Quantum Optics (3 ECTS)

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This course provides an introduction to the basic concepts and main tools of quantum optics. It then describes a number of applications, such as the generation of non-classical states of light (single-photon states, squeezed states, entangled states) and the field-atom interaction inside an optical cavity (cavity quantum electrodynamics).

• What is light? Introduction through description of seminal experiments.

• Density operator formalism. Pure states, statistical superposition, non-isolated systems, purity, entanglement.

• Field quantization ◦ decomposition into modes, identification of conjugate variables, quantization ◦ reminder of the algebra of a a+, ◦ Hamiltonian operators, momentum ◦ mode basis and state basis.

• Some field states: ◦ the vacuum and its properties; ◦ single-mode states, quadratures, Heisenberg quadrature relation, one-photon states, Fock state, Glauber state, Schrödinger cats, squeezed states, Wigner function ◦ multimode states, entanglement, two-photon states◦

• Production of quantum fields ◦ quantum approach to matter-light interaction: with two-level atom, with second-order nonlinear medium ◦ spontaneous emission, parametric fluorescence, production of squeezed and entangled states ◦ deterministic or conditional production of one-photon states ◦

• Propagation and detection of quantum fields ◦ simple photodetection, coincidence photodetection ◦ input-output relations ◦ quantum approach to light interference ◦ intensity fluctuations in different devices: attenuators, amplifiers ◦ homodyne detection and quantum tomography ◦ coincidence experiments, Hong Ou Mandel, losses effect.

Cavity Quantum Electrodynamics

• Jaynes Cummings hamiltonian, «dressed » states

• Spontaneous emission in cavity, weak and strong coupling regimes, Purcell factor

The course includes TD and one TP.