QUANTUM OPTICS AND INFORMATION

[Michele Modugno & Gonzalo Muga]

Introduction (Chap. 1 of Gerry-Knight, 4 h). Scope and aim of the course: Quantum Optics as a generic vehicle for quantum information and technologies. History.

Field quantization (Chap. 2 of Gerry-Knight, 8 h). Quantization of a single-mode field. Quantum fluctuations of a single-mode field. Quadrature operators for a single-mode field. Multimode fields. Thermal fields. Vacuum fluctuations and the zero-point energy. The quantum phase.

Coherent states (Chapter 3 of Gerry-Knight, 8 h). Eigenstates of the annihilation operator and minimum uncertainty states. Displaced vacuum states. Wave packets and time evolution. Generation of coherent states. More on the properties of coherent states. Phase-space pictures of coherent states. Density operators and phase-space probability distributions. Characteristic functions.

Emission and absorption of radiation by atoms (Chapter 4 of Gerry-Knight, 12 h). Atom–field interactions. Interaction of an atom with a classical field. Interaction of an atom with a quantized field. The Rabi model and "laser adapted" interaction picture. Fully quantum-mechanical model; the Jaynes–Cummings model. The dressed states. Density-operator approach: application to thermal states. The Jaynes–Cummings model with large detuning: a dispersive interaction.

Dissipative interactions and decoherence (Chapter 8 of Gerry-Knight, 6 h). Introduction. Single realizations or ensembles? Individual realizations. Decoherence. Generation of coherent states from decoherence: nonlinear optical balance.

Experiments in cavity QED and with trapped ions (Chapter 10 of Gerry-Knight, 6 h). Rydberg atoms. Rydberg atom interacting with a cavity field. Experimental realization of the Jaynes–Cummings model. Creating entangled atoms in CQED. Formation of Schrödinger cat states with dispersive atom–field interactions and decoherence from the quantum to the classical. Quantum nondemolition measurement of photon number. Realization of the Jaynes–Cummings interaction in the motion of a trapped ion.

Bibliography

Introductory Quantum Optics by Gerry and Knight (Cambridge), Chapters 1, 2, 3, 4, 8, and 10.

Additional material is provided via Egela (other books, articles, news, and auxiliary notes for specific topics).

Assessment by **written final exam**.