MSc in Astrophysics and Relativity – Programme Structure

Programme Structure – Full-Time					
Module title	**Module Code**	**Semester**	**Type**	**Credits**	**Resit Category**
Semester 1					
Computational Physics	MS535	1	Core	7.5	1
Differential Geometry & General Relativity	MS536	1	Core	7.5	1
Partial Differential Equations	MS509	1	Core	7.5	1
Astrophysics I	PS526	1	Core	7.5	1
Semester 2 ***Core modules***					
Theoretical, Physical & Computational Cosmology	PS527	2	Core	7.5	1
Data Science and Machine Learning	MS538	2	Core	7.5	1
Semester 2 ***Optional module: students choose two of the following modules***					
Advanced Astrophysics 1: Galaxies, Exoplanets, Observational Techniques	PS528	2	Optional	7.5	1
Advanced Astrophysics 2: High Energy Astrophysics	PS529	2	Optional	7.5	1
Advanced General Relativity 1: Gravitational Waves	MS539	2	Optional	7.5	1
Advanced General Relativity 2: Black Hole Physics	MS540	2	Optional	7.5	1
Semester 3					
Project (Astrophysics and Relativity)	FSH512	3	Core	30	2

Module Outlines

MS535 Computational Physics

In this module, students will be introduced to the ideas of computational astrophysics including programming language paradigms, numerical methods, algorithms, stochastic methods and high performance computing. Students will have the option to learn and use different programming languages including Python, C, C++.

MS536 Differential Geometry and General Relativity

This module introduces students to General Relativity – Einstein's geometric theory of the gravitational field – and provides them with the mathematical tools required for its study. General Relativity underpins a wide range of astrophysical phenomena where gravitation is the dominant force at work (black holes, the Big Bang, gravitational wave emission), and where precision measurements of phenomena influenced by gravity are important (the GPS system). The module includes the study of the conceptual foundations of GR and Einstein's equation, and applications of this theory to our universe.

MS509 Partial Differential Equations

This module introduces students to both the methods and underlying theory of solving partial differential equations. Students will become familiar with first order quasi-linear and second order linear partial differential equations. A selection of analytic techniques for solving some partial differential equations that frequently occur in applications will be given. This module provides both a platform for modelling with partial differential equations and an introduction to analysing the nature of these equations. Students will develop an ability to critique the various solution methods and to demonstrate a deep understanding of when and why they can be used.

PS526 Astrophysics I

In this module, students will study the life-cycle of stars of different masses, and study the role of radiative processes in a variety of astrophysical phenomena. They will analyse the key role of plasmas in astrophysics, and study the structure and formation of the interstellar medium. They will analyse and critique different models of stellar and galactic formation.

PS527 Theoretical, Physical and Computational Cosmology

Students will begin by considering the characterisation of Theoretical and Physical Cosmology, and then go on to study a range of topics under these headings: Theoretical Cosmology deals with phenomena from the very early Universe including Inflation, Big Bang Nucleosynthesis, Recombination and CMB physics. Physical Cosmology refers to cosmological phenomena which are observable and used to probe cosmology including Lyman-alpha forest, Baryon Acoustic Oscillations, Void statistics, Supernova measurements and Galaxy Surveys. Computational cosmology focuses on how large scale simulations are used to probe the large scale structure of the universe.

MS538 Data Science and Machine Learning

This module will equip students with the skills to handle and analyse the large, complex data sets that arise in electromagnetic and gravitational wave astronomy. Topics from probability, statistics and computing and data science will be covered, and students will apply these in settings related to astrophysics and relativity.

PS528 Advanced Astrophysics 1: Galaxies, Exoplanets, Observational Techniques

This module focuses on studying the nearby universe, focusing in particular on galaxies and exoplanets. As part of this module, different observational techniques will be discussed.

PS529 Advanced Astrophysics 2: High Energy Astrophysics

This module focuses on the non-thermal processes governing the high energy Universe, including radiative processes and particle acceleration. The objects of study range from our Sun, to Active Galactic Nuclei, to Gamma Ray Bursts and to the Universe as a whole.

MS539 Advanced General Relativity 1: Gravitational Waves

The recent direct detection of gravitational waves has opened up a qualitatively new window into astronomy and fundamental physics, and this module provides students with a foundation in this area. The physics of gravitational waves will be developed in general relativity, from the generation and propagation of these waves through to their observable consequences.

MS540 Advanced General Relativity 2: Black Hole Physics

This module covers both classical and quantum aspects of black holes. Topics include the no-hair conjecture, black hole formation, laws of black hole mechanics, Hawking radiation and black hole thermodynamics, black hole evaporation and the information loss 'paradox'.

FSH512 Project (Astrophysics and Relativity)

In this module, students will work under an academic supervisor (a researcher from the Centre for Astrophysics and Relativity) to carry out a project in the areas of astrophysics and/or relativity. Formal aspects of the module will help the students to develop research skills, technical writing skills and presentation skills. Students will have the option of pursuing a project in an area of their own choice, or in an area proposed by an academic member of the programme team. Indicative project topics include:

- Perturbations and stability of black holes;
- The information loss problem;
- Event rate estimates for LISA sources;
- Black holes in modified theories of gravity;
- Colliding gravitational waves;
- The motion of extended bodies in GR;
- Gravitational collapse and cosmic censorship;
- Structure and spectra of accretion disks;
- Optical phases of exoplanets;
- Reconstructing physical conditions from broad band spectra;
- Dynamics of proto-planetary disks;
- Turbulence in the interstellar medium.