BP 8: SYMR: Nuclear Magnetic Resonance: From Applications in Condensed Matter Physics to New Frontiers

Time: Tuesday 9:30–12:45 Location: H1

Invited Talk BP 8.1 Tue 9:30 H1

NMR with a Magnetic Resonance Force Microscope — •Beat H. Meier, Kai Eberhardt, Joss Rosmarie, and Tomka Ivan — Physical Chemistry, ETH Zurich

Magnetic Resonance Force Microscopy (MRFM) is a sensitve method to detect magnetic resonance in small volume elements and has the potential to be used for magnetic resonance imaging (MRI) on the nanoscale. As with MRI, MRFM is not limited to the three spatial dimensions. Spectroscopic dimensions can be added, providing detailed chemical and structural information at the atomic level. The talk will introduce the basic principles of imaging with the microscope and discuss the available spectral information, e.g. from dipolar and quadrupolar interactions and - most demanding but most usefull - from chemical shift.

Invited Talk BP 8.2 Tue 10:00 H1

Probing Novel Electronic States in Strongly Correlated Electron Materials Using NMR and NQR — •Nicholas Curro — Department of Physics, University of California, Davis CA 95616, USA

In the last two decades several new materials have been discovered which exhibit strong electron-electron interactions that lead to novel ground states such as superconductivity, coexisting antiferromagnetism and superconductivity, and "hidden" order. NMR/NQR are ideal probe of these new states, several of which only emerge under extreme conditions in high magnetic fields, low temperatures and high pressures. By taking advantage of the hyperfine interaction, NMR/NQR can provide detailed information about order parameters and their dynamics throughout the phase diagram of these systems. Furthermore, NMR provides a local spectroscopy of the response of these systems to impurity doping. Several heavy fermion and iron pnictide materials will be discussed.

Invited Talk BP 8.3 Tue 10:30 H1

Interplay of Structure and Dynamics in Macromolecular and Supramolecular Systems as Revealed by NMR Spectroscopy — •Hans Wolfgang Spiess — Max-Planck-Institute for Polymer Research, Mainz, Germany

Traditionally, the determination of structure and the elucidation of dynamics of matter are considered separately. With the advancement of characterization techniques, however, this separation becomes more and more artificial. For instance, advanced solid state NMR spectroscopy provides information on the geometry and the time scale of molecular motions independently. This site selective and specific information is highly valuable, as in soft matter function of complex synthetic as well as natural systems is often achieved by separating regions of order and disorder. Incompatibility of building blocks, e.g., backbone and side groups in macromolecules, or non-covalent interactions, such as hydrogen bonds, ionic forces or pi-pi interactions lead to self organization, in which the different units are spatially separated and may display different dynamics. Solid state NMR techniques combining fast magic angle spinning (MAS) and double quantum (DQ) NMR spectroscopy provide site-specific information about these aspects and their relation to processing and function of the materials, e.g., proton- and photoconductivity.

15 min. break

Invited Talk BP 8.4 Tue 11:15 H1

Big times for small NMR — •Bernhard Blümich — RWTH Aachen University, ITMC, Worringerweg 1, D-52056 Aachen, Germany

NMR is most widely known for diagnostic imaging in medicine and molecular analysis in chemistry. The measurement procedure requires magnetic fields and radio-frequency waves. The largest component of an NMR machine is the magnet. While the electronics are shrinking noticeably over the years, the magnets become bigger as higher field strength is realized. Small magnets can be built from permanent magnet material at field strengths common four decades ago. Recent advances in magnet design have led to desktop magnets and miniature magnets that surround the sample in the conventional way and in magnets that accommodate the object in the stray field for relaxation analysis, imaging, and high-resolution spectroscopy. Such magnets are inexpensive and portable. Their availability makes a diversity of studies possible, which are out of question for high-field super-conducting magets. These are high-throughput analysis by parallel operation of many spectrometers, in-line monitoring with long-time use of an NMR machine in one application, NMR analysis at the site of the object, and NMR analysis in dangerous environments. The advances in building small NMR magnets are summarized, and the use of small-scale NMR devices is demonstrated with applications to chemical engineering, medicine, and materials testing.

Invited Talk BP 8.5 Tue 11:45 H1

Traveling-Wave MRI — •Klaas Prüssmann — Insitute for Biomedical Engineering, ETH and University of Zurich, Switzerland

High-field magnets of sufficient inner diameter permit the formation of axially traveling RF waves at NMR frequencies. Such traveling waves can be exploited to excite and detect NMR across large distances. This principle has been demonstrated in a wide-bore 7T magnet with an inner RF screen of 58 cm in diameter, using a patch antenna for RF transmission and reception. Proton NMR spectra of an ethanol solution have been obtained at antenna distances up to more than 3 m. In high-field MRI of humans the traveling-wave approach has the potential to improve RF uniformity, as illustrated by initial in-vivo results. The presentation will also include brief discussions of the reciprocity and efficiency of traveling-wave probes, wave impedance matching, and propagation-related phase delays. Finally it will address the feasibility of using multiple waveguide modes for establishing spatial diversity of RF fields, which underlies the practically important concepts of RF shimming and parallel MRI.

Invited Talk BP 8.6 Tue 12:15 H1

Life on the Edge: The Origins and Proliferation of Protein Misfolding Diseases — •Chistopher M. Dobson — University of Cambridge, Department of Chemistry, Lensfield Road, Cambridge CB2 1EW, UK

The failure of proteins to fold, or to remain correctly folded, can give rise to serious cellular malfunctions that frequently lead to disease. One particularly important group of such diseases is associated with the aggregation of misfolded proteins into thread-like structures known as amyloid fibrils, and includes disorders ranging from Alzheimer's disease to late-onset diabetes. The manner in which the normal soluble forms of peptides and proteins can convert into these pathogenic amyloid structures is being uncovered by a wide variety of in vitro experimental studies along with theoretical simulations and bioinformatics studies [Dobson and Chiti, Annu. Rev. Biochem. 75, 333-366 (2006)]. As with folding, these studies are increasingly being linked to events occurring in vivo using a variety of strategies. Of particular interest are experiments designed to link the principles of misfolding and aggregation to the effects of such processes in model organisms such as Drosophila (the fruit fly). This talk will try to draw together some of the ideas that are emerging from recent in our laboratory based on NMR spectroscopy, including evidence for the extremely narrow boundary between normal and aberrant behaviour [Tartaglia et al., Trends Biochem. Soc. 32, 204-206 (2007)], and how this concept sheds light on the origin, current proliferation and potential means of prevention of the associated diseases.