Examination Questions
"Quantum Optics"

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1st Semester

Question 1

1. Expansion of the electromagnetic field in modes (types of oscillations). Hamiltonian form of the electromagnetic field equations. Quantization of the electromagnetic field.

2. Interaction of an atom with a mode of the electromagnetic field.

Question 2

1. Expansion of the field in plane waves in free space. Density of states. Hamiltonian form of the field equations when expanded in plane waves. Quantization of the electromagnetic field using its expansion in plane waves.

2. Coherent states.

Question 3

1. Properties of operators $\hat{a}$ and $\hat{a}^\dagger$. Quantum state of the electromagnetic field with a definite energy.

2. Quantum nondemolition measurements. Ramsey interferometer.

Question 4

1. Multimode states.

2. Emission and absorption of light by an atom. Hamiltonian of the atom-field system.

Question 5

1. Coherent states.

2. Spontaneous emission. Weisskopf-Wigner approximation.

Question 6

1. Mixed states of the electromagnetic field.

2. Interaction of an atom with a mode of the electromagnetic field.

Question 7

1. Representation of the density operator via coherent states.
2. Spontaneous emission. Weisskopf-Wigner approximation.

Question 8

1. Properties of creation operators $\hat{a}^\dagger$ and annihilation operators $\hat{a}$.
2. Ramsey interferometer. Quantum nondemolition measurements.

2nd Semester

Question 1

1. Laser model
2. Coherent properties of light. First-order coherence.

Question 2

1. Theory of laser generation
2. Squeezed states: applications of squeezed states.

Question 3

1. Statistics of laser photons
2. Coherent properties of light. Second-order coherence.

Question 4

1. Laser theory. Representation of coherent states
2. Photoelectric effect

Question 5

1. Statistics of laser photons
2. Equation for the field density matrix in the number representation

Question 6

1. Laser model
2. Nonclassical light.

Question 7

1. Theory of laser generation
2. Bell inequalities. Nonclassicality of entangled states

Question 8

1. Quantum description of optical interference experiments
2. Nonclassical light.

Question 9

1. Mach-Zehnder interferometer
2. Squeezed states. Quadrature squeezing. Generation of squeezed states. Observation of squeezed states.

Question 10

1. Laser theory. Representation of coherent states. Natural linewidth of laser radiation.
2. Entangled states: definition, generation, detection

Question 11

1. Coherent properties of light. First-order coherence
2. Entangled states: applications. Quantum teleportation.

Question 12

1. Coherent properties of light. Second-order coherence
2. Bell inequalities. Nonclassicality of entangled states

Question 13

1. Interaction of the electromagnetic field of a resonator (harmonic oscillator) with a reservoir of atoms at temperature T.

2. Photoelectric effect