

**Ultrafast Laser Physics – Doctoral School in Physics****Year:**

- A.A. 2023/2024 (every other year)

**Hours:**

- Ca. 20 hours

**Language:**

- English

**Learning objectives:**

The course will cover fundamental concepts and recent developments in the field of ultrafast laser physics, and it will introduce the basic theory to understand ultrafast ( $10^{-16}$ - $10^{-9}$ s) phenomena in chemistry, biology and condensed matter physics. It has the goal to give also to the non-expert an efficient starting position to enter into the field of ultrafast laser physics providing all the detailed derivations. The course will cover fundamental technological and theoretical aspects of: (i) Linear pulse propagation and dispersion compensation, (ii) Nonlinear pulse propagation and nonlinear optics with ultrashort pulses, (iii) Pulse generation, pulse duration measurements.

**Program & contents:**

1. Principles of femtosecond laser systems
  - Overview of laser oscillators and pulse amplification
  - Parametric generation and amplification
  - Pulse measurement/characterization
2. Time-resolved methods
  - Transient absorption (pump-probe) spectroscopy and fluorescence up-conversion
  - Time-resolved core-level spectroscopies (X-ray absorption, emission, photoelectron spectroscopy, etc.) using synchrotron and XFEL radiation, as well as table-top High Harmonic Generation (HHG) sources.
  - Electron-based methods (scattering, crystallography, microscopy, spectroscopy)
3. Theory (no, or minimal, pre-existing knowledge is required)
  - Non-linear optics

**Expected results:**

The student shall be capable of formulating his/her own creative questions upon reading an article in ultrafast science

**Learning pre-requisites:**

A basic (M.Sc.) knowledge of Photonics and Spectroscopy are recommended

**Teaching methods:**

- Interactive Lectures
- Guest lectures\*. Within the module “Hot topics in ultrafast science”, 3 seminars will be held by guest lecturers who are internationally recognized experts in:
  - Ultrafast Electron Microscopy
  - Ultrafast Spectroscopy
  - Ultrafast Science at Free-Electron Lasers and synchrotrons

**Exam:**

- Oral presentation

**Literature:**

- O. Svelto, Principles of Lasers, Springer, New York, ISBN 978-1-4419-1301-2
- U. Keller, Ultrafast Lasers - A Comprehensive Introduction to Fundamental Principles with Practical Applications, Springer International Publishing, eBook ISBN 978-3-030-82532-4, 2021

**Additional Notes:**

This course may be of interest to PhD students in the Schools of Engineering and Physical Chemistry