerequisites
Admission to MRes

Corequisites

Co-badged status

Unit description
This unit presents an introduction to nuclear and particle physics, and to cosmology. The first part of the course deals with phenomenology of nuclear structure and reactions, relativistic wave equations, and discusses elements of quantum field theory, high energy physics and Grand Unification. The second part of the course applies general relativity and particle physics to the Universe as a whole. The geometry of the Universe and its evolution is discussed via the Friedman equations. The key pieces of evidence for the current concordance model of the Universe (a Big Bang with inflation, dark matter and dark energy) are discussed, including the expanding and accelerating Universe, the Cosmic Microwave Background radiation and the elemental abundances produced by the Big Bang. Both the beginning of the Universe and its ultimate fate are examined with respect to observational evidence. Both parts of the unit may include additional relevant topics from the current research.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://www.mq.edu.au/study/calendar-of-dates

Learning Outcomes

On successful completion of this unit, you will be able to:

Knowledge of the typical scales (mass, energy, time, etc.) relevant in nuclear and particle physics and ability to apply them for estimates in astrophysical and cosmological applications

Ability to use basic notions of scattering [particularly cross-sections] and ability to apply elements of the Lagrangian formalism, especially in problems involving symmetries and interactions

Familiarity with exact and approximate conservation laws, particularly with relativistic formulation of conservation of energy, momentum, and symmetries and charges, and ability to use them in calculations and estimate their validity in astrophysical setting

Knowledge of basics of nuclear physics and ability to use its result in analysis of astrophysical processes. Awareness of basics of nuclear technology. Familiarity with goals and methods of high energy physics. Knowledge of relevant scales and elementary processes and ability to use the high-energy data in solving cosmological problems.

Basic knowledge of relativistic wave equations and their applications to inflationary cosmology. Ability to solve simple inflationary models and evaluate their experimental consequences.

Familiarity with elements of the early universe physics. Knowledge of the basic features of the cosmic microwave background (CMB) radiation.

Knowledge of basic equations of nucleosynthesis. Ability to apply them to model the early Universe and stellar evolution

Familiarity with structure formation and ability to evaluate observational data and theoretical models. Familiarity with evidence for dark matter and role of dark matter in models of structure formation.

Familiarity with main observational constraints on cosmological parameters. Ability to estimate their uncertainties and evaluate their impact on cosmological models and predicted evolution of the Universe.

General Assessment Information

Unless agreed in advance, no extension will given except in cases of medical/family emergency, jury duty or military service. Format of the final exam and the allowed material are to be determined in consultation with the students

Assessment Tasks

Name	Weighting	Hurdle	Due
Assignments	30%	No	continuous
Midterm	20%	No	Week 8
Final exam	50%	No	Final Examination Period

Assignments

Due: **continuous**
Weighting: **30%**

Problem-solving assignments will be issued every one or two weeks.

On successful completion you will be able to:

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Midterm

Due: **Week 8**
Weighting: **20%**

The test will cover technical topics that are covered in the first part of the unit [e.g., cross-section, conservation laws, wave equations].

The test will be held during a regular lecture slot in the first week after the mid-semester break. The test duration will be 50 minutes, including reading time.

On successful completion you will be able to:

- Knowledge of the typical scales (mass, energy, time, etc.) relevant in nuclear and particle physics and ability to apply them for estimates in astrophysical and cosmological applications
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- Basic knowledge of relativistic wave equations and their applications to inflationary cosmology. Ability to solve simple inflationary models and evaluate their experimental consequences.

Final exam

Due: **Final Examination Period**
Weighting: **50%**

Written examination covering both parts of the unit.

On successful completion you will be able to:

- Knowledge of the typical scales (mass, energy, time, etc.) relevant in nuclear and particle physics and ability to apply them for estimates in astrophysical and cosmological applications
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Delivery and Resources

Technology

PC/tablet, access to internet, lectern, whiteboard, pens, erasers

Lecture and Tutorial

Three weekly lectures + one tutorial. Times: @ timetables

Information on ILearn

The lecture notes and relevant video material will be available on iLearn.

Unit Schedule

Daniel Terno [Weeks 1-6 and 13] will present an introduction to particle and nuclear physics, introduction to relativistic wave equations and inflationary cosmology. The elements of the relevant mathematical techniques and the basic notions necessary for the future practical work [such as scattering/reaction cross-sections] are also included. The content and presentation will be adjusted to the student background and progress.

Mark Wardle [Weeks 6-12] will present selected topics in cosmology, with an emphasis on the observational evidence for current models. Topics include the comic microwave background, dark matter, dark energy, newtonian and general relativistic cosmological models, and the early universe.

Note that there may be minor adjustments to the schedule as the semester proceeds.

Learning and Teaching Activities

guided reading

preliminary review of the underlying concepts and refresher on the relevant computational techniques

problem solving

solving problems -- entry level/intermidiate

tutorial

presentation of the solved problems + application of the learned material to the current research

lecture

review of the relevant physical principles and computational techniques

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central). Students should be aware of the following policies in particular with regard to Learning and Teaching:

- Academic Appeals Policy
- Academic Integrity Policy
- Academic Progression Policy
- Assessment Policy

- Fitness to Practice Procedure
- Grade Appeal Policy
- Complaint Management Procedure for Students and Members of the Public
- Special Consideration Policy *(**Note:** The Special Consideration Policy is effective from 4 December 2017 and replaces the Disruption to Studies Policy.)*

Undergraduate students seeking more policy resources can visit the Student Policy Gateway (https://students.mq.edu.au/support/study/student-policy-gateway). It is your one-stop-shop for the key policies you need to know about throughout your undergraduate student journey.

If you would like to see all the policies relevant to Learning and Teaching visit Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central).

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/study/getting-started/student-conduct

Results

Results shown in *iLearn*, or released directly by your Unit Convenor, are not confirmed as they are subject to final approval by the University. Once approved, final results will be sent to your student email address and will be made available in eStudent. For more information visit ask.mq.edu.au.

Assignments: unless by previus agreement and at the discretion of the lecturer no extension will be given except in the cases of medical/family emergency, jusry duty or military service. Late assignments (without previous agreement) will not be accepted. Submission of less than 70% of assignment reduces the maximal weight [15%] as as fraction of the missing work.

Midterm: usual special consideration policy applies.

Project: no extension will be given, unless under special consideration policy

Student Support

Macquarie University provides a range of support services for students. For details, visit http://students.mq.edu.au/support/

Learning Skills

Learning Skills (mq.edu.au/learningskills) provides academic writing resources and study strategies to improve your marks and take control of your study.

- Workshops
- StudyWise
- Academic Integrity Module for Students
- Ask a Learning Adviser

Student Services and Support

Students with a disability are encouraged to contact the Disability Service who can provide appropriate help with any issues that arise during their studies.

Student Enquiries

For all student enquiries, visit Student Connect at ask.mq.edu.au

IT Help

For help with University computer systems and technology, visit http://www.mq.edu.au/about_us/offices_and_units/information_technology/help/.

When using the University's IT, you must adhere to the Acceptable Use of IT Resources Policy. The policy applies to all who connect to the MQ network including students.

Graduate Capabilities

PG - Capable of Professional and Personal Judgment and Initiative

Our postgraduates will demonstrate a high standard of discernment and common sense in their professional and personal judgment. They will have the ability to make informed choices and decisions that reflect both the nature of their professional work and their personal perspectives.

This graduate capability is supported by:

Learning outcome

- Knowledge of basics of nuclear physics and ability to use its result in analysis of astrophysical processes. Awareness of basics of nuclear technology. Familiarity with goals and methods of high energy physics. Knowledge of relevant scales and elementary processes and ability to use the high-energy data in solving cosmological problems.

Assessment task

- Assignments

PG - Discipline Knowledge and Skills

Our postgraduates will be able to demonstrate a significantly enhanced depth and breadth of knowledge, scholarly understanding, and specific subject content knowledge in their chosen fields.

This graduate capability is supported by:

Learning outcomes

- Knowledge of the typical scales (mass, energy, time, etc.) relevant in nuclear and particle physics and ability to apply them for estimates in astrophysical and cosmological applications

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Assessment tasks

- Assignments
- Midterm
- Final exam

PG - Critical, Analytical and Integrative Thinking

Our postgraduates will be capable of utilising and reflecting on prior knowledge and experience, of applying higher level critical thinking skills, and of integrating and synthesising learning and knowledge from a range of sources and environments. A characteristic of this form of thinking is the generation of new, professionally oriented knowledge through personal or group-based critique of practice and theory.

This graduate capability is supported by:

Learning outcomes

- Knowledge of the typical scales (mass, energy, time, etc.) relevant in nuclear and particle physics and ability to apply them for estimates in astrophysical and cosmological applications
- Ability to use basic notions of scattering [particularly cross-sections] and ability to apply elements of the Lagrangian formalism, especially in problems involving symmetries and interactions
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Assessment tasks

- Assignments
- Midterm
- Final exam

PG - Research and Problem Solving Capability

Our postgraduates will be capable of systematic enquiry; able to use research skills to create new knowledge that can be applied to real world issues, or contribute to a field of study or practice to enhance society. They will be capable of creative questioning, problem finding and problem solving.

This graduate capability is supported by:

Learning outcomes

- Ability to use basic notions of scattering [particularly cross-sections] and ability to apply elements of the Lagrangian formalism, especially in problems involving symmetries and interactions
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Assessment tasks

- Assignments
- Midterm
- Final exam

PG - Effective Communication

Our postgraduates will be able to communicate effectively and convey their views to different social, cultural, and professional audiences. They will be able to use a variety of technologically supported media to communicate with empathy using a range of written, spoken or visual formats.

This graduate capability is supported by:

Assessment tasks

- Assignments
- Midterm

- Final exam

PG - Engaged and Responsible, Active and Ethical Citizens

Our postgraduates will be ethically aware and capable of confident transformative action in relation to their professional responsibilities and the wider community. They will have a sense of connectedness with others and country and have a sense of mutual obligation. They will be able to appreciate the impact of their professional roles for social justice and inclusion related to national and global issues

This graduate capability is supported by:

Learning outcome

- Knowledge of basics of nuclear physics and ability to use its result in analysis of astrophysical processes. Awareness of basics of nuclear technology. Familiarity with goals and methods of high energy physics. Knowledge of relevant scales and elementary processes and ability to use the high-energy data in solving cosmological problems.