Imperial College London

Module Outline

Lasers

Module Code	PHYS96023	FHEQ Level	Level 6
Pre-requisites	Light & Matter	Co-requisites	None
Primary Department	Physics		
Module Leader	Prof John Tisch		
Additional Teaching Departments	None		
Teaching Staff	Prof John Tisch + Associate		
Programmes on which the Module is delivered			Core/Elective
All UG Physics programmes (F300, F303, F309, F325, F390, F3W3)			Elective
Learning Outcomes	On completing the Lasers course, students will have: A mathematically rigorous understanding of laser physics. They will learn the basic mechanisms of laser action and how real-world lasers operate. Students will obtain an appreciation of the spatial, temporal and spectral properties of laser emission and how these properties can be controlled through the physical properties of the laser device. Some of the exciting new physics that can be accessed using the unique properties of laser light will be introduced.		
Description of Content	**1. Laser Physics** 1.1. Overview: unique properties of lasers and their impact 1.1.1 What is a laser? 1.1.2 Pump sources 1.1.3 Properties of laser light & impact of lasers 1.2 Spontaneous emission, absorption and stimulated emission 1.2.1 The 3 basic processes (spontaneous emission, absorption, stimulated emission) 1.2.2 Relation between Einstein coefficients 1.3 Line Broadening 1.3.1 Homogenous and Inhomogeneous broadening 1.3.2 Broadening Mechanisms (natural, collisional, Doppler, non-uniform solids) 1.3.3 Combination of broadening mechanisms 1.4 Gain and laser threshold 1.4.1 Rate equation for 2 level system with radiation 1.4.2 Amplification and gain coefficient 1.4.3 Cross-section for absorption and stimulated emission 1.4.4 Population inversion 1.4.5 Lasing threshold condition 1.5 Multi-level Systems 1.5.1 Why no gain for 2 level system 1.5.2 General multi-level system 1.5.3 Rate equation for general system in absence of radiation 1.5.4 Rate equation for general system in presence of radiation 1.5.5 Gain saturation 1.5.6 4 level systems 1.5.7 3 level systems		

	1.5.8 Examples of solid-state gain media (Ruby [3 level], Nd:YAG [4 level]) **2 Laser Cavities** 2.1 Steady state intracavity intensity 2.2 Output power 2.3 Cavity modes 2.3.1 Field condition for steady-state oscillation 2.3.2 Longitudinal modes 2.3.3 Transverse modes 2.3.4 Mode selection (longitudinal and transverse) 2.4 Cavity stability 2.4.1 RTM for cavity 2.4.2 Cavity stability condition 2.4.3 Cavity stability examples 2.4.4 Unstable cavities **3 Gaussian beams** 3.1 Helmholtz Equation 3.2 Gaussian beam solutions 3.2.1 Intensity 3.2.2 Power 3.2.3 Beam width 3.2.4 Divergence 3.2.5 Wavefront ROC 3.2.6 Phase 3.3 Propagation of Gaussian beams through optical systems 3.3.1 Collimation 3.3.2 Focusing 3.3.4 Gaussian beams in cavities 3.4 Higher order transverse modes **4 Pulsed Lasers** 4.1 Applications of pulsed lasers 4.2 Physics of pulses 4.2.1 Time and frequency representation 4.2.2 Pulse propagation in dispersive media 4.3 Techniques for pulsed laser operation 4.3.1 Gain switching 4.3.2 Q-switching 4.3.3 Mode-locking

Assessment	Assessment Type	Weighting
Written exam	Exam	100%

Learning & Teaching Hours	Independent Study Hours	Placement Hours	Total Hours
23.5	51.5	0	75

ECTS Credit	3	CATS Credit	6
Date of introduction	October 2016	Date of Last Revision	April 2019