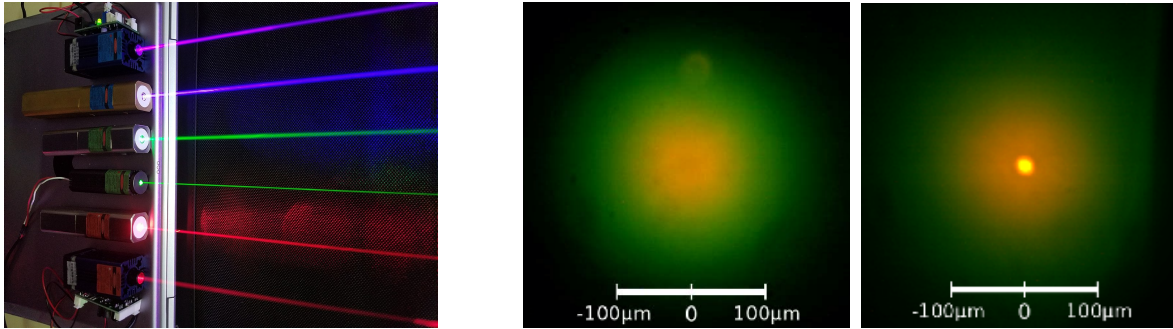


Quantum Optics



Content

1. Introduction

2. Quantization of Maxwell Field:

- Canonical field quantization
- Quantum fluctuation effects:
electric field vacuum correlations, Casimir effect, Lamb shift

3. Quantum States of Radiation Field:

- Fock, coherent, squeezed, and thermal states
- Density operator and quasi-probability distribution in phase space

4. Emission and Absorption of Light by Matter:

- Non-relativistic treatment of matter
- Perturbative treatment: Einstein processes
- Rabi model: classical light-matter interaction
- Jaynes-Cummings model: quantum mechanical light-matter interaction

5. Quantum Mechanical Equations of Light Field and Atoms:

- Without and with coupling to environment providing losses/pumping
- Semiclassical and quantum mechanical laser theory

6. Theory of Photon Bose-Einstein Condensation:

- Experimental set-up, paraxial approximation in microcavity
- Kerr and thermo-optic interaction
- Open dissipative quantum many-body systems: Lindblad dynamics

References

- M. Born and E. Wolf, *Principles of Optics: Electromagnetic Theory of Propagation, Interference and Diffraction of Light*, 7th Edition, Cambridge University Press, 1999
- C. Cohen-Tannoudji, J. Dupont-Roc, and G. Grynberg, *Atom Photon Interactions*, Wiley, 2010
- C. Gardiner and P. Zoller, *Quantum Noise*, Springer, 2004
- C. Gerry and P. Knight, *Introductory Quantum Optics*, Cambridge University Press, 2004
- G. Grynberg, A. Aspect, C. Fabre, and C. Cohen-Tannoudji, *Introduction to Quantum Optics: From the Semi-Classical Approach to Quantized Light*, Cambridge University Press, 2010
- H. Haken, *Laser Theory*, Vol. XXV/2c of Encyclopedia of Physics, Springer, 1970
- R. Loudon, *The Quantum Theory of Light*, Oxford University Press, 2000
- L. Mandel and E. Wolf, *Optical Coherence and Quantum Optics*, Cambridge University Press, 1995
- M. Sargent, M. O. Scully, and W. E. Lamb, *Laser Physics*, Perseus, 1978
- W. P. Schleich, *Quantum Optics in Phase Space*, Wiley, 2001
- M. O. Scully and M. Zubairy, *Quantum Optics*, Cambridge University Press, 1998
- D. A. Steck, *Quantum and Atom Optics*, <http://steck.us/teaching>, 2020
- D. F. Walls and G. J. Milburn, *Quantum Optics*, 2nd Edition, Springer 2008

Organizational Remarks

- **Lectures:**
 - 4 hours per week \cong 8 ECTS credits
 - Certificate for active participation:
 - * Seminar talk of 15 minutes at semester end
 - * Suggestions for topics announced around middle of June
- **Exercises:**
 - 2 hours per week \cong 4 ECTS credits
 - Certificate for active participation:
 - * 50 % from all points of all exercise sheets
 - * Five times calculations at black board
- **Oral module exam possible**
- **Further organizational information:**
<https://www-user.rhrk.uni-kl.de/~apelster/Vorlesungen/SS23/qo.html>