

# Ultrafast Optical Physics II

## SoSe 2015

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Lectures: Fr 08.30-10.00 SemRm 1, Jungiusstrasse 9/Recitations: Fr 10.30-12.00 SemRm 1, Jungiusstrasse 9

Lectures on July 3 and July 31 will take place on campus Bahrenfeld, bldg. 99, seminar room V

Start: 10.04.2015

### Content:

Linear and nonlinear pulse propagation: Optical solitons and pulse compression.

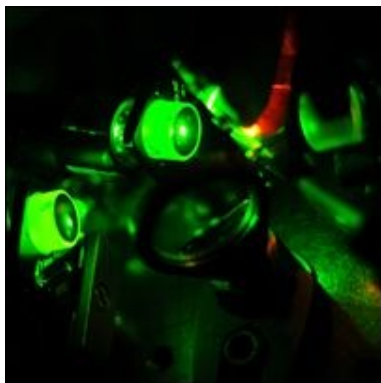
Laser dynamics: Single-mode, multi-mode, Q-switching, mode locking.

Pulse characterization: Autocorrelation, FROG, SPIDER and 2DSI.

Noise in mode-locked lasers and frequency combs.

Laser amplifiers and parametric amplifiers and oscillators.

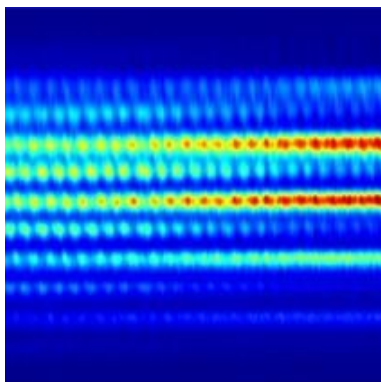
Soft and hard X-ray sources including attosecond pulse generation.



High repetition-rate Kerr-lens  
Mode-locked Ti:sapphire laser



Methan-stabilized HeNe-Laser in  
a molecular optical clock



FROG-CRAB characterization of  
an attosecond pulse train



Near-IR optical parametric  
amplifier

**Required Textbook:**

Class notes will be distributed in class.

**Recommended Textbook:**

Ultrafast Optics, Andrew M. Weiner, Hoboken, NJ, Wiley (2009).

**Additional References:**

Waves and Fields in Optoelectronics, H. A. Haus, Prentice Hall, NJ (1984).

Ultrashort laser pulse phenomena: fundamentals, techniques, and applications on a femtosecond time scale, J.-C. Diels and W. Rudolph, Academic Press (2006).

Few-Cycle Laser Pulse Generation and Its Applications, Ed. F. X. Kärtner, Topics in Applied Physics Vo. 95, Springer Verlag (2004).

Principles of Lasers, O. Svelto, Plenum Press, NY (1998).

Optical Resonance and Two-Level Atoms, L. Allen and J. H. Eberly, J. Wiley & Sons NY (1975).

Elements of Quantum Optics, P. Meystre, M. Sargent III, Springer-Verlag, NY, (2007).

**Requirements:**

10 Problem Sets and Term Paper

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 | Noah Chang<br>10/04/2015    | <b>Introduction to Ultrafast Optics</b>   |
| 2 |                             | <b>Optical Pulses and Dispersion</b>  |
| 3 | Noah Chang<br>17/04/2015    | <b>Linear Pulse Propagation (I)</b><br><i>Problem Set 1 Out</i>   |
| 4 |                             | <b>Linear Pulse propagation (II)</b>  |
| 5 | Franz Kärtner<br>24/04/2015 | <b>Nonlinear Schrödinger Equation (NLSE) and Soliton</b><br><i>Problem Set 1 Due, Problem Set 2 Out</i> |
| 6 |                             | <b>Pulse Compression and Dispersion Compensation Techniques</b>   |

|    |  |   |
|----|--|---|
|    | 01/05/2015                                   | <b>Labour Day, No Class</b>   |
| 7  | Franz Kärtner<br>08/05/2015                  | <b>Two Level System and Maxwell-Bloch Equations</b><br><i>Problem Set 2 Due, Problem Set 3 Out</i>            |
| 8  |  | <b>Laser Rate Equations and CW-Operation</b>  |
| 9  | Franz Kärtner<br>20/05/2015<br>17:30 – 20:30 | <b>Relaxation Oscillations and Q-Switching</b><br><i>Problem Set 3 Due, Problem Set 4 Out</i>                 |
| 10 |  | <b>Master Equation and Active Mode-Locking</b>  |
| 11 | Franz Kärtner<br>22/05/2015                  | <b>Passive Mode-Locking with Saturable Absorbers</b><br><i>Problem Set 4 Due, Problem Set 5 Out</i>           |
| 12 |  | <b>Semiconductor Saturable Absorbers and Kerr-Lens Mode-Locking</b><br><i>Distribute Term Paper Proposals</i> |
|    | 29/05/2015                                   | <b>No Class</b>   |
| 13 | Noah Chang<br>05/06/2015                     | <b>Pulse Characterization I – Autocorrelation</b><br><i>Problem Set 5 Due, Problem Set 6 Out</i>              |
| 14 |  | <b>Pulse Characterization II – FROG, SPIDER and 2DSI</b>  |
| 15 | Noah Chang<br>12/06/2015                     | <b>Noise in Mode-Locked Lasers</b><br><i>Problem Set 6 Due, Problem Set 7 Out</i>                             |
| 16 |  | <b>Femtosecond Laser Frequency Combs</b><br><i>Term Paper Proposal Due</i>                                    |
| 17 | Franz Kärtner<br>19/06/2015                  | <b>Pulse Amplification</b><br><i>Problem Set 7 Due, Problem Set 8 Out</i>                                     |
| 18 |  | <b>Parametric Interactions: OPA and OPO</b>   |
| 19 | Noah Chang<br>26/06/2015                     | <b>Broadband Parametric Amplification</b><br><i>Problem Set 8 Due, Problem Set 9 Out</i>                      |
| 20 |  | <b>Mid-IR and Terahertz (THz) Ultrafast Sources</b>   |
| 21 | Franz Kärtner<br>03/07/2015                  | <b>Ultrafast X-Ray Sources</b><br><i>Problem Set 9 Due, Problem Set 10 Out</i>                                |
| 22 |  | <b>Ultrafast Optics Group Lab Tour</b>  |
| 23 | 31/07/2015                                   | <b>Term Paper Presentation</b><br><i>Problem Set 10 Due, Term Papers Due</i>                                  |
| 24 |  | <b>Term Paper Presentation</b>  |