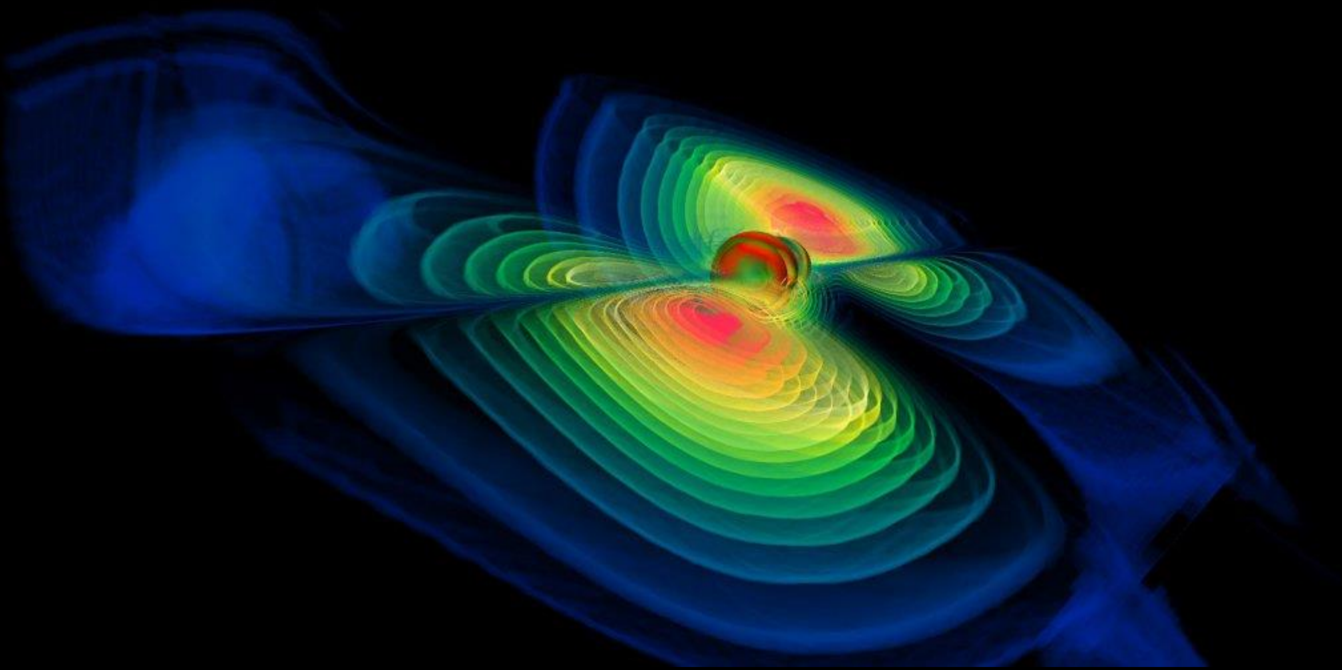
University of Glasgow | School of Physics & Astronomy



PHYS5006: Gravitational Wave Detection

Course Information Guide

1 Course Details

Coordinator:	Prof Ik Siong Heng	Schedule:	Typically 2 lectures per week
SCQF Credits:	10	ECTS Credits:	5
Assessment:	Oral examination (50%) Coursework (50%)	Co-requisites:	None
Level:	Masters		
Typically Offered:	Semester 1	Prerequisites:	None

2 Course Aims

This course provides a comprehensive introduction to the physics of gravitational wave detection. Starting from the fundamentals of Einstein's General Theory of Relativity, the course will explore: the basic operating principles of gravitational wave detectors; astrophysical sources of gravitational waves and current observations; current topics in advanced detector design; future plans for ground-based and space-based detectors and gravitational wave data analysis techniques.

The aim is to provide students with an opportunity to develop knowledge and understanding of the key principles and applications of gravitational wave physics, and their relevance to current developments in the field of gravitational wave detection, at a level appropriate for a professional (astro-)physicist.

3 Intended Learning Outcomes

At the end of the course students should be able to:

- explain qualitatively, from the General Theory of Relativity, how metric perturbations in free space take the form of a wave equation, propagating at the speed of light and describe how gravitational waves are produced by the asymmetrical acceleration of matter
- describe the physical principles underlying detectors of gravitational waves with particular emphasis on detectors using laser interferometry
- outline the most promising astrophysical sources for the production of significant levels of gravitational radiation, estimate the amplitude of this radiation from a compact binary system, and qualitatively summarise observed gravitational wave sources
- outline the main noise sources which limit the performance of interferometric gravitational wave detectors and discuss how such sources can be mitigated, with particular reference to seismic noise, thermal noise and photo-electron shot noise
- describe the plans for building more sensitive detectors on the ground and in space, providing quantitative details of such detectors, and describe how the signals from

various astrophysical sources may be extracted from the data collected by these detectors.

4 Course Outline

- Theoretical foundations and principles of gravitational waves: an introduction to General Relativity; an introduction to gravitational wave detection methods and gravitational wave detectors
- Interferometers as gravitational wave detectors: detecting signals in light; building blocks of a modern interferometer; interferometer topologies; quantum noise and quantum-non-demolition
- Noise sources in interferometric gravitational wave detectors: general description of gravity gradient noise, seismic noise and thermal noise; details of thermal noise in interferometer mirror components
- Science and sources: the production of gravitational waves; the quadrupole approximation; black holes and neutron stars; gravitational wave emission from compact binary coalescences; observations of gravitational waves and their source properties
- Data analysis: signal morphologies; coherent and coincident analysis methods for transient sources; directional sensitivity for transient sources; matched filtering; detector response functions; analysis methods for continuous sources
- Future detectors: space-based detectors (LISA) and their potential sources; drag-free control; LISA Pathfinder; third-generation ground-based detectors; Einstein telescope.

5 Further Information

Further information can be found on the course Moodle page and also using the links below:

- Course specification
- Reading list