Plenary Talk PV I Mon 8:30 HSZ 01

Electronic properties of graphene based van der Waals heterostructures — •Philip Kim — Department of Physics, Columbia University, New York, NY 10027, USA

By assembling atomically thin van der Waals (vdW) materials, such as hexa boronitride, transition metal chalcogenide and graphene, we can construct novel quantum structures. These quantum heterostructured materials can be further modified by electrochemical intercalation and electrolyte gating. In this talk, I will discuss the method of transferring graphene to two-dimensional atomic layers of vdW solids to build functional heterostacks. I will discuss novel electron transport phenomena can occur across the heterointerfaces of designed quantum stacks to realize exotic charge transport phenomena in atomically controlled quantum heterostructures and their derivatives.

Plenary Talk PV II Mon 14:00 HSZ 01

Diffraction before destruction: Imaging proteins with X-ray free-electron laser pulses — •Henry Chapman — Center for Free-Electron Laser Science, DESY, Hamburg, 22607 Germany — Department of Physics, Hamburg University, 22761 Germany — Center for Ultrafast Imaging, Hamburg, 22761 Germany

The ultrafast pulses from X-ray free-electron lasers have opened up a new method for structure determination of macromolecules. These pulses are of high enough intensity and of sufficiently short duration that individual single-shot diffraction patterns can be obtained from a sample before significant radiation damage occurs. This “diffraction before destruction” method may enable the determination of structures of proteins that cannot be grown into large enough crystals or are too radiation sensitive for high-resolution crystallography. Ultrafast pump-probe studies of photoinduced dynamics in proteins or other materials can also be studied. We have carried out experiments in coherent diffraction from protein nanocrystals, including membrane bound proteins, at the Linac Coherent Light Source (LCLS) at SLAC. The crystals are delivered to the pulsed X-ray beam in a continuously flowing liquid jet, allowing the collection of millions of diffraction patterns that are merged. The method has begun to yield new structures and has the potential to increase the rate at which structures can be solved. We aim to be able to obtain structures from the smallest possible crystals of only a single unit cell, i.e. single molecules. A dedicated instrument for serial nanocrystallography will be deployed at the European XFEL in Hamburg.

Plenary Talk PV III Mon 14:00 HSZ 02

Structure-Property-Function relationships in Molecular Electronic Materials and their application to Photovoltaics — •Jenny Nelson[1], Jarvist Frost[1], Anne Guilbert[1], Florian Steiner[1], Sheridan Few[1], Michelle Vezie[1], Valerie Vaissier[1], Thomas Kirchartz[2], and Roderick Mackenzie[3] — [1]Department of Physics and Centre for Plastic Electronics, Imperial College London, South Kensington, London SW7 2AZ, UK — [2]IEK5 Photovoltaics, Forschungzentrum Jülich, 52425 Jülich, Germany — [3]Faculty of Engineering, University of Nottingham, Nottingham, NG7 2RD, UK

The application of molecular semiconductor materials to optoelectronics presents both an opportunity, in terms of the vast range of material properties and applications that can be achieved through chemical synthesis, and a challenge, in relating optoelectronic properties of the resulting devices to the chemical structure and microstructure of the materials. The challenge is complicated by the intrinsic disorder in electronic energy levels and structural heterogeneity of organic semiconductors. We show how a combination of modelling tools including electronic structure calculation, molecular dynamics, quantum chemical calculation, and Monte Carlo simulation can be used to rationalise the influence of chemical structure on molecular packing, electronic energy levels and electronic transport properties for a range of materials. We then show how the response of organic photvoltaic devices can be explained using device models that incorporate energetic disorder. Finally we consider the remaining challenges in achieving a fully predictive approach to development of organic electronic materials.

Plenary Talk PV IV Tue 8:30 HSZ 01

Coherent Mechanics: Tuning and Playing an Electric Nano-Guitar — •Jörg P. Kotthaus — Center for NanoScience and Fakultät für Physik, LMU München, Germany

Nanomechanical resonators operating with high quality factors $Q = f/\Delta f$ at radio frequencies f in the 10 MHz regime gain importance as sensors for smallest masses, forces, and displacements, but also as potential devices for coherent information processing. With tightly stretched nanostrings of silicon nitride exhibiting Q-factors up to 1 million, relevant damping mechanisms limiting Q are explored. Combining electric gradient field actuation with microwave-cavity-assisted motion detection provides a completely electrically controlled platform to study the coherent dynamics of nanoscale resonators over a wide temperature range. Coherent control in the non-linear excitation regime is utilized to induce fast switching between bistable states.

Coupling two orthogonal transverse resonance modes via gradient fields creates a classical analogue of a quantized two-level system and is studied in its coherent motion. With Landau-Zener-type experiments one can explore the transition from adiabatic to diabatic behavior. Pulsed excitation experiments investigate the coherent dynamics on a Bloch-like energy sphere and yield classical equivalents of Rabi oscillations, Ramsey fringes, and Hahn echoes, which further illuminate mechanisms of decoherence. With the quantum regime of mechanics now becoming accessible such resonators might eventually become useful for information processing with true quantum mechanical features.

Prize Talk PV V Tue 13:15 HSZ 01

Magnetism and electronic correlations in real materials — •Alexander Lichtenstein — Institut für Theoretische Physik, Universität Hamburg, 20355 Hamburg, Germany — Laureate of the Max-Born-Prize

Effects of electron correlations in magnetic materials, including transition or rare-earth metals, superconducting oxides, and impurities on Graphene will be discussed. Modern density functional theory (DFT) describe in principle only ground state properties but not spectroscopy of the strongly correlated magnetic materials [1]. We used a "first-principle" dynamical mean field theory (DFT+DMFT) which allowed to investigate the correlations effects in real materials. In order to investigate collective non-local excitations we formulate a general framework which start from the DMFT solution for strongly correlated materials within a numerically exact continuous-time Quantum Monte Carlo impurity solver [2] and use a path integral transformation to find an optimal diagrammatic series for many-body Green functions. Prospects of theoretical description of the correlated systems with strong non-local interactions will be addressed.

[1] M.I. Katsnelson, V.Yu. Irkhin, L. Chioncel, A.I. Lichtenstein, and R.A. de Groot, Rev. Mod. Phys. 80, 315 (2008)

[2] E. Gull, A.J. Millis, A.I. Lichtenstein, A.N. Rubtsov, M.Troyer, and P. Werner, Rev. Mod. Phys. 83, 349 (2011)

Special Talk PV VI Tue 14:00 BEY 154

Herausforderung Lehramts-Studium Physik — •Siegfried Grossmann — Fachbereich Physik, Philipps-Universität Marburg

Angesichts geringer Beliebtheit bei (zu) vielen Schülerinnen und Schülern, einer viel zu häufigen Abwahl unseres Faches sowie stetig sinkender Stunden-Anteile der Physik in der Schule müssen wir uns Gedanken darüber machen, ob wir die Bedeutung der Physik nicht durch mehr Aufmerksamkeit für eine gute Lehramtsausbildung in den Fachbereichen positiv beeinflussen und den Trend umkehren können. Hiermit hat sich eine Arbeitsgruppe der DPG, gefördert durch die Wilhelm und Else Heraeus-Stiftung intensiv beschäftigt und nun ihre Ergebnisse vorgelegt. Nähere Analyse zeigt, dass die für die Lehramtsausbildung zur Verfügung stehende Zeit ernüchternd knapp ist, deutlich weniger noch als für die Bachelorausbildung! Das LA-Studium muss effektiv gestaltet und nach Inhalt und Form am Ausbildungsziel orientiert werden. Um etwa der modernen Physik mehr Raum zu geben, müssen die klassischen Anteile eher zurückgenommen werden, muss die Betreuung verbessert werden, muss themenorientiertes das fachsystematische Lernen ergänzen; müssen rezeptive Lernformen durch eigen-aktive bereichert werden. In der Studie werden Gedanken, Anregungen und konkrete Vorschläge gegeben, wie man all das in einem LA-Studium sui generis erreichen kann.

Special Talk PV VII Tue 15:00 BEY 154

The German Research Foundation – a short overview — •Cosima Schuster and Michael Mössle — Deutsche Forschungsgemeinschaft, Bonn

The German Research Foundation (DFG) is the central funding organization for basic research in Germany. As a self-governing organization for science and research it offers a broad spectrum of funding opportunities from individual grants to larger coordinated programmes. The talk will give an overview about DFG funding possibilities and the decision processes. In particular, funding programmes for early career scientists will be discussed in detail: the postdoctoral research fellowship for a stay abroad, the temporary position as principal investigator("Eigene Stelle"), and the Emmy-Noether-programme.

Plenary Talk PV VIII Tue 17:40 HSZ 01

Using Spectroscopy to Probe Layered Materials — •Mildred Dresselhaus — Massachusetts Institute of Technology

The talk reviews information provided by Raman spectroscopy about few-layered graphene, transition metal dichalcogenides, and a combination of these materials when stacked together. Comparison with single wall, double wall, and triple wall carbon nanotubes will be made. The use of these layered materials as substrates will also be discussed.

Plenary Talk PV IX Wed 8:30 HSZ 01

The Spin on Electronics! Science and Technology of spin currents in nano-materials and nano-devices — •Stuart Parkin — IBM Research - Almaden, San Jose, California, USA

Recent advances in manipulating spin-polarized electron currents in atomically engineered magnetic heterostructures make possible entirely new classes of sensor, memory and logic devices - a research field generally referred to as spintronics. A magnetic recording read head, initially formed from a spin-valve, and more recently by a magnetic tunnel junction, has enabled a 1,000-fold increase in the storage capacity of hard disk drives since 1997. The very low cost of disk drives and the high performance and reliability of solid-state memories, may be combined in the Racetrack Memory. The Racetrack Memory is a novel three dimensional technology which stores information as a series of magnetic domain walls in nanowires, manipulated by spin polarized currents. Spintronic devices may even allow for plastic devices that mimic synaptic switches in the brain, thereby allowing for the possibility of very low power computing devices.

Prize Talk PV X Wed 13:15 HSZ 01

Electrically driven exciton-polariton lasers — •Sven Höfling — SUPA, School of Physics and Astronomy, University of St Andrews, St Andrews, KY16 9SS, United Kingdom — Laureate of the Walter-Schottky-Prize

Semiconductor diode lasers play a major role in everyday life in our information society. These lasers generate coherent light by stimulated emission of photons. In contrast, laser-like operation can be obtained also by stimulated scattering of bosonic quasi-particles called exciton-polaritons into the ground state of strongly coupled light-matter systems in microcavities. This polariton laser regime can be reached with pump thresholds much lower than needed for conventional laser operation. The exciton-polaritons decay spontaneously by the leakage of photons from the microcavity, which produces a monochromatic and coherent light output above threshold. By utilizing a magnetic field as a tool and probe for polaritonic lasing, exciton-polariton laser operation under electrical pumping is demonstrated, which is essential for developing practical applications.

Plenary Talk PV XI Wed 14:00 HSZ 01

Motions in the molecular machinery powering life — •Gerhard Hummer — Abteilung Theoretische Biophysik, Max-Planck-Institut für Biophysik, 60438 Frankfurt am Main

The molecular machines powering living organisms are highly efficient energy transducers that interconvert chemical, mechanical, electrical, and light energy. We use molecular simulations and statistical mechanical theory to identify and quantify the molecular mechanisms underlying biological energy conversion processes. Central questions are how simple redox reactions in mitochondria drive the pumping of protons across a membrane against a potential of $\sim$0.2 V, without violation of the laws of thermodynamics; how the resulting electrical and chemical potentials in turn drive the rotary molecular motor ATP synthase; and how this rotation is coupled to the regeneration of ATP, the energy currency of live. Remarkably, common physical principles emerge in the function of the energy-transducing proteins, despite large variations in their structure and function.

Plenary Talk PV XII Wed 14:00 HSZ 02

Materials physics on its way to in-depth understanding of real materials — •Reiner Kirchheim — Georg-August-Universität Göttingen, Göttingen, Germany

Man-made materials used in real life are single crystalline, polycrystalline or amorphous with properties optimized by controlling the defect structure and composition of the material. Any further development to novel and advanced materials requires an in-depth understanding of the generation of defect-structures and their interaction with the various chemical components. For instance making materials harder defect generation has to be suppressed and/or their motion has to be retarded. The latter is often achieved effectively by adding solute atoms which interact attractively with the defect where solute occupancy is described by Fermi-Dirac-Statistics. Then the defects have to drag along a solute cloud reducing its velocity. If defects are defined more generally as discontinuities of atom coordination, one can easily show that their formation energies are decreased by segregating atoms or molecules. This comprises the well-known reduction of the surface energy by surfactants. In analogy atoms reducing formation energies of vacancies, dislocations and interfaces etc. are called defactants. Depending on whether the rate determining process is defect motion or generation materials are softened or hardened. The relevance of the defactant concept is exemplified for high strength steels with carbon as a defactant in iron, hydrogen embrittlement or new design rules for nanocrystalline alloys.

Evening Talk PV XIII Wed 20:00 HSZ 01

Wind of change: Was kommt nach der Nuklearenergie? — •Robert Schlögl — Fritz-Haber-Institut der MPG, Faradayweg 4-6, 14195 Berlin — Max-Planck-Institut für Chemische Energiekonversion, Stiftstr. 34-36, 45470 Mülheim an der Ruhr

Die Energiewende in Deutschland fußt auf drei Hypothesen: Wir wollen keine Kernenergie mehr, wir reduzieren den Energieverbrauch durch Einsparungen und wir ersetzen fossile durch regenerative Energie. Dafür hat die Bundesregierung ein Konzept vorgelegt, das eine interessante Mischung aus Wegen und Zielen darstellt. Erst jetzt mitten in der Umsetzung beginnt die Debatte über das Zielsystem. Dabei werden vielfältige wissenschaftliche Annahmen getroffen, die nicht immer gut begründet sind. Die Auffassung, dass Energieversorgung ein System darstellt und demnach auch systemisch zu behandeln ist, findet sich relativ selten in der aktuellen Diskussion.

Plenary Talk PV XIV Thu 8:30 HSZ 01

Topological Defects, Symmetry Breaking, and Phase Transition Dynamics — •Wojciech Zurek — Los Alamos / University of Ulm

As a result of the critical slowing down (the divergence of the relaxation time near the critical point) the dynamics of the non-equilibrium second order phase transition ceases to be adiabatic in the vicinity of the critical point. This results in a local choice of the broken symmetry of the order parameter, and can lead to the formation of topological defects. The Kibble-Zurek mechanism uses equilibrium scalings of the relaxation time and healing length in the vicinity of the critical point to describe the associated non-equilibrium dynamics of symmetry breaking and to estimate the density of topological defects as a function of the quench rate through the transition. Originally developed for classical phase transitions, it has been by now extended to quantum phase transitions (where local symmetry breaking is seeded by quantum rather than classical—e.g., thermal—fluctuations). During recent years, several new experiments investigating formation of defects in phase transitions induced by a quench both in classical and quantum mechanical systems were carried out, and more are on the way. At the same time, some established results were called into question. I will review Kibble-Zurek mechanism focusing in particular on this recent surge of activity, and suggest possible directions for further progress.

Prize Talk PV XV Thu 13:15 HSZ 01

Semiconductor Hetero-, Nano- and Quantum-Systems — •Gerhard Abstreiter — Walter Schottky Institut, Physik Department, and Institute for Advanced Study, TU München, 85748 Garching — Laureate of the Stern-Gerlach-Medal

First I will present a brief historical overview about the development of semiconductor hetero-structures and their importance for device applications based on Ga(In)As/AlGaAs and Si/Ge materials systems. In a second part the electronic and optical properties of semiconductor quantum dots and hetero-nanowires will be discussed. This includes the electro/optical and coherent control of charges, spins, and excitons in In(Ga)As quantum dots as well as infrared optical properties of, and coherent emission from III-V based hetero-nanowires.

Plenary Talk PV XVI Thu 14:00 HSZ 01

Understanding branched flow: from semiconductors to freak waves — •Eric Heller — Harvard University, Cambridge, Massachusetts USA

Branched flow results from a common situation involving wave or ray propagation through weakly deflecting random media for long path lengths. In nature it affects light waves, radio waves, sound waves, ocean waves and matter waves in important ways. Yet its importance is just beginning to be recognized in some of the fields it affects. For example imaging by scanning probe microscopy by the Westervelt group at Harvard recently revealed branched electron flow in 2DEG semiconductor microstructures with vanishing or modest magnetic fields. Branched flow is often the form taken by momentum diffusion and it determines the coherent mean free path.

Branched flow effects have successfully explained observed large enhancements of freak wave probability in the world's oceans. This in turn has been modeled with microwaves in the laboratory of Prof. Dr. Hans-Juergen Stoeckmann in Marburg.

Recent theoretical progress and experiments point to branched flow as a growing field with many applications. Interesting theoretical questions involving formation of the branches, control of branched flow, wave-ray correspondence, source averaging, and more remain and will be described in this talk, along with the nature and applications of branched flow mentioned above.

Plenary Talk PV XVII Thu 14:00 HSZ 02

Optical Antennas for Enhanced Light-Matter Interactions — •Lukas Novotny — ETH Zürich, Photonics Laboratory, 8093 Zürich

Optical antennas consisting of plasmonic materials provide extreme light localization and small mode volumes, thereby boosting the sensitivity and signal-to-noise ratio in applications ranging from single photon sources to photodetection. Optical antennas can also be employed to efficiently control and manipulate light on the nanometer scale and to achieve directional emission. I will review the physical properties of optical antennas, present recent results, and discuss applications.

Plenary Talk PV XVIII Fri 8:30 HSZ 01

Optical Tweezers: Gene Regulation, Studied One Molecule at a Time — •Steven Block — Depts. of Applied Physics and Biology, Stanford University, Stanford CA, U.S.A.

Technical advances have led to the birth a new field, dubbed "single molecule biophysics." Single-molecule methods can record molecular characteristics that are otherwise obscured by traditional, ensemble-based approaches, revealing rich new behaviors. An entire arsenal of techniques with single-molecule sensitivity has now been developed. Prominent among these technologies has been the optical trap, or "optical tweezers," which is based on radiation pressure from an infrared laser. When combined with suitable in vitro assays for function, optical trapping microscopes can measure molecular properties with exquisite precision, down the atomic level (currently achieving a resolution of ˜1 angstrom in a bandwidth of ˜100 Hz), while exerting controlled forces in the piconewton (pN) range. Ultrasensitive systems for measuring force and displacement permit the nanomechanical properties of single molecules to be explored noninvasively. Among the notable successes for optical traps have been measurements of the fundamental steps (and forces) generated by motor proteins and processive nucleic acid enzymes, the strengths of noncovalent bonds between proteins, and the kinetics and energetics of folding in biopolymers, including DNA and RNA. This talk will give special attention to recent success in following the co-transcriptional folding of a nascent RNA molecule in real time as it is synthesized by RNA polymerase, and how its folding can regulate gene expression.