PX435-7.5 Neutrino Physics

22/23

Department
Physics
Level
Undergraduate Level 4
Module leader
John Marshall
Credit value
7.5
Module duration
5 weeks
Assessment
100% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

Neutrinos are very interesting particles. Originally they fitted into the Standard Model quite neatly. There are three flavours associated with the electron, muon and tau and all were supposed to have zero mass. However, observations of flavour oscillations (muon neutrinos turning into electron neutrinos for example) showed that flavour eigenstates and mass eigenstates couldn't be the same and that the idea of massless neutrinos was a non-starter. Although this meant that yet more parameters (some angles and some masses) had to be introduced into the Standard Model, it also provided a possible explanation of the matter/antimatter asymmetry in the universe. This module looks at the observation of neutrinos (they are very hard to detect as they interact only very weakly with other matter), the discovery of the flavour oscillations, and how their properties (as currently known) can be accommodated within the framework of the Standard Model.

Module web page

Module aims

This module should give an overview of the physics of neutrinos, explain the state of the field today, and describe the experimental work that underlies our current knowledge.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

Introduction and historical overview; motivation for proposing the neutrino; first discovery by Reines and Cowan and subsequent discoveries; number of neutrinos; neutrino properties and interactions; neutrino electron elastic scattering; neutrino nucleon quasi-elastic scattering; neutrino nucleon deep inelastic scattering

Neutrino mass; origin of neutrinos and detection; solar neutrinos; atmospheric neutrinos; terrestrial neutrino sources;
neutrino oscillations; flavour oscillations in vacuum and matter; solution of the solar and atmospheric problems

Limitations of oscillation experiments; direct mass searches; kinematic mass determination; double beta decay

Summary of current understanding; outstanding questions and the future of experimental neutrino physics

Learning outcomes

By the end of the module, students should be able to:

- Explain the theory of neutrino mass and the implications of a non-zero mass.
- Demonstrate an understanding at an advanced level of the present state of the field
- Describe the properties of neutrinos, and the different types of interactions that they undergo.
- Describe the different sources of neutrinos, and the landmark experiments that studied them.

Indicative reading list

K. Zuber, Neutrino Physics, IoP Series in High Energy Physics

View reading list on Talis Aspire

Subject specific skills

Knowledge of mathematics and physics. Skills in modelling, reasoning, thinking.

Transferable skills

Analytical, communication, problem-solving, self-study

Study

Study time

Type	Required
Lectures	15 sessions of 1 hour (20%)
Private study	60 hours (80%)
Total	75 hours

Private study description

Working through lecture notes, solving problems, wider reading, discussing with others taking the module, revising for exam, practising on past exam papers

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Assessment group B3

	Weighting	Study time
In-person Examination	100%	
Answer 2 questions		

Feedback on assessment

Personal tutor, group feedback

Past exam papers for PX435

Availability

Courses

This module is Optional for:

- Year 4 of UPXA-F303 Undergraduate Physics (MPhys)

This module is Option list B for:

- Year 4 of UPXA-FG33 Undergraduate Mathematics and Physics (BSc MMathPhys)
- UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)

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