Introduction to quantum optics

1. Course title: Introduction to quantum optics

2. Lecturer: Mihail Petrov
Assistants: Danil Kornovan

3. Annotation (500-700 characters, in plain and simple language):

Quantum optics studies the properties of light and light-matter interaction from the grounds of modern quantum mechanics. You will learn the basic quantum concepts of photon and polariton, how one can entangle photons, and find out whether one can violate Heisenberg principle.

The course aims at giving the students the fundamental picture of quantum optics through the basic problems solving. We will focus on the light properties governed by the quantum nature of light, will go into the deeps of light-matter interaction, and figure out how this interaction can be enhanced in micro- and nanoresonators. The gives overview of the main theoretical models, however the key experimental techniques will be discussed as well.

4. Study program and semester: master program "Nanophotonics and metamaterials", 2nd semester

5. Detailed content and structure with sectioning of lectures/seminars:

	Topic	Classes type
Part I. Light-matter interaction: semiclassical approach		
1	Two-level system in a light field. Rabi oscillations	Lecture
2	Density matrix: from general properties to a two-level system	Lecture
3	Light interaction with a three level-system	Seminar
Part II. Quantum properties of light		
4	Secondary quantization of electromagnetic field	Lecture
5	Fock states and coherent states	Lecture
6	Quantum noise and squeezed states	Lecture
7	Coherence of light and photon detection	Lecture
Part III. Light-matter interaction: fully quantum picture		
8	Two-level system in a quantized field	Lecture
9	Jaynes-Cummings model: polaritons	Lecture
10	Spontaneous relaxation: Weiskopf-Wigner model	Lecture
11	Local density of states and Purcell effect	Seminar
12	Optical cavities	Seminar
13	Field fluctuations and Langevin equation	Lecture
14	Quantum theory of relaxation. Lindblad equation	Lecture
15	Atom in a cavity. Weak and strong coupling regime	Lecture

Additional topics		
16	Quantum entanglement. Bell inequality.	Lecture
17	Laser cooling and ultra-cold atoms	Lecture
18	Fluctuations driven optical forces	Seminar
19	Local field operators. Quantization of light in lossy and dispersive media	Lecture

6. Textbooks:

1. Marlan O. Scully, M. Suhail Zubairy. Quantum Optics. Cambridge University Press, pp. 656, 1997
2. Leonard Mandel, Emil Wolf. Optical Coherence and Quantum Optics. Cambridge University Press, pp. 1134, 1995
3. Martin Fox. Quantum Optics: An Introduction. Oxford University Press, pp. 400, 2006
4. Miguel Orszag.Quantum optics. Springer, 2008, 414 p.
5. Rodney Loudon. The Quantum Theory of Light. Oxford University Press, pp. 448, 2000
6. L. Novotny and B. Hecht, Principles of Nano-Optics. Cambridge University Press, 2012.

7. Course prerequisites:

quantum mechanics, electrodynamics, nanophotonics

8. Assignments (please, attach a couple of examples):

-There is a block of home problems, which are aim to help student in mastering the course (30-40 problems of various level).
-During seminar classes the students are supposed to solve problems in class

9. Grading policy:

Please see additional info in attached file (Grading_policy.pdf)

Highest final grade for the course	100
Highest final grade for the problem solving	50
Highest final grade for the final oral examination	50

10. Additional notes: