Lectures and Seminars of the CUI course programme in the WiSe2014-2015

CUI Main Lecture

Lecture	Lecturers	Start	Time	Place
Modern X-Ray Physics - Spectroscopy	Prof. G. Grübel Prof. W. Wurth Dr. M. Martins	14.10.14	Tuesdays 12:45-14:15 Thursdays 08:30-10:00	SemRm 4*

Lectures

Lecture	Lecturers	Start	Time	Place
Ultrafast Optical Physics I	Prof. M. Drescher	17.10.14	Fridays 15:00-16:30	SemRm 1*
Solid-state lasers	Dr. C. Kränkel	13.10.14	Mondays 10:15-11:45	Hörsaal II*
Theory of Photon-Matter Interactions	Prof. R. Santra	13.10.14	Mondays 10:15-11:45 Thursdays 10:15-11:45	Hörsaal AP*
The Basis of Modern Molecular Physics	Prof. J. Küpper Dr. T. Laarmann	14.10.14	Tuesdays 10:30-12:00 Fridays 10:30-12:00	SemRm I CFEL, Bld. 99, Campus Bahrenfeld
Struktur-Funktions-Analyse biologischer Makromoleküle**	Prof. C. Betzel Prof. H. Schlüter Prof. R. Willumeit Dr. T. Hackl	13.10.14	Mondays 13:00-13:45 Fridays 11:00-13:00	Mondays SemRm AC1; Fridays Hörsaal D

** Department of Chemistry, Martin-Luther-King-Platz 6, 20146 Hamburg.

Seminars

Seminar	Lecturers	Start	Time	Place
Multifunktionale Nanostrukturen	Prof. K. Nielsch Dr. D. Görlitz	16.10.14	Thursdays 16:00-17:30	Bibliothek AP Sitzungszimmer*
Quantendynamik von Nanosystemen im Nichtgleichgewicht	Prof. M. Thorwart	14.10.14	Tuesdays 14:00-15:30	Rm 9/222*
Many-body theory of ultra-cold atoms and solid state systems	Prof. L. Mathey	15.10.14	Wednesdays 14:00-15:30	ZOQ SemRm, (Bld. 90), Campus Bahrenfeld
Nanostrukturphysik	Dr. G. Meier Dr. K. Buth Dr. T. Matsuyama Prof. U. Merkt	13.10.14	Mondays 14:30-16:00	Bibliothek AP*
Molecular Physics	Prof. Küpper	16.10.14	Thursdays 10:00-11:30	SemRm I, CFEL (Bld. 99), Campus Bahrenfeld
Vielteilchensysteme und quantenstatistische Methoden	Prof. M. Potthoff	15.10.14	Wednesdays 14:30-16:00	SemRm 1*

Lectures organized by IMPRS-UFAST[§]

Lecture	Lecturers	Start	Time	Place
Source Technology	Prof. F. Kärtner Prof. T. Uphues *Note that all the lectures take place in the CFEL (Bld. 99)*	17.02.15	09:00-11:00	SemRm IV
		19.02.15	09:00-11:00	SemRm V
		24.02.15	13:00-15:00	SemRm IV
		26.02.15	09:00-11:00	SemRm V
		26.02.15	13:00-15:00	SemRm V
		05.03.15	09:00-11:00	SemRm IV
Basics of chemistry and biochemistry	Prof. U. Hahn Prof. R. J. D. Miller	18.11.14 19.11.14	TBA	TBA
		25.11.14 26.11.14	10:00-13:00	CFEL, (Bld. 99) SemRm IV (1.111)
Quantum Coherence and Ghost Imaging	Prof. Yanhua Shih (University of Maryland)	19.01.15 20.01.15 21.01.15	14:15-16:15	CFEL, (Bld. 99) SemRm III (ground floor)
		22.01.15 23.01.15	10:15-12:15	

[§] The attendace to these lectures is limited to a specific number (typically 15). Priority is given to members of IMPR-UFAST. If you like to attend, please send first an e-mail to Dr. Sonia Utermann (sonia.utermann@mpsd.mpg.de).

Abbreviations:
SemRm = Seminar room
Bld. = Building
CFEL = Center for Free-Electron Laser Science
IMPRS-UFAST = International Max Planck Research School for Ultrafast Imaging and Structural Dynamics
SFB = Sonderforschungsbereich
GRK = Graduiertenkolleg
ZOQ = Zentrum für Optische Quantentechnologien
ILP = Institut für Laserphysik
AP = Angewandte Physik
DESY = Deutsches Elektronen-Synchrotron
FBC = Fachbereich Chemie

Remark on *Place*:
*If the event does not take place at the DESY-Bahrenfeld campus, then it will take place at the department of Physics of the University of Hamburg (Jungiusstraße 9, 20355 Hamburg). See also www.physik.uni-hamburg.de.
SemRm 1 and 2 = Seminar room (1. Floor, right straircase)
SemRm 4 = Seminar room (2. Floor, left straircase)
SemRm 6 = Seminar room (3. Floor, left straircase)
Hörsaal I = Wolfgang Pauli-Hörsaal
Hörsaal II = Otto Stern-Hörsaal

Abstract: CUI Main Lecture

Modern X-Ray Physics – Spectroscopy: The course will present the basics of modern x-ray physics and will concentrate in particular on spectroscopy. This includes a general introduction into x-ray physics as well as applications of soft x-ray spectroscopy to study condensed matter and small quantum system.

- Interaction of soft x-rays with matter
  X-ray absorption, photo effect, Auger effect, x-ray emission
- Accelerator based x-ray sources
  Synchrotron radiation and Free Electron Lasers
- Experimental methods
  Photoelectron spectroscopy, x-ray absorption spectroscopy
- X-ray optics
  Optical materials, EUV lithography, ray tracing
- Applications of soft x-rays
  Small quantum systems, solid-state spectroscopy

This course will give insight in the research field of modern x-ray physics and provide the knowledge to work in this field and to understand the current literature.

Abstracts: Lectures

Ultrafast Optical Physics I: Ultra-short light pulses are the key to studying highly dynamic processes in nature. They also find an increasing number of applications in technology, information processing and medicine. This introductory course will mediate the special concepts neccessary to understand ultrafast phenomena. The techniques will be discussed to create ultrashort optical pulses and to characterize their temporal properties. This in particular involves nonlinear optical effects. The associated exercise will aid to consolidate the content of the curriculum by solving problems and discussing examples.

Solid-state lasers: Lasers have found numerous applications in science and daily life. Many of these applications from low power green laser pointers to high power material processing devices rely on solid state gain materials such as crystals and glasses in bulk and fiber geometry. This lecture focuses on the fundamentals of theses lasers. It covers the basics of absorption and emission, the interaction between light and matter, optical resonators, Gaussian radiation, pump mechanisms, rate equations and threshold conditions for 3- and 4-level lasers based on rare earth ions, transition metals and semiconductors as well as different operation modes such as Q-switching and mode-locking. Furthermore, insights into the growth of crystals and fibers as well as a short introduction of selected kinds of lasers with their principal characteristics and applications will be given.

Theory of Photon-Matter Interactions:

Textbooks:

- *Molecular Quantum Electrodynamics,* by D. P. Craig and T. Thirunamachandran, Dover
- *Quantum Theory of Light*, by R. Loudon, Oxford University Press
- *Modern Quantum Chemistry*, by A. Szabo and N. S. Ostlund, Dover
- *Quantum Theory of Many-Particle Systems*, by A. L. Fetter and J. D. Walecka, Dover
- *Atomic Structure Theory*, by W. R. Johnson, Springer

Syllabus

1. Canonical formalism
   (a) Transverse and longitudinal fields
   (b) Coulomb gauge
   (c) Lagrangian and Hamiltonian
2. The radiation field
   (a) Quantization of the field
   (b) Fock states
   (c) Coherent states
   (d) Radiative density operator
   (e) Quantum theory of optical coherence
3. Many-electron problem
   (a) Second quantization
   (b) Hartree-Fock method
   (c) Hartree-Slater method
   (d) Configuration interaction
   (e) Many-body perturbation theory
4. Interaction between the photon and electron fields

(a) Time-dependent perturbation theory
(b) Few-photon absorption
(c) Calculation of resonance states using complex absorbing potentials
(d) Relaxation of excited electronic states (fluorescence, Auger decay, ICD, radiationless decay)
(e) Rayleigh, Raman, and Compton scattering
(f) AC Stark effect and Lamb shift

5. Case studies (includes an introduction to nonperturbative techniques)
   (a) Laser-induced alignment of molecules
   (b) Laser dressing of electronic states
   (c) Strong-field physics: tunnel ionization
   (d) Processes at high x-ray intensity

The Basis of Modern Molecular Physics: This module introduces the basic concepts of modern experiments in molecular physics. The students will acquire a detailed understanding of atoms and molecules, their interaction with external fields and other particles, and of experimental concepts in molecular physics. They will develop the skills to envision, plan, simulate, and eventually perform novel experiments to investigate the fundamental and applied aspects of molecular physics in quantum mechanics, chemistry, material science, biology, and so forth. Participants will learn to search for current (primary) literature, to explore a new scientific field, and to independently read and understand articles on previously unknown AMO physics.

Struktur-Funktions-Analyse biologischer Makromoleküle: The students will extend their knowledge about methods and procedures in structural biology and the analysis of interactions between biological macromolecules. In the lecture methods like protein crystallography, nuclear magnetic resonance spectroscopy (NMR), electron microscopy, small angle X-ray scattering and mass spectroscopy will be introduced and the significance of synchrotron radiation and X-ray lasers will be addressed. The course will be hold preferably in German.
Please, note also that, while for the lectures there is sufficient space to host CUI members, for the tutorials and the practical part of the course a limited number of participants can be accepted. Hence, in case you are interested in, please, inform first Prof. Betzel (Christian.Betzel@uni-hamburg.de).

Abstracts: Seminars

Multifunctional Nanostructures: In this seminar talks are given by external guests or group members. The topics are selected from the following 3 categories:

1. Synthesis of nanostructures for magnetic or/and thermoelectric applications (structured thinfilms, nanowires, nanotubes, electrochemical deposition, atomic layer deposition ALD,...),
2. Magnetic properties of nanostructures (switching behaviour of the magnetization, magnetic interactions, magnetic domain walls, magnetoresistance, magnetocaloric behaviour, ...),
3. Thermoelectric properties of nanostructures (conversion efficency, Seebeck coefficient, powerfactor, figure of merit ZT, ...).

Many-body theory of ultra-cold atoms and solid state systems: In this research oriented seminar we discuss many-body effects in ultra-cold atoms and solid state systems. Subjects include, for example, Bose-Einstein condensation, superconductivity and superfluidity, low-dimensional systems and fluctuating orders, renormalization group methods and many-body dynamics. Presentation subjects can be chosen from a wide range of fields, such as laser physics, solid state physics, quantum field theory, and atomic physics. The presentations can deal with fundamental questions or applied concepts, such as cooling and detecting methods, or technological aspects of
ultra-cold atom systems or solid state systems. Both experimentalists and theorists are very welcome, and a lively discussion is desired.

Nanostruktur: The Seminar is on topics in micro- and nanometer-scale science and technology. Studies range from thin films to micro- and nanostructures and include squares, circles, nanowires, and even more complex micro- and nanoscale geometries. The focus of the seminar is on magnetic nanostructures. Ferromagnetic nanostructures are ideal systems to tailor physical properties of the single object via material parameters, layer sequences, and lithographical processes. Magnetization dynamics on the nanosecond and subnanosecond time scale in ferromagnetic micro- and nanostructures are in the focus of interest in frequency space as well as in real space. E.g., broadband ferromagnetic-resonance measurements obtained by vector-network analyzer spectroscopy are discussed in the presentations of the seminar. Transmission x-ray microscopy with a spatial resolution down to 10 nanometers and a temporal resolution below 100 picoseconds is important to give access to magnetization dynamics on its genuine time- and length scale. Complexity created by periodic arrangement of well-understood building blocks plays not only an important role in biochemistry, photonics, and engineering but is also of increasing importance for magnetism on the nanoscale. Magnetic interactions can be engineered to yield one-, two-, and three-dimensional crystal-like structures that show new intriguing properties that are discussed in the Seminar „Nanostrukturphysik“.

Molecular Physics: This seminar provides a regular lecture series on modern topics in molecular physics. International experts provide introductions and in-depth discussions of state-of-the-art research in molecular and laser physics. Seminars are held in tutorial style, and questions during talks that help the audience to better follow the presentation are highly appreciated. Students will learn to follow research seminars, to extract useful information from seminars and related discussions, and how to articulate questions and comments.
Speakers typically visit CFEL for one or two days and are available for discussions of their and your work.

Abstracts: Lectures organized by IMPRS-UFAST

***Source technology**:* The course provides an overview of the working principles of modern light/x-ray/electron sources, including the respective physics background and their current strengths and limitations. The focus will be on techniques and technical basics.

***Basics of chemistry and biochemistry**:* The first half of the course will take place in the department of chemistry, UHH, the second half in CFEL, Bahrenfeld campus.

In this course, chemistry will mainly be understood as reactions. The course gives an overview about the basics of reaction chemistry and discusses what is already known and what can be measured in the laboratory nowadays (i.e. describing the current frontiers and where the research performed at CFEL can make a difference). In the biochemistry part, the basic principles of nucleic acids (DNA, RNA, their replication etc.) and proteins, their structure and function etc. will be discussed. Also here it will be interesting to work out where the new coherent sources can advance the field.

Key topics:

Mechanism of chemical reactions / kinetics on “normal” timescales / photochemistry / conical intersections, what can be measured with modern fs experiments and how / basic principles, structure and function of nucleic acids and proteins / chemical reactions in biochemistry / relevant timescales

Quantum Coherence and Ghost Imaging: Ghost imaging, either based on the coincidence measurement of entangled photon pair or based on the correlation measurement of photon-number fluctuations of randomly paired photons in thermal state, has attracted a great deal of interests. Fundamentally, we are surprised by its nonlocal behavior. Practically, the following advantages over classical imaging technology are attractive: (1) a ghost camera can “see” targets that can never be observed by classical camera; (2) the image is turbulence-free; and (3) the imaging resolution is mainly determined by the angular diameter of the light source. These aspects are particularly attractive for sunlight long distance imaging: the angular diameter of the sun is $\sim$ 0.53 degree, providing in principle a turbulence-free resolution of 200μm for any object on earth at any distance without the need of huge lenses. To achieve these advantages, it is necessary to understand the physics of ghost imaging correctly. For instance, ghost imaging should be the result of the second-order coherence of light, which is in principle different from classical imaging. However, a large number of publications on “ghost imaging” are based on the first-order coherence of light. First-order coherence of light, as we all know, produces classical images. The classical approaches may never achieve the above advantages of ghost imaging. This talk will address all these problems and concerns by introducing and discussing the working mechanism and physics of ghost imaging and ghost camera, especially emphasizing the two-photon interference nature of the second-order coherence of light.