TUT 1: Physics with Neutrons – From Proteins via Polymer Thin Films to Spin Waves (CPP)

New neutron sources (FRM II, ESS, SNS) combined with advanced instrumentation enable the detailed characterization of structural as well as dynamic properties of hard and soft condensed matter. The tutorial covers a few of these methods: Small-angle neutron scattering allows one to investigate mesoscopic structures, e.g. in material and life science. Neutron reflectometry and grazing incidence small angle neutron scattering are used to reveal magnetic structures in thin films and lateral structures at interfaces, for instance. Neutron spectroscopy enables, among others, the investigation of magnetic excitations and is complementary to laboratory based spectroscopy methods.

Organization/Chair: Christine M. Papadakis (TU München)

Time: Sunday 16:00–18:30 Location: HSZ 403

Tutorial TUT 1.1 Sun 16:00 HSZ 403
Neutrons as a sensitive tool to investigate nano- and mesostructured materials — •Stephan Förster — University of Bayreuth, Fakultät für Chemie

Neutrons can be similarly used as x-rays to investigate the structure of nano- and mesoscale synthetic and biological materials. Since, compared to photons, neutrons posses a spin, penetrate deeper into materials, and because the neutron-scattering cross-sections can vary strongly for different isotopes of the same element, they are a much more sensitive and versatile tool.

In the tutorial the basic experiments that can be performed with neutrons, in particular neutron scattering, are described and a number of examples from material and life science are given for illustration. The tutorial also includes practical hints for the application of beam time at neutron facilities.

Tutorial TUT 1.2 Sun 16:45 HSZ 403
Reflectivity and GISAS — •Roland Steitz — Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany

Current problems in soft and hard matter science often require insight on the nanometer scale. In this contribution we show how surface sensitive scattering of neutrons, namely neutron reflectivity (NR) and grazing incidence small angle neutron scattering (GISANS) can be utilized to reveal details on thin films and stratified systems at solid-gas and solid-liquid interfaces. The first chapter provides a brief revision of the experimental techniques and underlying principles. Successive paragraphs deal with selected examples highlighting various aspects of experimental systems under study. Paragraph two examines polymer films at solid-gas interfaces, paragraph three addresses immobilisation of a protein at solid-liquid interfaces, paragraph four investigates the structure of the boundary of a hydrophobic polymer film and its adjacent water phase. The last two paragraphs concern laterally structured systems at interfaces and magnetic thin films, respectively.

It is noted that in particular neutrons penetrate deeply into matter, which makes them most suitable for studies of buried interfaces. In addition, investigations with neutrons benefit from the negligible impact of neutrons on the sample, i.e. there is no radiation damage, and as long as soft matter samples are considered neutrons can be used to highlight defined areas of interest by partial deuteration of the sample.

15 min. break

Tutorial TUT 1.3 Sun 17:45 HSZ 403
Neutron spectroscopy on solids — •Astrid Schneidewind — Helmholtz-Zentrum Berlin für Materialien und Energie

Neutron scattering is an outstanding and often a unique technique to study the dynamic properties of solids on an atomic scale. The tutorial will give an overview about the opportunities and the constraints of the method. Coming from the understanding of the properties of the neutron and the lattice, the nuclear and magnetic cross-sections for the interaction of the neutron with the lattice will be shown. Typical problems and the results of the required measurements will be presented and used to illustrate the aspects of the different techniques, with focus on three axis spectroscopy and time-of-flight methods. The specific role of neutron scattering in studies on magnetism will be accentuated. Finally, the complementarities to other methods as Raman and infrared spectroscopy, NMR and X-ray scattering will be pointed out.

TUT 2: Energy Concepts of the Future (AGjDPG, AKE)

„Energy“ is a widespread and often discussed topic – in sciences as well as in politics. Physicists have to answer the questions about power generation, energy storage, sustainability and safety. For new investigations, one has to combine physics with other natural, material and engineering sciences. Numerous technologies meet the future challenges. This tutorial gives an insight into four very different state of the art research projects:

Notebooks and other portable electronics are working with Lithium-Ion-Batteries. In order to use this technology in hybrid or electric vehicles they have to become less flammable and safer. New electrolytes are the solution.

Fuel cells are already used in spacecraft and submarines, so why is this technology not already widespread even though fuel cells are an efficient energy converter?

As energy demand increases so does carbon dioxide production. Plants and especially algae convert carbon dioxide into oxygen. This tutorial explains the physics of using the process of photosynthesis on an industrial scale in photobioreactors.

In order to reduce carbon dioxide production, renewable energy technologies are essential. The world's biggest project is DESERTEC. How does the solar thermal power system work? How to provide power day and night? What is the status quo? This international project has also some political and socio-economic implications, which will be discussed shortly.

Organization/Chair: Anna Bakenecker (Münster)

Time: Sunday 16:00–18:30 Location: HSZ 03

Tutorial TUT 2.1 Sun 16:00 HSZ 03
Electrolytes in lithium-ion batteries: state of the art and future trend — •Andrea Balducci — Institute of Physical Chemistry, University of Muenster, Muenster, Germany

Lithium ion batteries dominate the consumer portable electronic and telecommunications market and they are also indicated as the most promising option for the next generation of hybrid and electric vehicles (HV, EV). However, when the present lithium ion technology is considered, the safety of batteries appears to be one of the main drawbacks holding the introduction of this technology in HV and EV. The commercial systems nowadays available use electrolytes commonly based on organic carbonates (e.g. Propylene Carbonate, PC, Ethylene Carbonate, EC) but since these electrolytes are flammable their use poses a serious safety risk and strongly reduces the battery operative temperature range. For such reasons, alternative electrolytes have been proposed and tested in the last decade. Between them, ionic liquids (ILs) instead of organic carbonates appear to be promising.

Tutorial TUT 2.2 Sun 16:35 HSZ 03
Fuel cells — •Uwe Reimer — Institute of Energy and Climate Research / IEK-3: Fuel Cells, High-temperature Polymer Electrolyte Fuel Cells, Forschungszentrum Jülich, Jülich, Germany

Fuel cells are efficient energy converters that are believed to play an important role in the future concept of energy production and storage. The tutorial explains the basic principles of fuel cells and provides an overview over the present available types. The advantages and disadvantages of fuel cells compared to other energy converters are briefly discussed. Today's application of fuel cells include space crafts and submarines, hence it can be said that the technology is ready and reliable. The question 'Why is it not already widely used?' may be answered at the end. Nevertheless, more questions will be raised, which should inspire the audience to think about the role of energy supply of the future. The topic 'fuel cells' is highly interdisciplinary, since it combines the areas of physics, chemistry, material science and engineering .

Break (10 min)

Tutorial TUT 2.3 Sun 17:20 HSZ 03
Physical aspects of photobioreactors for growing biomass — •Hilmar Franke — Applied. physics, Univ. Duisburg-Essen, Duisburg, Germany

Using photosynthesis CO_2 can be converted in the presence of water and light into biomass and O_2. On hot summer days one may observe the blossoming of algae on seashores or lakes. Often this phenomenon occurs in the presence of high concentrations of nutrients. The function of photobioreactors is to transfer this blossoming or high growth rate of biomass into the laboratory or a large scale industrial plant.
The climate gas CO_2 is produced during the oxidation of carbon or hydrocarbon compounds.
On earth there are many natural and industrial sources for CO_2, but only few sinks. The process of photobiological fixation of carbon dioxide in photobioreactors may contribute to the installation of a recycling technology for CO_2!
In this talk we will focus on the different physical aspects of photobioreactors (PBR) which may lead to efficient large scale plants:
A major problem is the **light exposure**. The exposure has to be optimized with respect to the *wavelengths* and the *intensity*. Using sunlight or LED's as an efficient system for *collecting*, *guiding* and *distribution* of light has to be developed.
Microalgae in PBR*s form a suspension in an aqueous environment with various ions of dissociated water and nutrient components. There are algae with an electric charge distribution. Depending on their shape even in an aqueous ionic environment this may cause an *electric dipole moment*. The **electrical properties** of a microalgae suspension may be used for characterization of important process parameters or the control of the system.
Photosynthesis requires CO_2, while O_2 is formed. Therefore an additional gas phase is present in the PBR. Especially in high columns **gravitation** controls any sedimentation profile. On the other hand clouds of gas bubbles form the reactive interface and the rising speed of gas bubbles depends on the bubble size which again depends on the local **pressure**.

Examples for potential applications of these physical aspects will be discussed.

Tutorial TUT 2.4 Sun 17:55 HSZ 03
DESERTEC - an international approach to use renewable energies at large scale — •Michael Düren — II. Physikalisches Institut, Justus-Liebig-Universität Gießen, Gießen, Germany

The DESERTEC concept combines solar power, wind power and other sources of renewable energy in a large and efficient electrical super grid that spans distances of several thousand kilometres. Fluctuations of the individual sources and loads are averaged out to a large extend. A special emphasis in this concept is given to a large network of solar thermal power stations that are located in deserts of the sun belt of the earth to maximize the yearly solar energy yield at a minimum of costs. The solar thermal power plants are equipped with large thermal storage capacity so that they can provide solar power day and night in accordance with the actual demand. The lecture will give an introduction into the basics of the physical and technological concepts and of the political and socio-economic implications of DESERTEC.

TUT 3: Collective Dynamics of Firms: A Statistical Physics Approach (SOE)

The dynamics of individual firms is hard to predict and depends on many firm specific factors, ranging from location and taxes to managerial talent. The collective dynamics observed on the aggregate level of a system of firms, however, shows some remarkable regularities, e.g. in the skewed distribution of firm sizes, or the Laplacian distribution of growth rates. We derive these regularities from analyzing data sets of real firms. The focus is then on explaining the dynamics by agent-based stochastic models of different complexity. Starting from simple multiplicative stochastic processes, we incorporate economic concepts such as entry and exit dynamics, competition and cooperation, adoption of behavior, or path dependence, to highlight different aspects of industrial organization.

Time: Sunday 16:00–18:00 Location: HSZ 04

Tutorial TUT 3.1 Sun 16:00 HSZ 04
Collective Dynamics of Firms: A Statistical Physics Approach — •Frank Schweitzer — Chair of Systems Design, ETH Zurich, Kreuzplatz 5, 8032 Zurich, Switzerland

The dynamics of individual firms is hard to predict and depends on many firm specific factors, ranging from location and taxes to managerial talent. The collective dynamics observed on the aggregate level of a system of firms, however, shows some remarkable regularities, e.g. in the skewed distribution of firm sizes, or the Laplacian distribution of growth rates. We derive these regularities from analyzing data sets of real firms. The focus is then on explaining the dynamics by agent-based stochastic models of different complexity. Starting from simple multiplicative stochastic processes, we incorporate economic concepts such as entry and exit dynamics, competition and cooperation, adoption of behavior, or path dependence, to highlight different aspects of industrial organization.

TUT 4: State of the Art of X-Ray Microanalysis (MI)

Advanced microanalysis allows researchers to examine in detail the composition of materials. At present, the detection of elements ranging from Beryllium (4) to Americium (95) can be carried out in condensed matter with very high local and spectral resolution. Microanalytical methods are able to provide in situ information on chemical, crystallographic, and structural parameters. In this tutorial, current frontiers of X-ray microanalysis for cutting-edge research in physics, engineering, geology, biosciences, and materials research are described. Fundamental physical processes related to energy and wavelength dispersive X-ray microanalysis, to X-ray fluorescence and tomography, and to ion-beam-induced microanalysis are specified. Experts from industrial and academic research explain the basics and present recent developments in instrumentation and break-throughs in detection and quantification.

Organization/Chair: Enrico Langer

Time: Sunday 16:00–19:15 Location: HSZ 401

Tutorial TUT 4.1 Sun 16:00 HSZ 401

Energy dispersive X-ray spectroscopy, from the method to the instrumentation — •Jana Berlin — Bruker Nano GmbH, Berlin, Germany

One of the most important interactions of beam and sample in the electron microscope is the generation of element-specific X-ray radiation. Energy dispersive X-ray spectrometry (EDS) uses semiconductor detectors to collect this radiation from the sample. "Energy-dispersive" means that the detector measures the relative abundance of emitted X-rays versus their energy. The signal can be evaluated both qualitatively (element identification) and quantitatively (element concentration in mass% or atom%). Spot measurements as well as one, two and nowadays even three-dimensional data acquisition are possible.

The instrumentation used for detection and analysis has made big advances within the past decade. Thermoelectrically cooled silicon drift detectors (SDD) have become state of the art technology, replacing liquid nitrogen cooled Si(Li) detectors. Properties and applications of the SDD technology in the analysis of different sample categories will be discussed to round off this tutorial.

Tutorial TUT 4.2 Sun 16:45 HSZ 401

WDS technique - advanced analytical tool for the SEM — •Frank Bauer — Oxford Instruments, Otto von Guericke Ring 10, D-65205, Wiesbaden, Germany

The typical and very common micro analytical equipment on scanning electron microscopes are energy dispersive systems (EDS). An advanced method in analytical investigations for higher accuracy and sensitivity is the wavelength dispersive X-ray spectroscopy (WDS) - in the normal practice the resolution of the detector and sensitivity for elements is in minimum ten times better. Compared to EDS the wavelength dispersive technique needs additional minimum requirements for the scanning electron microscope (SEM) in case of beam current, emission, geometry, etc.

The fundamental physical background of this technique will be shown. Examples of the advantages and also the limitations of WDS are discussed.

15 min. break

Tutorial TUT 4.3 Sun 17:45 HSZ 401

Hard X-ray scanning microscopy and tomography with elemental, chemical, and structural contrast — •Christian G. Schroer — Institut für Strukturphysik, TU Dresden, 01062 Dresden, Germany

In this tutorial, hard x-ray scanning microscopy and tomography is reviewed. There is a growing demand for these techniques in many fields of science, from physics and chemistry, to materials, earth, and envrionmental science, biology and nanotechnology. The large penetration depth of hard x-rays in matter allows one to investigate the inside of a specimen without destructive sample preparation or inside a special sample environment, such as a chemical reactor or a pressure cell. In combination with tomographic techniques, the three-dimensional inner structure of the sample can be reconstructed. X-ray analytical techniques, such as fluorescence, absorption or scattering (SAXS, WAXS) can be used as contrast in the scanning microscope, yielding elemental, chemical, and nano-structural contrast. Currently, spatial resolutions around 50 nm are achieved. In combination with coherent x-ray diffraction imaging techniques, spatial resolutions down to 10 nm and below are reached. A variety of application examples are given.

[1] A. Schropp, et al., J. Microscopy (2010). DOI: 10.1111/j.1365 2818.2010.03453.x.
[2] C. G. Schroer, et al., Phys. Rev. Lett., 101 (9), 090801 (2008).
[3] C. G. Schroer, et al., Appl. Phys. Lett., 88 (16), 164102 (2006).
[4] C. G. Schroer, et al., Appl. Phys. Lett., 82 (19), 3360 (2003).
[5] C. G. Schroer, Appl. Phys. Lett., 79 (12), 1912 (2001).

Tutorial TUT 4.4 Sun 18:30 HSZ 401

2D- and 3D-microanalysis using focussed MeV-ion beams — •Tilman Butz — Institute for Experimental Physics II, Universität Leipzig, 04103 Leipzig, Germany

This tutorial introduces the following ion beam techniques for analysis and material modification: Analysis: Rutherford Backscattering Spectrometry (RBS), mainly for thin film analysis; Particle Induced X-Ray Emission (PIXE), elemental maps, main and trace elements; Scanning Transmission Ion Microscopy (STIM), density contrast; STIM-tomography, 3D density; PIXE-tomography, 3D elemental images, main elements only. Modification: Proton Beam Writing (PBW), photo resists, semiconductors, 2D- and 3D-microstructures, creating magnetic order in graphite; Proton Beam Sculpting, 3D-microstructures with complex morphology; Targeted irradiation of living cells with counted ions, low dose radiation research.

Examples for all techniques will be given. The requirements for the application of these ion beam techniques will be discussed. Advantages compared to electron microprobes will be addressed as well as limitations, e.g. the issue of radiation damage. At present, lateral resolutions below 100 nm are achievable by STIM and about 350 nm by PIXE. Minimum detection limits depend on the element and can be as low as 0.1μg/g. Microstructures with feature sizes in the order of 100 nm can be created.