Laser Physics and Nonlinear Optics - A short course highlighting important aspects (two credits)

June 26, 2019

Part A

Idea of a LASER. Heuristic description of a single mode laser based on Statz and de Mars equation. Optical feedback, steady states and threshold.

Optical resonators. Mobius transformation applied to Gassian beams through linear optical elements. Longitudinal and transverse modes. Stable and unstable resonators. Quality factor. Beam and spin optics.

Semiclassical theory of single mode operation. Density matrix formulation of light-matter interaction. Self-consistency. Maxwell-Bloch equations. Susceptibility and dispersion. Lasing frequency, frequency pushing and pulling. Homogeneous and inhomogeneous broadening. Mode-locked and Q-switched operation. Few applications (optical tweezers, EIT, EIA etc.). A brief introduction to the quantum theory of laser fluctuations.

Part B

The constitutive relation. Response function theory of linear and nonlinear optical susceptibilities. Nonlinear oscillator based models and the density matrix apporach. Local field corrections.

Wave mixing phenomena. Parametric and non-parametric processes. Harmonic generation, Kerr nonlinearity, four-wave-mixing and optical bistability. Parametric downconversion for correlated photon pair generation. Birefringent and quasi phase matching. PPLN. Frequency comb.

Books

1. M Sargent, M O Scully and W E Lamb Jr., Laser Physics (Addison-Wesley, New York)

2. A E Siegman, Lasers (University Science Books, California, 1986)

3. A Yariv, Quantum Electronics, Third Edition, (John Wiley, New York, 1989)

4. Stephen C Rand, Lectures on Light: Nonlinear and Quantum Optics using the Density Matrix, (Oxford University Press, Oxford, 2010)

5. R. W. Boyd, Nonlinear Optics, Third Edition, (Elsevier, Amsterdam, 2008)