16.10.2018

Advanced Course in Experimental Physics EV-A

(Lasers, Atomic Physics and Quantum Optics)

Winter Term 2018/2019

Prof. Dr. Joachim von Zanthier

1. Fundamental Aspects of the Laser
    - I. History
    - II. Principal working scheme
    - III. Fundamental properties
    - IV. Applications
2. Optical Resonators
    - I. Ray optics and ray transfer matrix analysis
    - II. Stability criteria for optical resonators
3. Propagation of Waves in Optical Media
    - I. Wave equation
    - II. Elementary solutions
4. Gaussian Beams
    - I. Solution of the paraxial wave equation
    - II. Gaussian beams of higher order
    - III. Properties of Gaussian beams
    - IV. Gaussian beams and resonators
    - V. Resonators as interferometer and spectrometer
5. Interaction of Light and Matter
    - I. Black body radiation
    - II. Classical description
    - III. Semiclassical description (Heisenberg picture and Schrödinger picture)
    - IV. Interaction of an atom with a monochromatic wave
6. Theory of the Laser:
    - I. Maxwell-Bloch equations
    - II. Laser operation in equilibrium
    - III. Rate equations
    - IV. Outcoupled laser power
    - V. Relaxation oscillations
    - VI. Micro-lasers
    - VII. Laser noise (Schawlow-Townes-Limit)
    - VIII. Generation and measurement of ultrashort pulses
7. Specific Laser Systems:
    - I. Gas lasers
    - II. Solid state lasers
    - III. Vibronic lasers
    - IV. Laser frequency analysis and - stabilization
8. Laserspectroscopy:
    - I. Spectral lines + -profiles, broadening mechanisms
    - II. Doppler free spectroscopy
9. Cooling and Trapping of Atoms with Laser Light
    - I. Semi-classical theory of light forces

II. Radiation pressure force: Doppler cooling
III. Magneto-optical trap
IV. Dipole force: optical tweezer
V. Trapping of single atoms
VI. Optical lattices for neutral atoms
VII. Bose-Einstein-Condensates

10. Introduction to Nonlinear Optics
I. Nonlinear polarization and susceptibility
II. Wave propagation in nonlinear media
III. Frequency doubling
IV. Sum-frequency and difference-frequency generation

11. Introduction to Quantum Optics
I. Photon correlation functions
II. Hanbury-Brown and Twiss experiment
III. Quantum nature of light: Photon statistics
IV. Resonance fluorescence