Imperial College London

Quantum Optics

Module Code	PHYS97084	FHEQ Level	Level 7
Pre-requisites	Light and Matter	Co-requisites	None
Primary Department	Physics		
Module Leader	Dr Florian Mintert and Dr Michael Vanner		
Additional Teaching Departments	None		
Teaching Staff	Dr Florian Mintert and Dr Michael Vanner		
Programmes on which the Module is delivered			Core/Elective
All UG Physics programmes (F300, F303, F309, F325, F390, F3W3)			Elective
Learning Outcomes	Be able to understand the quantum nature of light and its interaction with quantum optical systems such as atoms, trapped ions, and quantum optomechanical systems.		
Description of Content	Quantum Optics provides a quantum mechanical description of light, atoms and their interactions. With the possibility of isolating single quantum entities such as photons, atoms and mechanical oscillators, quantum optics can provide tools to develop powerful new quantum technologies. In quantum optics, the following topics are covered: **1. Introduction** - why quantum optics? - Planck formula **2. Semiclassical atom-field interaction** - Einstein's rate equation - Semiclassical approach (two-level atom) - Electric dipole approximation - Pauli spin operators and density operator - Optical Bloch equations - Ramsey interferometry - Dark state/STIRAP **3. Field quantisation** - Coulomb gauge, properties of bosonic operators - Quantum states: Fock state, single photon state, thermal state, coherent state - Beam splitters: homodyne measurements - Two-mode squeezed state: multimode entanglement **4. Atom-field interaction** – minimal coupling – dipole interaction – Jaynes-Cumming model – Haroche experiments (complementarity test, entanglement generation) – Rempe's single photon generation - Parametric down conversion for entanglement generation and quantum state reconstruction **5. Fluctuations and correlations** – Mach-Zehnder interferometry: First-order correlations – Hanbury Brown and Twiss experiment: second-order correlations		

	– Antibunching and sub-Poissonian statistics – Hong-Ou-Mandel interference **6. Quasiprobabilities – statistical properties and reconstruction** - Wigner function (Wigner and Weyl) - Characteristic function – expectation value of moments - Properties of the Wigner function - Husimi Q function - Examples of Q function - Generalisation of quasiprobability functions - P function

Assessment		Assessment Type	Weighting
Written Exam		Exam	100%
Learning & Teaching Hours	Independent Study Hours	Placement Hours	Total Hours
47	103	0	150
ECTS Credit	6	CATS Credit	12
Date of introduction	October 2016	Date of Last Revision	May 2020