

# 66-358 / 359 Nonlinear Optics

## WiSe 2021-2022

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**Lectures:** Mo 13:00-14:30 and We 13:00-14:30, Seminar room 1074, Notkestraße 9

**Recitations:** Do 15:00-16:30, Seminar room 1074, Notkestraße 9

**Start:** October 11, 2022

**Online Access Link:**

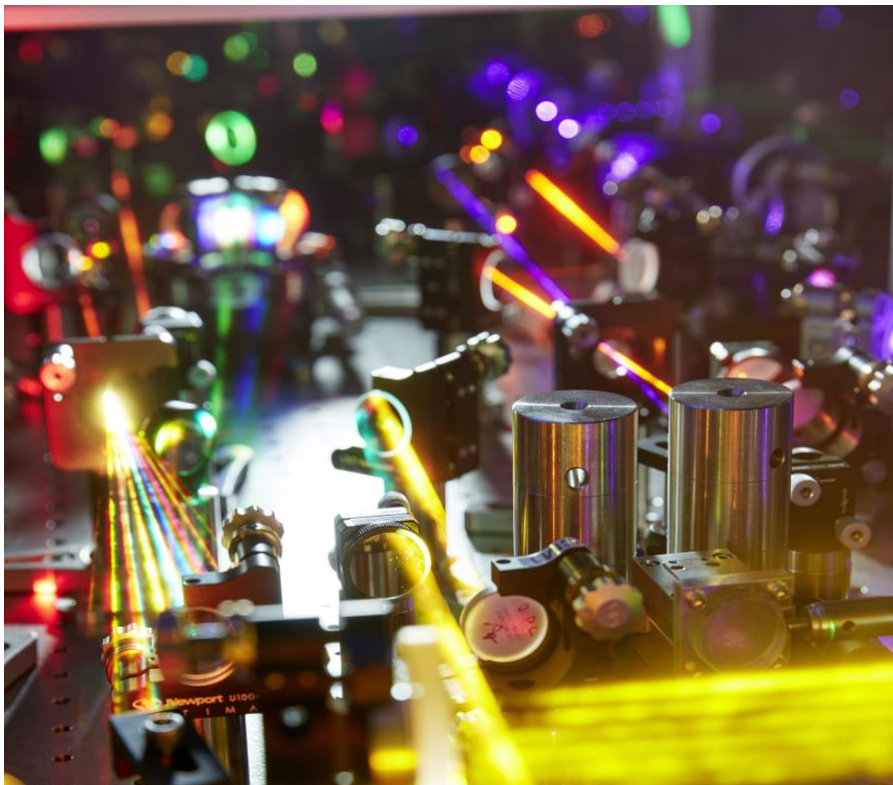
<https://uni-hamburg.zoom.us/j/64203244710?pwd=U3lzbzRpTEZlcnHN6aUpJTnhVc0E4Zz09>

**Meeting ID:** 642 0324 4710

**Passcode:** NLO21-22

### Content:

Nonlinear optical susceptibilities and symmetries, nonlinear wave equation, second-harmonic generation, phase matching, quasi-phase matching, optical rectification, Manley-Rowe relations, sum- and difference-frequency generation, THz generation, optical parametric amplification, ultrashort-pulse optical parametric (chirped-pulse) amplification, third-order nonlinear effects: third-harmonic generation, Kerr effect, self-phase modulation, self-focusing, stimulated Raman- and Brillouin-scattering, optical solitons, optical solitons, dispersion engineering of fibers, integrated waveguides, numeric simulation of waveguide and nonlinear optical processes, similaritons, dark solitons, nonlinear attractors, nonlinear microresonators and integrated combs.



**Required Textbook:**

Class notes will be distributed in class.

**Recommended Textbook:**

*Nonlinear Optics*, R. W. Boyd, Academic Press, Third Edition (2008).

**Additional References:**

1. *The Principles of Nonlinear Optics*, Y. R. Chen, J. Wiley & Sons NY (1984).
2. *The Elements of Nonlinear Optics*, P. N. Butcher & D. Cotter, Cambridge Studies in Modern Optics 9 (1990).
3. *Nonlinear Fiber Optics*, G. P. Agrawal, Academic Press (1998).
4. *Solitons: an introduction*, P. G. Drazin & R. S. Johnson, Cambridge Texts In Applied Mathematics, NY (1989).
5. *Extreme Nonlinear Optics*, M. Wegener, Springer (2005).

**Requirements:**

11 Problem Sets (30 %)

Oral Exam (50 %)

Participation (20 %)

Collaboration on problem sets is encouraged.

**Course Policy:**

**Collaboration:** Collaboration on problem sets is permitted. However, you must list who you collaborated with, when you hand in your problem sets. Groups may discuss the problems, strategies for solutions, etc. However, each person is expected to do all of the problems independently. You may not copy the problem solutions from other members in your group. Evidence of copying will be considered cheating.

**Plagiarism:** Direct copying of text from other sources (books, review articles, etc.) on the term papers will be considered plagiarism. Reproduction of figures or data is permitted provided that the reference is cited.

### Tentative Schedule:

1 FXK	11.10.2021 Mo	<b>Introduction to Nonlinear Optics</b>
2 FXK	13.10.2021 We	<b>Important Nonlinear Optical Processes Overview</b>
3 FXK	18.10.2021 Mo	<b>Nonlinear Optical Susceptibilities</b> <i>Problem Set 1 Out</i>
4 FXK	20.10.2021 We	<b>Susceptibility Tensors</b>
5 FXK	25.10.2021 Mo	<b>Nonlinear Wave Equation</b> <i>Problem Set 1 Due, Problem Set 2 Out</i>
6 TH	27.10.2021 We	<b>Second-Harmonic Generation</b>
7 FXK	1.11.2021 Mo	<b>Frequency Doubling of Pulses, Quasi-Phase Matching</b> <i>Problem Set 2 Due, Problem Set 3 Out</i>
8 FXK	3.11.2021 We	<b>Optical Parametric Oscillation/Amplification, Difference Frequency Generation</b>
9 TH	8.11.2021 Mo	<b>Electro-Optic Effect and Modulators</b> <i>Problem Set 3 Due, Problem Set 4 Out</i>
10 TH	10.11.2021 We	<b>Acousto-Optic Modulators and Bragg Cells</b>
11 TH	15.11.2021 Mo	<b>Third-Order Nonlinear Effects</b> <i>Problem Set 4 Due, Problem Set 5 Out</i>
12 TH	17.11.2021 We	<b>Self-Phase Modulation and Self-Focusing</b>
13 FXK	22.11.2021 Mo	<b>Raman and (Stimulated) Brillouin Scattering</b> <i>Problem Set 5 Due, Problem Set 6 Out</i>
14 FXK, TH	24.11.2021 We	Lab Demonstrations I
15 FXK	29.11.2021 Mo	<b>Optical Solitons</b> <i>Problem Set 6 Due, Problem Set 7 Out</i>
16 TH	1/12/2021 We	<b>Dispersion engineering in fiber</b>
17 TH	6/12/2021 Mo	<b>Integrated waveguides</b> <i>Problem Set 7 Due, Problem Set 8 Out</i>
18 TH	8/12/2021 We	<b>FEM and FDTD numeric simulation of waveguide and nonlinear structures</b>
19 TH	13/12/2021 Mo	<b>Supercontinua, NLSE and numeric simulation</b> <i>Problem Set 8 Due, Problem Set 9 Out</i>
20 TH	15/12/2021 We	<b>Similaritons, dark solitons, and nonlinear attractors</b>
21 FXK	03/01/2022 Mo	<b>Ultrafast Terahertz (THz) Sources</b> <i>Problem Set 9 Due, Problem Set 10 Out</i>
22 FXK	05/01/2022 We	<b>Applications of Ultrafast Terahertz (THz) Sources</b>
23 FXK	10/01/2022 Mo	<b>Ultrashort-Pulse Optical Parametric Amplification</b> <i>Problem Set 10 Due, Problem Set 11 Out</i>
24 FXK	12/01/2022 We	<b>Ultrashort-Pulse Optical Parametric Chirped Pulse Amplification</b>
25	17/01/2022	<b>High-Energy Few-Cycle Parametric Sources</b>

FXX	Mo	<i>Problem Set 11 Due</i>
26 TH	19/01/2022 We	<b>Nonlinear Microresonators</b>
27 TH	24/01/2022 Mo	Integrated combs, Brillouin and Raman laser, OPOs
28 FXX, TH	26/01/2022 We	Lab Demonstrations II
29	27/01/2022	<b>BA and MS Thesis Topics</b>