# Lectures and Seminars of the CUI course programme in the SoSe2015

## CUI Main Lecture

| Lecture | Lecturers | Start | Time | Place |
|---|---|---|---|---|
| Structural biochemistry | Prof. C. Betzel<br>Dr. M. Perbandt<br>Prof. B. Meyer<br>Dr. F. Buck<br>Dr. T. Hackl<br>Prof. R. Willumeit | 10.04.15 | Fridays<br>10:00-11:30 | Hörsaal C<br>FBC |

## Lectures

| Lecture | Lecturers | Start | Time | Place |
|---|---|---|---|---|
| Modern X-Ray Physics – Scattering and imaging | Prof. G. Grübel<br>Prof. W. Wurth<br>Dr. M. Martins | 07.04.15 | Tuesdays<br>12:45-14:15<br>Thursdays<br>08:30-10:00 | Hörsaal AP* |
| Ultrafast Optical Physics II | Prof. F. Kärtner<br>Dr. N. Chang | 10.04.15 | Fridays<br>08:30-10:00 | SemRm 1* |
| Introduction to the physics of quantum gases | Prof. A. Hemmerich | 01.04.15 | Wednesdays<br>08:30-10:00<br>Fridays<br>08:30-10:00 | Hörsaal AP* |
| Condensed matter and ultra-cold atoms | Prof. L. Mathey | 02.04.15 | Thursdays<br>14:00-15:30 | SemRm 2* |
| Out-of-equilibrium statistics and theory of transport | Prof. M. Thorwart | 07.04.15 | Tuesdays<br>10:15-11:45 | SemRm 5* |

# Seminars

| Seminar | Lecturers | Start | Time | Place |
|---|---|---|---|---|
| Multifunctional nanostructures | Prof. K. Nielsch<br>Dr. R. Zierold | 02.04.15 | Thursdays 16:00-17:30 | Sitzungs-zimmer AP* |
| Physics of nanostructures | Dr. G. Meier<br>Dr. K. Buth<br>Dr. T. Matsuyama<br>Prof. U. Merkt | 13.04.15 | Mondays 14:15-15:45 | Bibliothek AP* |
| Quantum dynamics of out-of-equilibrium nanosystems | Prof. M. Thorwart<br>Dr. P. Nalbach | 07.04.15 | Tuesdays 14:00-15:30 | SemRm 6* |
| Many-body theory of ultracold atoms and solid state systems | Prof. L. Mathey | 01.04.15 | Wednesdays 14:00-15:30 | ZOQ SemRm, (Bld. 90) |
| Molecular physics | Prof. J. Küpper | 02.04.15 | Thursdays 10:00-11:30 | SemRm II CFEL (Bld. 99) Bahrenfeld |
| Many-body systems and quantum statistical methods | Prof. M. Potthoff | 01.04.15 | Wednesdays 14:15-15:45 | SemRm 2* |
| Dissipative quantum dynamics | Dr. P. Nalbach | 08.04.15 | Wednesdays 13:45-15:15 | Hörsaal AP* |

**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
AP = Angewandte Physik (Jungiusstraße 9, 20355 Hamburg)
DESY = Deutsches Elektronen-Synchrotron
FBC = Fachbereich Chemie (Martin-Luther-King-Platz 6, 20146 Hamburg)

**Remark on *Place*:**
*The event does 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 staircase)
SemRm 6 = Seminar room (3. Floor, left staircase)

## Abstract: CUI Main Lecture

***Structural biochemistry***: The students will be introduced in structural biology and the analysis of interactions between biological macromolecules. In the lecture methods like protein crystallization, crystallography, nuclear magnetic resonance spectroscopy (NMR), electron microscopy, small angle X-ray scattering and mass spectroscopy will be addressed. The course language will be preferably German.

## Abstracts: Lectures

***Modern X-Ray Physics – Scattering and imaging***: This course (4+2 hours weekly) will provide an introduction into the methods of modern X-ray physics. It covers the hard x-ray regime with the focus on scattering applications. Knowledge on soft X-ray applications, covered by the precursor course (Methoden moderner Roentgenphysik I) is helpful but not a prerequisite.
The program will include: Basics of modern X-ray physics (sources, refraction+reflection, kinematical scattering theory and its applications, introduction into small-angle, anomalous and coherent scattering). Basics of modern x-ray applications in biology, surface and interface science and soft matter research.
The program will include a site visit to the DESY Photon Science facilities.

***Ultrafast Optical Physics II***: The content of the course is the following:

- 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
- Nonlinear polarizations in matter: the perturbative expansion approach.
- Ultrafast Fourier-transform spectroscopy: 2 and more dimensions
- From GHz to the ultraviolet: investigating transient states of matter with light
- More ways to see: Raman, CARS & fluorescence - also good for imaging
- High-harmonic generation and its applications
- Ultrafast X-ray science: femtosecond molecular movies w/ atomic resolution

***Introduction to the physics of quantum gases***: The lecture has two parts: In part 1 the quantum optical concepts and experimental tools are introduced: two-level atom, dressed states, quantum states of light, laser cooling, atom traps. The second part introduces the basics of Bose-Einstein condensation and the dynamical properties of Bose-Einstein condensates. Among others we will go across the following topics: making and observing Bose-Einstein condensates, Gross-Pitaevskii equation, superfluidity and vortices, phase and interference of Bose-Einstein condensates, optical lattices, quantum phase transition in bosonic Hubbard model, etc. Upon request of the audience, the lecture may be given in English or German. Lecture notes are available at the following link

http://photon.physnet.uni-hamburg.de/en/ilp/hemmerich/teaching/

***Condensed matter and ultra-cold atoms***: We explore the physics of condensates of ultra-cold atoms and related ordered states, such as superconducting states. We describe their properties first within a mean-field description, and then establish the formalism of path integrals, effective actions and spontaneous symmetry breaking. We study Landau theory to describe continuous phase transitions, and introduce and apply the concept of the renormalization group to capture the critical behaviour.

## Abstracts: Seminars

***Multifunctional nanostructures:*** In this seminar external guests or group members give talks. 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 efficiency, Seebeck coefficient, powerfactor, figure of merit ZT, ... ).

***Physics of nanostructures:*** 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 „Physics of nanosctructures“.

***Quantum dynamics of out-of-equilibrium nanosystems***: The seminar addresses the non-equilibrium quantum dynamics of systems, which interact with quantum mechanical fluctuations produced from some external environment. They typically lead to decoherence and relaxation phenomena, before a stationary state in the statistical sense is eventually reached. By the framework of open quantum systems, a vast number of physical systems and effects are described, ranging from excitonic energy transfer in biomolecular light-harvesting complexes, to quantum mechanical charge, spin and heat non-equilibrium transport, to activation phenomena in pumped quantum systems, to cooperative effects in ultracold quantum gases, to the dynamics

of a ferromagnetic domain wall under the influence of a spin-polarized current, to name only those which are in the focus of our research group. During the seminar, selected topics of these fields will be discussed.

***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.

***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.

***Many-body systems and quantum statistical methods:*** In Potthoff's group the physical properties of quantum systems consisting of a macroscopically large number of strongly interacting fermions are studied. These systems may show collective behaviour that cannot be understood on an independent-particle level. The field covers collective magnetism, correlation-driven metal-insulator transitions, high-temperature superconductivity and unconventional states of matter in general. We are interested in classical and quantum phase transitions in low-dimensional lattice systems and nanostructures, in elementary excitation spectra and in non-equilibrium phenomena. The employed methods range from field-theoretical techniques and exact diagonalization over (dynamical) mean-field theory and cluster techniques to (quantum) Monte-Carlo methods and density-matrix renormalization group. An important focus is on new methodical developments. For further information about the time schedule of the seminar, please, visit the following webpage http://theorie.physnet.uni-hamburg.de/group_vts/groupseminar.html

***Dissipative quantum dynamics****:* We will discuss theoretical concepts to model and understand dissipation, friction and currents in quantum physics. Thus, we introduce methods like system-bath approaches, quantum master equations and super-operator techniques in order to treat the dynamics of open quantum systems. Specifically, we focus on model problems as the damped harmonic oscillator, the free-boson, the spin-boson and the resonant level model. We discuss these topics in direct connection to present problems of current research, specifically energy transfer in photosynthesis, decoherence in quantum information technology, excitation dynamics in conical intersections as in rhodopsin, relaxation dynamics in molecular complexes, transfer in ion channels, quenches through phase transitions, currents

through quantum dots and molecules, low temperature properties of glasses and cooling of magnetic quantum dots.