Plenary Talk — PV I — Mon 8:30 — H1

Optical Dressing of Molecules and Materials — •Thomas W. Ebbesen — ISIS, University of Strasbourg, 8 allee Monge, Strasbourg, France

Strong coupling of light and matter can give rise to a multitude of exciting physical effects through the formation of hybrid states. Organic molecules have been increasingly used for the study of strong coupling since their large transition dipole moment permits the observation of vacuum Rabi splitting approaching 1 eV at room temperature. Such large modifications in the energy levels have significant implications for molecular and material sciences as well as physics. After introducing the fundamentals of strong coupling, our recent research on this topic will be presented.

Plenary Talk — PV II — Mon 14:00 — H1

Exploring the Functionality of Advanced Materials through Scanning Transmission Electron Microscopy — •Stephen Pennycook — Oak Ridge National Laboratory, Oak Ridge, TN, USA

The scanning transmission electron microscope can today form probes of sub-Ångstrom dimensions with sufficient current for electron energy loss spectroscopy. Not only can single atoms be imaged and identified, but their electronic structure, optical properties and even their dynamics can be studied.

In monolayer materials such as BN and graphene, stable point defect complexes consisting of substitutional Si and N atoms lead to localized surface plasmon resonances at the sub-nanometer scale. Core loss spectroscopy is able to identify the nature of their bonding, distinguishing sp3 from sp2d configurations, confirmed by density functional theory. The STEM probe can also be used to gently excite the dynamics of small clusters. A Si6 magic cluster embedded in a small hole in monolayer graphene explores a number of metastable configurations.

In complex oxide materials the ability to measure transition metal valence, to track oxygen vacancy ordering and to measure atomic positions to picometer levels has produced new insights into their functionality. Examples will be presented from multiferroics, cobaltites and ionic conductors. Future directions to directly map functionality at the nanoscale will be discussed.

Research supported by the U.S. Department of Energy, Basic Energy Sciences, Materials Sciences and Engineering Division.

Plenary Talk — PV III — Mon 14:00 — H15

The Dynamics of Wealth, Persuasion, and Popularity — •Sidney Redner — Boston University, Boston, USA

In this talk, I discuss how a number of simple models of statistical physics can be adapted to help elucidate some well-known social dynamics phenomena. I first present a way to describe the wealth distribution of a society through an idealized model in which random pairs of individuals repeatedly exchange some amount of their assets. I will then treat the connection between the kinetic Ising model and basic models of social persuasion, in which individuals are regarded as social atoms. Models of this genre can help understand how consensus may or may not be achieved in a socially-interacting population. Finally, I will review the preferential attachment model of popularity and show how this ostensibly global dynamical evolution of complex networks can be obtained by a purely local growth rule. Throughout, I will show how these three models can be treated within the unifying framework of non-equilibrium statistical physics.

Plenary Talk — PV IV — Tue 8:30 — H1

Majorana Fermions in Semiconductor Nanowires — •Leo Kouwenhoven — Kavli Institute for NanoScience Delft, The Netherlands

Majorana fermions can arise as emergent particles in specially designed nanoscale conductors. We have combined superconductors and semiconducting nanowires with strong spin-orbit interaction. At finite magnetic field we find peaks in the density-of-states at zero-bias. The properties of this zero-bias peak compare well with the predictions for Majorana bound states. Background information of this work including a recent publication can be found at kouwenhovenlab.tudelft.nl

Prize Talk — PV V — Tue 13:15 — H1

Critical Quasi-particles and Scaling of Metals Near a Quantum Critical Point: a Strong Coupling Scenario. — •Peter Woelfle — ITKM and INT, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany — Laureate of the Gentner-Kastler-Prize

A phenomenological theory of the critical properties of metals near a quantum critical point (QCP) governed by critical bosonic fluctuations at small momentum is presented. Assuming critical behavior of the electron quasi-particles (qp) all over the Fermi surface, as seen in a diverging effective mass m*, we determine the induced modification of the bosonic excitation spectrum. We use that the concept of electron qps is well-defined as long as the qp width is less than their excitation energy, which is still the case in the so-called non-Fermi liquid regime. In case that the interaction of the bosonic fluctuations is still weak, while the boson-qp interaction is strong, a controlled theory leads to a self-consistent equation for m*, with two physical solutions: the usual weak coupling solution and a strong coupling solution featuring a power law divergence of m* as a function of energy scale. We apply the theory to the antiferromagnetic (AFM) quantum phase transition observed in heavy fermion compounds (critical energy fluctuations), finding good agreement with data for YbRh2Si2 [1,2] and CeCu(6-x)Au(x). [1] P. Wölfle, and E. Abrahams, PR B 84, 041101 (2011); Ann. Phys. (Berlin) 523, 591 (2011); PR B 80, 235112 (2009). [2] E. Abrahams and P. Wölfle, PNAS 109, 3228 (2012). [3] E. Abrahams, J. Schmalian, and P. Wölfle, to be publ.

Plenary Talk — PV VI — Tue 14:00 — H1

The Thin-Disk Laser - from Physics to Industrial Applications — •Thomas Graf — Institut für Strahlwerkzeuge (IFSW), University of Stuttgart

The unique properties of the thin-disk laser result from the arrangement of the laser-active medium as a thin crystal disk which is pumped very intensively and efficiently by diode lasers and which can be cooled much more homogeneously than conventional solid-state slab or rod lasers. The thin-disk geometry was originally motivated by the reduction of thermally induced aberrations to facilitate the generation of good beam quality at high average powers. But the thin gain medium has also significant advantages for the generation of ultra-short pulses (e.g. due to reduced nonlinearities) and the application in industrial materials processing (e.g. due to the ruggedness against back reflections). All this makes the thin-disk laser an interesting tool for many applications ranging from fundamental science to industrial manufacturing. Starting from the basic laser physics the presentation will discuss the specific properties of thin-disk lasers and highlight some of the many fascinating applications ranging from the measurement of the proton radius to cutting of carbon fiber reinforced plastics (CFRP). The examples also illustrate how the specific requirements of given applications determine the goals for the development of suitable laser sources.

Plenary Talk — PV VII — Tue 14:00 — H15

Self-assembly, Self-organization and Control of Colloidal Suspensions — •Sabine H. L. Klapp — Institut für Theoretische Physik, Sekr. EW 7-1, Technische Universität Berlin, Hardenbergstrasse 36, D-10632 Berlin

For more than a century, colloidal suspensions have been appreciated as model systems of condensed-matter phenomena such as condensation, freezing and nucleation. Recently, the fundamental insights emerging from the study of colloids receive attention not only in physics, but also in materials science, chemistry and biology, main goals being the deliberate design of functional advanced materials and unraveling biological transport phenomena. Moreover, colloidal suspensions are increasingly used to explore non-equilibrium phenomena such as pattern formation and synchronization. In the present talk I will discuss recent theoretical and computer simulation studies in this area, considering a variety of colloidal systems which are either in thermal equilibrium or driven out of equilibrium by external fields. Starting from the ordering of charged colloids at interfaces, I will describe the rich manifold of phenomena encountered in magnetic colloids (ferrofluids), such as self-assembly into chains and anomalous diffusion in static magnetic fields, as well as self-organization in rotating fields. As a further example of non-equilibrium behavior I will consider shear-induced phenomena, focusing on recently discovered effects such as spontaneous dynamic polarization in polar nanorods and oscillating motion in shear-driven colloidal layers. Finally, I will discuss strategies to manipulate the dynamical behavior of colloidal systems by feedback control.

Plenary Talk — PV VIII — Tue 17:20 — H1

Beyond Graphene: Electronic Properties of Van der Waals Heterostructures — •Andre Geim — University of Manchester, UK

Following the advent of graphene, several other one-atom or one-molecule thick crystals have been isolated and tentatively studied.

They range from semiconducting monolayers to wide-gap insulators to metals. This library of two-dimensional materials opens a possibility to construct various 3D structures with on-demand properties, which do not exist in nature but can be assembled in Lego style by stacking individual atomic planes on top of each other in a desired sequence. I will overview our recent progress in making such materials and studying their electronic properties.

Plenary Talk — PV IX — Wed 8:30 — H1

Mechanics and dynamics of rapid cell movement — •Julie Theriot — Stanford University School of Medicine, Stanford, CA, USA

Directed, purposeful movement is one of the properties most closely associated with living organisms. At the cellular level, rapid crawling movements of cells as diverse as soil amoeba and human white blood cells depend on coordination of multiple dynamic elements over a wide range of distance and time scales. Using isolated fish skin cells called keratocytes as a model system, we have developed a biologically realistic force-based physical model for whole-cell motility that links molecular mechanisms to overall cell shape and speed. Under normal conditions, motile keratocytes assume a simple fan-like shape, and can move persistently with nearly constant shape and speed. Persistent steady-state motility involves the balanced interaction of forces generated by actin filament assembly and disassembly, myosin-based network contraction and demolition, cell-substrate adhesion, membrane tension, and hydrostatic pressure within the cell. Dramatic departures from steady-state movement can be induced in keratocytes by environmental perturbations, including alteration of substrate adhesivity and exposure of cells to electric fields. Quantitative comparison of cellular responses to these perturbations with the predictions of the physical model has enabled us to extend the model to encompass complex cell behaviors in changing conditions. Some features of the motile behavior of cells with more complicated shapes, including human white blood cells, can also be explained within the same mechanical framework.

Prize Talk — PV X — Wed 13:15 — H1

Metallic Nanostructures in Strong Light Fields: Phenomena and Applications — •Claus Ropers — Materials Physics Institute and Courant Research Centre Physics, University of Göttingen, 37077 Göttingen, Germany — Laureate of the Walter-Schottky-Prize

Metallic nanostructures provide a versatile means to tailor the propagation and localization of light fields on sub-wavelength dimensions. The associated near-field enhancements can amplify numerous nonlinear processes including harmonic generation, nonlinear photoemission and atomic or molecular ionization. In the vicinity of nanostructures, such phenomena display distinctive properties and scalings that are governed by the confined light-matter interaction. These features promise fundamental discovery as well as novel applications in imaging and spectroscopy with ultrahigh spatio-temporal resolution.

In this talk, I will present several experimental directions in which the optical properties of nanostructures are harnessed for these goals using far-infrared to extreme ultraviolet (EUV) wavelengths. Examples include nonlinear EUV generation in plasmonic waveguides and resonant bow tie antennas as well as tip-enhanced photoemission with unique strong-field dynamics. Furthermore, the generation of ultrashort high-brilliance electron pulses from sharp metal tips and their application in time-resolved electron imaging and diffraction will be discussed.

Plenary Talk — PV XI — Wed 14:00 — H1

Magnetic Monopoles in Spin Ice — •Roderich Moessner — Max-Planck-Institut fuer Physik komplexer Systeme, Dresden

Fractionalisation is a counterintuitive phenomenon, in which an elementary particle appears to break into two independent entities. A celebrated example of this is spin-charge separation, in which an electron's magnetic (spin) and electric (charge) properties appear to become independent degrees of freedom.

Spin ice materials provide a rare instance of fractionalisation in three dimensions. Their elementary excitations result from the fractionalisation of their microscopic magnetic moments; these excitations can be thought of as magnetic monopoles.

This talk presents an elementary introduction to theoretical concepts for, and experimental studies of, spin ice. It focuses on the unique signatures of the peculiar nature of its excitations. These include unusual neutron scattering structure factors, dynamical arrest and long lived non-equilibrium metastable states, as well as a response to external magnetic fields that promotes spin ice as a new type of magnetic system which has been called a magnetic plasma, a magnetic Coulomb liquid, or a magnetolyte. This talk reviews several of these striking phenomena, and discusses open questions and future perspectives.

Plenary Talk — PV XII — Wed 14:00 — H15

Novel Strategies for the Assembly of Quasicrystals: Epitaxial Growth of Three-dimensional Nanoporous Frameworks — •Christof Wöll — Inst. of Functional Interfaces (IFG), Karlsruhe Institute of Technology (KIT), 76021 Karlsruhe, Germany

Engineering artificial materials with properties that may not be found in nature is a topic of pronounced scientific interest. A particularly appealing approach is to assemble metacrystals from nanoparticles (NPs). Metacrystals consisting of NPs positioned at the sites of a regular, strictly periodic array are predicted to exhibit exciting electronic, magnetic and optical properties. We will describe a novel strategy for the assembly of such 3d NP superlattices employing concepts from supramolecular chemistry. Metal-organic frameworks, MOFs, are highly regular, crystalline, 3-dimensional shelf systems with nm-sized pores. By employing liquid-phase epitaxy, such supramolecular frameworks can be grown from solution on modified solid substrates, yielding crystalline, oriented and homogenous layers referred to as SURMOFs[1]. Loading the SURMOF pores with metal NPs opens the possibility to create strictly periodic, metal or semiconductor NP 3d superlattices. We will discuss the physical and some of the chemical properties of these nanoporous (pore sizes of up to 10 nm have been reported) novel materials, describe the fabrication of surface-anchored MOFs on solid substrates using liquid-phase epitaxy (LPE) and discuss some of the strategies to load SURMOFs with nanoparticles.

[1] Epitaxially grown metal-organic frameworks Hartmut Gliemann, Christof Wöll, Materials Today 15, 110 (2012)

Evening Talk — PV XIII — Wed 20:00 — H1

Vom Cubit zum neuen Kilogramm — •Klaus von Klitzing — Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany

Im Oktober 2011 hat die Generalkonferenz für Maß und Gewicht auf der 24. Sitzung seit ihrer Gründung im Jahr 1889 eine Resolution verfasst, die unser internationales Einheitensystem grundlegend verändern wird. Insbesondere eine Neudefinition des Kilogramms war wünschenswert, da heute noch die Einheit der Masse über ein Unikat definiert ist und dieses "Ur-Kilogramm" anscheinend nicht stabil ist.

Der Vortrag gibt einen Überblick über die Entwicklung der Maßeinheiten beginnend mit der historischen Längeneinheit Cubit bis zur greifbaren Realisierung der Vision von Maxwell und Planck, unveränderliche Naturgrößen wie Atome und Naturkonstanten als Basis für unser Maßsystem zu verwenden.

Plenary Talk — PV XIV — Thu 8:30 — H1

Magnonic Transport Phenomena — •Burkard Hillebrands — Fachbereich Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

Magnons, the quanta of spin waves, the dynamic excitations of a magnetic material, can be used as spin and information carrier. The young field building on this concept is magnon spintronics. It supplements the now well established field of spintronics, where spin is used in addition to the charge of an electron to gain new functionality. A particular new subfield is insulator spintronics, where magnetic insulator materials, such as Yttrium Iron Garnet, are used for information processing using magnons with the particular benefit of reduced heat dissipation since there are no electric currents involved. And, furthermore, magnons carry energy or heat. Magnonic transport has been demonstrated over macroscopic distances up to several millimeters, and magnons can be detected via spin pumping and the inverse spin Hall effect in addition to conventional microwave techniques. This establishes the bridge between magnons and conventional electronics. I will give an introduction into magnon spintronics. Specifically I will address magnonic transport phenomena in the field of magnon caloritronics, where the interaction between magnons and temperature / a temperature gradient becomes predominant. Applications to magnon logics will be discussed.

Prize Talk — PV XV — Thu 13:15 — H1

Near Field Optics – Science of the "Invisible Light" — •Wolfgang Dieter Pohl — Felsenhofstr.10, CH8134 Adliswil — Laureate of the Stern-Gerlach-Medal

Near Field Optics (NFO) helps to understand the interaction of individual nano-structures with optical fields. Scanning NFO microscopes and the optical antenna are two popular examples. A typical feature of NFO is a bright region of sub-wavelength size which does (nearly) not radiate. The existence of such regions is shown indirectly by effects such as fluorescence or nonlinear phenomena.

Plenary Talk PV XVI Thu 14:00 H1

Computational Materials Science Applied to Magnetism of Bulk and Nano-scale Materials — •Olle Eriksson — Department of Physics and Astronomy, Uppsala University, Sweden

A general background to density functional theory will be given, highlighting in particular the capabilities of theory to describe magnetic properties such as spin and orbital moments, as well as the magneto crystalline anisotropy. The latter property will be discussed in some further detail, due to the emerging interest in finding replacement materials for the currently used permanent magnets, that are based on rare-earth elements. Challenges with density functional theory in its conventional implementation will also be discussed, and results from dynamical mean field theory will be given for complex magnetic oxides and diluted magnetic semiconductors. At the end of the presentation the development in describing the magnetization dynamics by an atomistic approach will be given, and examples of the magnetization dynamics of bulk, thin films and nano-clusters will be discussed.

Plenary Talk PV XVII Thu 14:00 H15

Observing the Interactions of Ions with Solid-Liquid Interfaces using X-rays — •Paul Fenter — Argonne National Laboratory, Argonne, IL USA

The interaction of ions with charged solid-liquid interfaces is of interest to a broad array of scientific fields ranging from geochemistry (e.g., contaminant transport in the environment), electrochemistry (e.g., energy storage), and even the biological sciences (e.g., trans-membrane transport). Interfacial processes are ultimately controlled by the distribution of ions at these interfaces but this behavior is often obscured by the presence of the liquid phase itself. I will review recent work where we use direct X-ray based probes (e.g., x-ray reflectivity and resonant scattering) to observe the structures and interactions of ions through direct in-situ measurements. These results illustrate the critical role of ion solvation in understanding the properties of charged solid-liquid interfaces.

Plenary Talk PV XVIII Fri 8:30 H1

Templated Self-assembly of Block Copolymer Films — •Caroline Ross — Massachusetts Institute of Technology, Cambridge, MA, USA

The microphase separation of block copolymer films produces periodic nanoscale patterns with feature sizes of a few nm and above, and has been proposed as a method for extending microelectronic fabrication beyond the limits of optical lithography. To control the long range order of the microphase separation, and to produce patterns with designed aperiodic features, templating strategies based on substrate topography have been developed in combination with modeling using self consistent field theory. The structures formed by self-assembly are governed by commensurability between the template and the equilibrium period of the block copolymer. The templating of complex patterns such as 3D cross-point structures from bilayer films of a diblock copolymer, and arrays of rings, square-symmetry posts and Archimedean tiling patterns from linear or star triblock terpolymers will be described. Pattern transfer and applications to nanoscale device fabrication will be discussed.