Graduate course

Nonlinear Optical Technology (SK3421)

(Ickelinjär Optisk Teknologi)

Aim: The course is targeted for doctoral students interested in lasers, nonlinear optics and relevant applications. Special emphasis will be placed on the theory of some specific nonlinear optical devices. The course includes the most recent developments in this field which are considered important for nonlinear optical technologies in the future.

Prerequisites: Working knowledge of quantum mechanics, familiarity with atomic and molecular physics, familiarity with basic solid-state physics is required.

Points: 12 credit points (ECTS).

Form: Lectures, home tasks distributed during lectures.

Language of instruction: English.

Passing: More than 50% of tasks solved.

Lecturers: Prof. Valdas Pasiskevicius (VP), Prof. Fredrik Laurell (FL), Assoc. Prof. Michael Fokine (MF), Prof. Walter Margulis (WM). Department of Applied physics/ Laser physics, KTH.

Course responsible: Prof. Valdas Pasiskevicius

Course organizational issues: Assoc. Prof. Emeritus Jens A. Tellefsen, Jr. (JAT)

Field of Study/School: TFY, SKB

Course Plan 2018

#	Date, Location, Time, Lecturer	Lecture	Contents	Task
1	Jan. 10, 13-15, A3:1041. JAT, VP	Introduction	Overview of procedures, course program and requirements.	
2	Jan 17, 13-15, VP A3:1041	Nonlinear material response	Reminder of the basics: nonlinear polarization, susceptibility tensors, symmetry properties, some useful approximations, quantum-mechanical treatment of material response.	1
3	Jan 24, 13-15, VP A3:1041	Resonant nonlinearities	Bloch equations, applications to two-level resonant system, saturable absorption, inhomogeneous broadening, optical Stark effect, four-wave mixing.	2
4	Jan 31, 13-15, VP A3:1041	Nonresonant 2^{nd} order nonlinear processes and devices	Coupled wave equations, solutions for sum- and difference-frequency mixing. Optical parametric generators, amplifiers and oscillators, intracavity frequency conversion.	3
5	Feb.7, 13-15, FL A3:1041	Nonlinear photonic crystals and waveguide devices	Linear and nonlinear Photonic Crystals, Quasi-Phase-Matching (QPM) and integrated devices for optical frequency conversion.	4
6	Feb 14, 13-15, VP A3:1041	Nonlinear interactions of ultrashort optical pulses	Modified coupled wave equations, sum- and difference-frequency mixing with broadband signals.	5

7	Feb 21, 13-15, VP A3:1041	Nonresonant 3rd order processes	Third harmonic generation, optical Kerr effect, self-focusing, self- and cross-phase-modulation, optical solitons, four-wave-mixing. Cascaded second order nonlinearity. Frequency conversion in microring resonators.	6
8	Feb. 28, 13-15, VP A3:1041	Nonlinear scattering	Phonons, spontaneous and stimulated Raman and Brillouin scattering, practical applications in pulse compression, and optical frequency conversion.	7
9	Mar. 12, 13-15, WM A3:1041	Nonlinear processes in optical fibers	Nonlinear Schrödinger equation, modulation instabilities, optical solitons in fibers, photonic crystal fibers	8
10	Mar. 14, 13-15, VP A3:1041	Nonlinear optical methods in biophotonics. Nonlinear optics at high intensities. Attosecond pulse generation	Nonlinear optical microscopy with applications in biophotonics, optical nanosurgery. Methods for high-intensity pulse generation, generalized nonlinear Schrödinger equation, high-harmonic generation, multiphoton ionization, attosecond pulse generation and detection, regimes of high-intensity physics.	
11	Mar.15, 13-15, MF A3:1041	Engineered nonlinear materials	Field-enhancement structures, engineered 3rd order nonlinear materials, nonlinear optical methods for material processing.	

The main course literature:

- P. N. Butcher, D. Cotter, "The elements of nonlinear optics", Cambridge University Press (1998).
- G. Agrawal, "Nonlinear fiber optics", Boston: Academic Press (Editions of 1995 or 2001).
- "The supercontinuum laser source", R. R. Alfano, ed., New York; Berlin : Springer-Vlg, (1989).
- Ch. Kittel, "Introduction to Solid State Physics", New York: John Wiley (1996).
- L. Novotny, B. Hecht, "Principles of nanooptics", Cambridge University Press (2006).
- J.-C. Diels, W. Rudolph, "Ultrashort laser phenomena", Academic Press, (1996).
- Selected articles and book chapters – references will be provided as required.
- G. New, "Introduction to nonlinear optics", Cambridge University Press (2011).
- R. W. Boyd, "Nonlinear Optics" 3rd ed. New York: Academic Press (2007).
- A. M. Weiner, "Ultrafast Optics" John Wiley (2009).