EC803 **QUANTUM OPTICS** **3-0-1-4**

Objectives

(1) Understanding the quantum description of radiation field and the quantum states of light and atomic interaction;

(2) Bloch equations, basic quantum phenomena in lasers, Introduction to Quantum communication;

(3) Application using Matlab or other computing techniques.

Keywords: Quantum Mechanics, Optics, Lasers.

Course Contents

Quantum Mechanics background: density operator, two level systems, second quantization of electromagnetic fields; Quantization of light field; Quantum states of light; Quantum coherence functions; Entanglement; Quantum beam splitter and interferometer; Non-classical states; Bunching and anti-bunching, HBT experiment; Atom-photon interaction; Jaynes-Cummings model and Dicke model; Dressed states and application; Spontaneous emission; Two level systems as quantum bits. Superposition states, the Bloch sphere, mixed states, density matrices, Pauli matrices. Single qubit dynamics (gates): NOT, square root of NOT-gate, Hadamard, phase shift, networks of gates, the measurement gate. Implementations: atom/ion in a laser field, photon polarisation, spin in a magnetic field. Mechanisms: Raman transitions, Rabi flopping, Ramsey fringes, spin echoes. Decoherence (simple treatment). Decoherence (simple treatment). Separable and inseparable (entangled) states of two spin systems. Two qubit gates: controlled-NOT, controlled-phase. Universality of gates (result only). Characterising an unknown state, state and gate fidelity (very basic), the no-cloning theorem. EPR, the four Bell states, the Bell inequalities.

TEXT BOOKS/ REFERENCES:

1. Quantum Optics by Walls and Milburn (Springer Science & Business Media, 06-Dec-2012)
2. Optical Resonance and Two-Level Atoms by Allen and Eberly (Courier Corporation, 04-May-2012)
3. Quantum Optics, Scully and Zubairy (Cambridge University Press, 04-Sep-1997)
4. Introduction to the Theory of Coherence and Polarization of Light by Emil Wolf (Cambridge University Press, 11-Oct-2007)
5. Atom Optics by Pierre Meystre (Springer Science & Business Media, 21-Sep-2001)
6. Quantum Simulations with Photons and Polaritons: Merging Quantum Optics with Condensed Matter Physics by Dimitris G. Angelakis (Springer, 03-May-2017)

7. Fundamentals of Quantum Optics and Quantum Information by Peter Lambropoulos, David Petrosyan (Springer Science & Business Media, 30-Jan-2007)
8. An Introduction to Hilbert Space and Quantum Logic by David W. Cohen (Springer Science & Business Media, 06-Dec-2012)
9. Numerical Methods for Time-Resolved Quantum Nanoelectronics by Joseph Weston (Springer, 21-Aug-2017)

There are also open resources on the Internet. Here are some examples:

1. Quantum and Atom Optics course by Daniel Steck, University of Oregon (available at http://atomoptics.uoregon.edu/~dsteck/teaching/quantum-optics/)
2. Quantum Optics and Quantum Dynamics course by Michael Hartmann at Technische Universität-München (available at http://einrichtungen.physik.tu-muenchen.de/quantumdynamics/teaching.html)
3. Modern Atomic and Optical Physics course by Mikhail Lukin, Harvard University (available at http://lukin.physics.harvard.edu/teaching/)