PX436-15 General Relativity

20/21

Department
: Physics

Level
: Undergraduate Level 4

Module leader
: Gareth Alexander

Credit value
: 15

Module duration
: 10 weeks

Assessment
: 100% exam

Study location
: University of Warwick main campus, Coventry

Description

Introductory description

Einstein's general theory of relativity (GR) is the basis for our understanding of black holes and the Universe on its largest scales. In GR the Newtonian concept of a gravitational force is abolished, to be replaced by a new notion, that of the curvature of space-time. This leads in turn to predictions of phenomena such as the bending of light and gravitational time dilation that are well tested, and others, such as gravitational waves, which have only recently been directly detected.

The module starts with a recap of Special Relativity, emphasizing its geometrical significance. The formalism of curved coordinate systems is then developed. Einstein's equivalence principle is used to link the two to arrive at the field equations of GR. The remainder of the module looks at the application of general relativity to stellar collapse, neutron stars and black-holes, gravitational waves, including their detection, and finally to cosmology where the origin of the "cosmological constant" - nowadays called "dark energy" - becomes apparent.

Module web page

Module aims

To present the theory of General Relativity and its applications in modern astrophysics, and to give an understanding of black-holes

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.

The geometry of space-time and the invariant “interval” in special relativity; geodesics and equations of motion applied to circular orbits within the Schwarzschild metric; 4-vector formulation of special relativity; metric of special relativity; the equivalence principle and local inertial frames; motivation for considering curved space-time; vectors and tensors in curved coordinate systems; geodesic motion revisited; motion in almost-flat space-time: the Newtonian limit; the curvature and stress-energy tensors; how the metric is determined: Einstein's field equations; Schwarzschild metric; observable consequences; black-holes; stability of orbits; extraction of energy; gravitational radiation and its detection; cosmology: the Robertson-Walker metric

Learning outcomes

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

- Explain the metric nature of special and general relativity, how the metric determines the motion of particles
- Undertake some calculations involving the Schwarzschild metric
- Describe the key features of black-holes
- Demonstrate knowledge of current attempts to detect gravitational waves

Indicative reading list

BF Schutz A first course in general relativity, Cambridge University Press,
M.P Hobson, G. Efstathiou, A.N. Lasenby, General Relativity - An Introduction for Physicists, CUP,
L. D. Landau, E. M. Lifshits, The Classical Theory of Fields

View reading list on Talis Aspire

Interdisciplinary

The theory of General Relativity, like quantum theory, has been the result of collaboration between people working in physics and in mathematics with insights flowing in both directions. At its core is a simple hypothesis about observations (the equivalence principle), which leads to a theory of gravity based on the differential geometry of curved spaces. This module covers both the necessary mathematics and computes some of the consequences for the physical Universe.

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	30 sessions of 1 hour (20%)
Seminars	(0%)
Private study	120 hours (80%)
Total	150 hours

Private study description

Self study

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Assessment group B1

	Weighting	Study time	Eligible for self-certification
Assessment component			
Online Examination Answer 3 questions from 4	100%		No

- Answerbook Pink (12 page)
- Students may use a calculator

Reassessment component is the same

Feedback on assessment

Personal tutor, group feedback

Past exam papers for PX436

Availability

Courses

This module is Optional for:

- TMAA-G1PE Master of Advanced Study in Mathematical Sciences
  - Year 1 of G1PE Master of Advanced Study in Mathematical Sciences
  - Year 1 of G1PE Master of Advanced Study in Mathematical Sciences
- Year 1 of TMAA-G1P0 Postgraduate Taught Mathematics
- Year 1 of TMAA-G1PC Postgraduate Taught Mathematics (Diploma plus MSc)
- Year 4 of UPXA-F303 Undergraduate Physics (MPhys)

This module is Option list A for:

- Year 1 of TMAA-G1P0 Postgraduate Taught Mathematics
- Year 3 of UMAA-G100 Undergraduate Mathematics (BSc)
- Year 3 of UMAA-G103 Undergraduate Mathematics (MMath)
- Year 4 of UMAA-G101 Undergraduate Mathematics with Intercalated Year

This module is Option list B for:

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

This module is Option list C for:

- UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)
  - Year 3 of G105 Mathematics (MMath) with Intercalated Year
  - Year 5 of G105 Mathematics (MMath) with Intercalated Year
- UMAA-G103 Undergraduate Mathematics (MMath)
  - Year 3 of G103 Mathematics (MMath)
  - Year 4 of G103 Mathematics (MMath)
- UMAA-G106 Undergraduate Mathematics (MMath) with Study in Europe
  - Year 3 of G106 Mathematics (MMath) with Study in Europe
  - Year 4 of G106 Mathematics (MMath) with Study in Europe