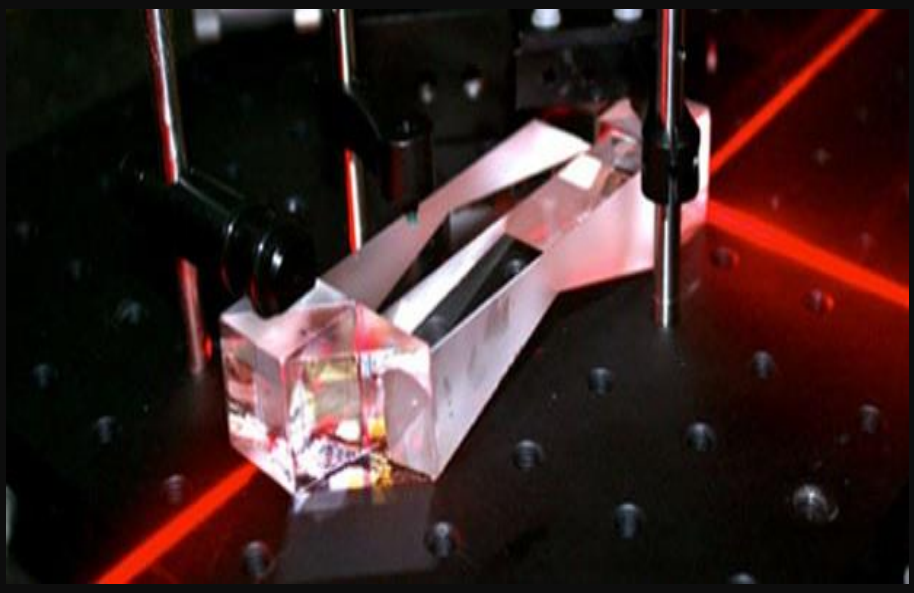
University of Glasgow | School of Physics & Astronomy



PHYS4014 Lasers & Non-linear Optics

Course Information Guide 2023-24

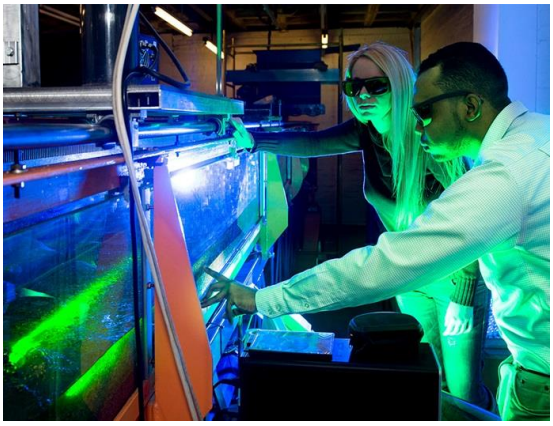
1 Course Details

Lecturers:	Dr Iain Martin	Schedule:	18 lectures, Mon 9am & Fri 11am
SCQF Credits:	10	ECTS Credits:	5
Assessment:	Examination (90%), Continual Assessment Quizzes (10%)	Co-requisites	None
Level:	Honours		
Typically Offered:	Semester 2	Prerequisites:	Physics 2

2 Course Aims

This course is an elective for third year Single Hons. Physics, Theoretical Physics and Designated Degree programmes in the School of Physics & Astronomy. It is also available in fourth and fifth year students, including those on Physics with Astrophysics programmes. The course aims to provide students with an opportunity to develop their knowledge and understanding of the key principles and applications of lasers and non-linear optics, and their relevance to current developments in physics. In particular, it will provide a working knowledge of:

- Laser principles;
- Types of lasers;
- Laser output structure;
- Laser intensity;
- Gaussian optics;
- Optical resonators;
- Non-linear optics;
- Electro-optic modulation of laser beams.



3 Intended Learning Outcomes

By the end of the course students will be able to:

- Demonstrate knowledge and a broad understanding of lasers and non-linear optics;
- Describe qualitatively and quantitatively process, relationships and techniques relevant to the topics included in the course outline, and apply these techniques to solve general classes of problems;
- Write down and, where appropriate, either prove or explain the underlying basis of physical laws relevant to the course topics, discussing their applications and appreciating their relation to the topics to the topics of other courses taken.

4 Course Outline

Laser principles: Light sources and coherence, spontaneous and stimulated emission of radiation and the Einstein A and B coefficients and the relationship between them, absorption and gain coefficients in lasing media, population inversions, optical pumping and the principles of optical cavities.

Different types of lasers: The design and operation of different types of lasers with particular reference to solid-state lasers excimer lasers tunable dye lasers and semiconductor diode lasers.

Laser output structure: Modes, Free Spectral Range, longitudinal and transverse laser modes, including the fundamental or TEM00 mode and the use of an intracavity etalon to force single mode operation, spatial hole-burning and its effects.

Laser intensity: Free running intensity, mode locked intensity, pulse period, pulse width, Poynting vector, E field in beam or pulse, techniques for modelocking and modulation.

Gaussian optics: General properties of Gaussian beams: the waist, divergence, radius of curvature, complex beam parameter q(z), modes of propagation of Gaussian beams, the ABCD law of transformation of a ray by an optical element, transformation matrix of simple optical systems.

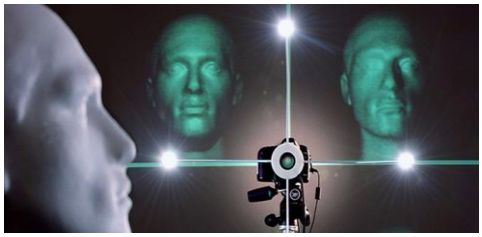
Optical resonators: Fabry-Perot, cavity resonance, power build-up, E field, optical resonators with spherical mirrors, mode stability criterion, stable and unstable resonators, modes in a general resonator, resonance frequencies of optical resonators, frequency stabilisation, Airy function.

Nonlinear optics: Physical origin of non-linear polarisation, birefringence, o- and e- rays, index ellipsoid for uniaxial crystals, second harmonic generation, phase-matching condition in SHG, optical parametric oscillation (OPO), phase-matching condition in OPO, frequency tuning in OPO.

Electro-optic modulation of laser beams: Electro-optic effect, electro-optic retardation, phase and amplitude modulation of light, transverse electro-optic modulators

5 Further Information

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



- Course specification
- Reading list