Plenary Talk PLV I Mon 8:30 HSZ 01

Spin-Photon Interfaces and Their Applications — •Mete Atatuere — University of Cambridge

Optically active spins in solids are often considered prime candidates for scalable and feasible quantum-optical devices. Numerous material platforms including diamond, semiconductors, and atomically thin layered materials are investigated, where each platform brings their own advantages along with their challenges. I will highlight the common challenges and the ways forward for some of the promising systems for applications in quantum networks and quantum sensing.

Plenary Talk PLV II Mon 14:00 HSZ 01

New directions in electromagnetic field mapping in materials in the transmission electron microscope — •Rafal E. Dunin-Borkowski — Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons, Forschungszentrum Jülich, 52425 Jülich, Germany

Transmission electron microscopy has been revolutionized in recent years, both by the introduction of new hardware such field-emission electron guns, aberration correctors and in situ stages and by the development of new techniques that take advantage of increased computational speed and the ability to control and automate modern electron microscopes. In this talk, I will describe how electron microscopy can be used to obtain quantitative information about not only local variations in microstructure and composition in materials, but also magnetic fields and charge density distributions with close-to-atomic spatial resolution. When combined with model-based iterative reconstruction, electron tomography and in situ techniques, this information can be obtained quantitatively, in three dimensions, as a function of temperature, with high temporal resolution and in the presence of applied fields, light and reactive gases. I will present results obtained from studies of magnetization distributions in individual magnetic nanocrystals and three-dimensional magnetic solitons in geometrically-confined structures, from measurements of electric fields in nanoscale materials and from studies of electron-light-matter interactions. I will conclude with a personal perspective on directions for the future development of transmission electron microscopy, which may require radical changes to the design of electron microscopes.

Plenary Talk PLV III Mon 14:00 HSZ 02

Microgels at Interfaces — •Regine von Klitzing — Institute for Condensed Matter Physics, TU Darmstadt, Germany

Rupturing foams (and emulsions) on demand is a big challenge for many applications. One strategy is to use stimuli-responsive surface-active polymer particles as stabilizers. Here we use thermosensitive microgel particles which show an LCST-like volume phase transition. In order to understand their impact on foam stabilisation it is important to get deeper insight into different length scales of the foams, i.e. from adsorption of microgels at the air/water interface studied by scanning force microscopy (AFM), via forces across microscopic foam lamellas measured with a thin film pressure balance and foam bubbles to macroscopic foams stabilized by PNIPAM microgels. The foam structure is investigated by small angle neutron scattering (SANS). The deformation of the microgels plays an important role for the stabilisation mechanism and is related to their inner structure (studied by SANS), the swelling behaviour and nanomechanical and nanorheological properties that are investigated by dynamic indentation with an AFM tip. The combination of these studies on different length scales almost completes the picture about the stabilisation ability of microgels and might by transferred to other types of colloidal dispersions.

Plenary Talk PLV IV Tue 8:30 HSZ 01

Stochastic thermodynamics: From concepts to model-free inference — •Udo Seifert — II. Institut für Theoretische Physik, Universität Stuttgart

Stochastic thermodynamics provides a universal framework for analyzing nano- and micro-sized non-equilibrium systems. Prominent examples are single molecules, molecular machines, colloidal particles in time-dependent laser traps and biochemical networks. Thermodynamic notions like work, heat and entropy can be identified on the level of individual fluctuating trajectories. They obey universal relations like the fluctuation theorem.

Thermodynamic inference as a general strategy uses consistency constraints derived from stochastic thermodynamics to infer otherwise hidden properties of non-equilibrium systems. As a paradigm for thermodynamic inference, the thermodynamic uncertainty relation discovered in 2015 provides a lower bound on the entropy production through measurements of the dispersion of any current in the system. Likewise, it quantifies the cost of temporal precision for biomolecular processes and provides a model-free bound on the thermodynamic efficiency of molecular motors and microscopic heat engines.

Plenary Talk PLV V Wed 8:30 HSZ 01

Advances in Ultrafast Electron Microscopy — •Claus Ropers — Max-Planck Institute for Multidisciplinary Sciences, Göttingen — University of Göttingen

Providing the most detailed views of atomic-scale structure and composition, Transmission Electron Microscopy (TEM) serves as an indispensable tool for structural biology and materials science. The combination of electron microscopy with pulsed electrical or optical stimuli allows for the study of transient phenomena, involving magnetization dynamics, strain evolution and structural phase transformations. Ultrafast transmission electron microscopy (UTEM) is a pump-probe technique, in which non-equilibrium processes can be tracked with simultaneous femtosecond temporal and nanometer spatial resolutions.

This talk will cover recent developments and applications in UTEM based on laser-triggered field emitters, including the real-space and diffractive probing of a structural phase transition. Moreover, the mechanisms involved in free-electron beams interacting with optical fields at photonic structures will be discussed, emphasizing quantum effects. In particular, recent progress in the coupling of electron beams to integrated photonic structures will be presented. Finally, harnessing developments in event-based electron spectroscopy, we demonstrate the preparation and characterization of electron-photon and electron-electron pair states.

Plenary Talk PLV VI Wed 14:00 HSZ 01

Topological defects in active and living matter — •M Cristina Marchetti — University of California Santa Barbara, USA

Topological defects play a central role in the physics of many materials, including magnets, superconductors and liquid crystals. In oriented active fluids defect acquire a new life as spontaneous local currents turn them into self-propelled particles that drive chaotic flows. There is growing evidence that living systems may exploit this relation between structure and dynamics and use defects to localize stress or perform specific functions. The intimate connection between defect textures and active flow suggests that properties of active materials can be engineered by controlling defects. In this talk I will describe our work on formulating the dynamics of active topological defects as particle-like excitations, their role in driving the turbulent-like dynamics of active liquid crystals, and recent approaches to manipulate the defect dynamics in both space and time.

Plenary Talk PLV VII Wed 14:00 HSZ 02

Ferroelectric and multiferroic domain walls for nanotechnology — •Dennis Meier — Department of Materials Science and Engineering, NTNU Norwegian University of Science and Technology — Center for Quantum Spintronics, Department of Physics, NTNU Norwegian University of Science and Technology

Ferroelectric and multiferroic domain walls have emerged as a new type of functional interface. Because of their distinct symmetry and chemical environment, the domain walls offer a wide variety of functional electric and magnetic properties, representing excellent 2D components for the development of more agile next-generation nanotechnology. In my talk, I will discuss fundamental key properties of domain walls in ferroics and how the field of domain wall nanoelectronics evolved from classical device ideas to advanced concepts, where the walls themselves are used as ultra-small electronic components. I will conclude with a discussion of open experimental challenges and newly discovered domain-wall phenomena that may play an important role in future directions of the field.

Plenary Talk PLV VIII Thu 8:30 HSZ 01

Nanomechanics: Tunes of the nanoguitar — •Eva Weig — Technical University of Munich, Garching, Germany

Nanomechanical resonators - freely suspended, vibrating nanostructures - show great promise as versatile elements in hybrid nanosystems, as sensors or signal transducers both in the classical and in the quantum realm. Here I will focus on nanomechanical string resonators. These seemingly simple devices exhibit remarkably large room temperature quality factors and enable electrostatic control. Nanostrings are thus an ideal testbed to explore a variety of dynamical phenomena. I will review recent progress in controlling the coherent as well

as the nonlinear dynamics of nanostring resonators. This includes the realization of a nanomechanical two-mode system mimicking the coherent dynamics of a quantum two-level system, and novel insights into squeezing and frequency comb generation.

Plenary Talk PLV IX Thu 14:00 HSZ 01

Metal Halide Perovskites for Photovoltaic Applications — •Laura Herz — University of Oxford, Department of Physics, Parks Road, Oxford OX1 3PU, U.K.

Organic-inorganic metal halide perovskites have emerged as attractive materials for solar cells with power-conversion efficiencies now exceeding 25%. This talk will provide an overview of our work unravelling the fundamental processes that have enabled these materials to be such efficient light-harvesters and charge collectors, examining e.g. fundamental mechanisms underpinning charge-carrier mobility and recombination. Our analysis of intrinsic photophysical parameters opens the promise of targeted material design for solar energy harvesting, based on readily accessible parameters, such as band structure, phonon frequencies and the dielectric function.

We further discuss a range of remaining challenges and opportunities relating to material microstructure, ionic migration and toxicity. We examine how the optoelectronic properties of hybrid perovskites are governed by their nanostructure and structural phases. In the context of silicon-perovskite tandem cells, we discuss the peculiar mechanisms underlying detrimental halide segregation in mixed iodide-bromide lead perovskites with desirable electronic band gaps near 1.8eV. We further outline the challenges and rewards of lead-free metal halide perovskites and their structural derivatives.

Plenary Talk PLV X Thu 14:00 HSZ 02

Single-electron-spin-resonance detection by microwave photon counting — •Patrice Bertet[1], Zhiren Wang[1], Leo Balembois[1], Eric Billaud[1], Milos Rancic[1], Marianne Le Dantec[1], Thierry Chaneliere[2], Alban Ferrier[3], Philippe Goldner[3], Sylvain Bertaina[4], Denis Vion[1], Daniel Esteve[1], and Emmanuel Flurin[1] — [1]Université Paris-Saclay, Gif-sur-Yvette, France — [2]Université Grenoble-Alpes, Grenoble, France — [3]Université PSL, Paris, France — [4]Université Aix-Marseille, Marseille, France

We report a new method for single-electron-spin-resonance spectroscopy at millikelvin temperatures. It consists in measuring the spin fluorescence signal at microwave frequencies using a microwave photon counter based on a superconducting transmon qubit. In our experiment, individual paramagnetic erbium ions in a scheelite crystal of CaWO4 are magnetically coupled to a small-mode-volume, high-quality factor superconducting microwave resonator to enhance their radiative decay rate. We detect the microwave photon spontaneously emitted by a spin following its excitation with a signal-to-noise ratio of 1.9 in one second integration time. Coherence times up to 3 ms are measured, limited by the spin radiative lifetime. The method applies to arbitrary paramagnetic species with long enough non-radiative relaxation time, and offers large detection volumes ($10\,\mu m^3$); as such, it may find applications in magnetic resonance and quantum computing.

Plenary Talk PLV XI Fri 8:30 HSZ 01

Physics in Nanopores: From Data storage to DNA/RNA analysis — •Ulrich Keyser — Cavendish Laboratory, University of Cambridge, JJ Thomson Ave, Cambridge, CB3 0HE, UK

DNA and RNA are the molecules of life. Their sequence encodes the blueprints from cells to viruses. Both polymers store information in their three-dimensional structure.

RNA and DNA are often analysed by translocating single molecules through small holes known as nanopores. An accurate understanding of the translocation dynamics is essential for the read out of polymer structure, including the localization of binding sites or sequences. Here we use synthetic nanopores and nanostructured DNA molecules to directly measure the velocity profile of driven polymer translocation through synthetic nanopores. We adjust nanopore geometry and translocation direction to resolve individual nanostructures only 7 nm apart and with a surface-to-surface gap distance of 2 nm. We then discuss the potential and challenges of our super-resolution nanopore sensing for future DNA data storage.

In the second part of the talk, we use our insights on polymer dynamics in nanopore confinement to analyse RNA molecules. We identify target RNA through making distinct three-dimensional structures with designed RNA:DNA interactions. Finally, we highlight multiplexed detection of RNA viruses - like SARS-CoV-2 and its variants - as one exciting application of nanopore sensing and DNA nanotechnology.