Plenary Talk PLV I Mon 8:30 H1

Linking the International System of Units to Fundamental Constants — •Joachim Ullrich — Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Brauschweig, Germany

In November 2018, the General Conference for Weights and Measures, CGPM, established by the Metre Convention in 1875, decided on the revision of the International System of Units (SI). The signatory states of the Metre Convention represent about 98 % of the world's economic power and, thus, the SI is the very foundation of global, international trade and the reliability of measurements worldwide. As suggested by Max Planck when postulating the "Planck constant" in 1900, the revised SI shall be based on fixing the numerical values of "defining constants": the velocity of light, the elementary charge, the Boltzmann, Avogadro and the Planck constants, the Cs hyperfine clock transition and the luminous efficacy. The revision is based on our present theoretical understanding of the microscopic world and is meant to ensure that the units are valid and realizable "for all times and civilizations, throughout the Universe" as envisioned by Max Planck. The talk will give an overview on the revised SI and its advantages as compared to the previous definitions, focusing in particular on future perspectives for innovative technologies. The question of whether the "defining fundamental constants" are indeed constant in time and the topic of next generation clocks will be addressed briefly.

Plenary Talk PLV II Mon 14:00 H1

Self-propelled topological defects in biological systems — •Julia M Yeomans — The Rudolf Peierls Centre for Theoretical Physics, Clarendon Laboratory, Parks Road, Oxford, OX1 3PU, UK

Active materials, such as bacteria, molecular motors and self-propelled colloids, are Nature's engines. They continuously transform chemical energy from their environment to mechanical work. Dense active matter shows mesoscale turbulence, the emergence of chaotic flow structures characterised by high vorticity and self-propelled topological defects.

The ideas of active matter are suggesting new ways of interpreting cell motility and cell division. I shall discuss recent results indicating that active topological defects may help to regulate turnover in epithelial cell layers and contribute to controlling the structure of bacterial colonies.

Plenary Talk PLV III Mon 14:00 H2

Diamond: a Brilliant Wide Bandgap Semiconductor — •Robert Nemanich — Arizona State University, Tempe, Arizona, USA

Diamond is a semiconductor with extreme and unique properties which enable applications for high power and high frequency electronics, radiation detectors, electron emitters for ultra high voltage vacuum switches and traveling wave tube cathodes, and thermionic emitters for energy conversion.

The extreme and unique properties have enabled phenomena not typical of other semiconductors. Results on high voltage diamond p-i-n diodes have shown high current density injection mode transport, high temperature operation, pulse counting neutron detection and efficient electron emission appropriate for high voltage vacuum switches. Lateral MOSFET devices with ALD dielectrics have sustained a stable two dimensional hole-gas with sheet charge densities greater than 1E13 per cm2. Diamond surfaces have shown record low work functions and demonstrated thermionic energy conversion.

The tremendous progress in diamond applications is now limited by materials challenges. As research progresses, new device concepts are being developed based on the outstanding, extreme and unique properties of diamond materials.

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Plenary Talk PLV IV Tue 8:30 H1

Impact of Turbulence on Cloud Microphysics — •Eberhard Bodenschatz — MPI for Dyanmics and Self-Organization, Physics Institute for Dynamics of Complex Systems, U. Goettingen

Clouds consist of water droplets and ice particles that are dispersed within a highly non-stationary, inhomogeneous, and intermittent turbulent flow. Despite decades of research, a vast community of scientists and considerable measurement infrastructure, insufficient understanding of cloud physics (moist convection and cloud evolution) is a primary source of uncertainty in weather and climate models. Two key factors that can be blamed for the 'cloud challenge' are the enormous scale separations, i.e., the evolution of clouds span a wide range of scales from hundreds of nanometers to hundreds of kilometers, and there is a strong interplay and coupling with turbulence at all scales. A huge challenge is to understand the microphysical processes occurring at sub-meter scales, such as inertial clustering and entrainment of environmental air in clouds. I will formulate the 'cloud challenge' and will show how experiments in the laboratory as well as in the field (Zugspitze, Mobile CloudKite Laboratory, Atlantic and Pacific excursions) can help solve this challenge. This work is supported by the Max Planck Gesellschaft, the Bayerische Staatsministerium fuer Umwelt und Verbraucherschutz, the ITN COMPLETE and the Knut and Alice Wallenberg Foundation. This work is conducted in collaboration with Gholamhossein (Mohsen) Bagheri, Guus Bertens, Johannes Guettler , Antonio Ibanez, John Lawson, Jan Molacek, Freja Nordsiek, Oliver Schlenczek.

Plenary Talk PLV V Tue 17:15 H1

The Dark Energy of Quantum Materials — •Laura H Greene — National MagLab and Florida State University

The nearly 80-year-old correlated electron problems remain largely unsolved; with one (of two) stunning success being BCS electron-phonon mediated conventional superconductivity. There are dozens of families of superconductors that are unconventional including the high-Tc cuprates, iron-based, and heavy fermions. Although these materials are disparate in many properties, some of their fundamental properties are strikingly similar, including their ubiquitous phase diagram; with intriguing correlated-electron phases above the superconducting transition. These remain among the greatest unsolved problems in physics, today; and a fun analogy stressing this will be presented. I will start with a short introduction to the MagLab.

Evening Talk PLV VI Tue 18:30 H1

Lise-Meitner-Lecture: Sculpted light in nano- and microsystems — •Halina Rubinsztein-Dunlop — University of Queensland, Brisbane, Australia

Use of spatial light modulators enables unprecedented control and highest versatility of light and its forms. Light can be now structured or sculpted in such a way that it enables control of matter and studies of light matter interactions in many fields of at scales ranging from nano to microsystems, from quantum physics to complex biological systems.

A light beam can exchange both linear momentum and angular momentum with a microscopic object. Methods based on these two phenomena promise high flexibility and an opportunity for driving these objects in microfluidic devices or inside a biological cell or developing methods that enable manipulation of large biological objects in vivo and combining it with optogenetics. It also allows production of flexible optical potential for use in quantum atom optics.

The use of the angular momentum of light enables introduction of controlled rotation of microscopic objects. Quantitative measurements of this rotation are possible through a measurement of the change of polarisation state of light after passing through the object. The transfer of the angular momentum can then be used for several applications in biology and medicine. One of such application is microrheology of complex fluids that exhibit both viscous and elastic behaviours. The use of orbital angular moment presents further advantages in creating highly controllable devices as for example bio-analogues.

Plenary Talk PLV VII Wed 8:30 H1

Mechanics of Single Protein Molecules — •Matthias Rief — Physikdepartment der TU München, Garching, Germany

Proteins are amazing molecular machines that can fold into a complex three dimensional structure. Even though powerful structural methods have allowed us taking still photographs of protein structures in atomic detail, the knowledge about the pathways for conformational changes and the associated dynamics is still limited. Over the past 15 years, our group has developed single molecule mechanical methods to study the dynamics and mechanics of protein structures. In my talk I will illustrate how these methods can be used to investigate and control the conformational mechanics of individual proteins. Examples include protein folding as well as protein-protein interactions and enzyme mechanics.

Plenary Talk PLV VIII Wed 14:00 H1

Physics and applications of nanomembranes: A fantastic voyage through disciplines — •Oliver G. Schmidt — Institute for

Integrative Nanosciences, Leibniz IFW Dresden, Germany

Nanomembranes are thin, flexible, transferable and can be shaped into unique 3D micro- and nanoarchitectures. This makes them attractive for various scientific disciplines and application scenarios ranging from flexible magnetoelectronics and strainable quantum photonic devices to unique 3D microsystems for functional deployment both on and off the chip.

If assembled into microtubes, rolled-up nanomembranes represent cylindrical microobjects with intriguing optical, plasmonic, electronic and magnetic properties. These lead to exciting application potential in 3D electronics and photonics, sensorics and energy storage units. As off-chip components rolled-up microtubes address novel biophysical and biomedical applications such as biomimetic microelectronics and powerful self-propelling microautonomous systems. Based on these concepts, cellular cyborg machinery is put forth as a new scheme for targeted drug delivery and reproduction technologies.

Plenary Talk — PLV IX — Wed 14:00 — H2

Vestigial order in quantum materials — •Jörg Schmalian — Karlsruhe Institute of Technology

A hallmark of the phase diagrams of quantum materials is the existence of multiple electronic ordered states. In many cases those are not independent competing phases, but instead display a complex intertwinement. In this talk, we focus on a realization of intertwined order with a fluctuation-driven vestigial phase, characterized by a composite order parameter. We demonstrate that this concept naturally explains the nematic state in iron-based superconductors and nematic superconductivity in doped topological insulators. In addition, we propose states of algebraic order in frustrated magnets and a mechanism for charge-4e superconductivity with half flux quanta, accompanied by Majorana bound states in triplet superconductors. The formalism, based on a symmetry classification of vestigial order, provides a general framework to understand the complexity of quantum materials. Electronic states with scalar and vector chiral order, spin-nematic order, Ising-nematic order, time-reversal symmetry-breaking order, and algebraic vestigial order emerge from one underlying principle

Evening Talk — PLV X — Wed 20:00 — H1

The overproduction of truth. Passion, competition, and integrity in modern science — •Gianfranco Pacchioni — University Milano-Bicocca, Dipartimento di Scienza dei Materiali, Milan, Italy

The way science is done has changed radically in recent years. Scientific research and institutions, which have long been characterized by passion, dedication and reliability, have increasingly less capacity for more ethical pursuits, and are pressed by hard market laws. From the vocation of a few, science has become the profession of many, possibly too many. These trends come with consequences and risks, such as the rise in fraud, plagiarism, and in particular the sheer volume of scientific publications, often of little relevance. We will critically review and assess the present-day policies and behaviors in scientific production and publication. We will touch on the tumultuous growth of scientific journals, in parallel with the growth of self-declared scientists over the world. We will investigate the loopholes and hoaxes of pretend journals and nonexistent congresses, so common today in the scientific arena, and discuss problems connected to the incorrect use of bibliometric indices, which have resulted in large part from the above distortions of scientific life. The solution? A slow approach with more emphasis on quality rather than quantity that will help us to rediscover the essential role of the responsible scientist.

Plenary Talk — PLV XI — Thu 8:30 — H1

Beyond the molecular movie: The ultrafast electronic structure view of surface dynamics — •Martin Wolf — Fritz Haber Institute of the Max Planck Society, 14195 Berlin, Germany

In a Born-Oppenheimer description, atomic motions evolve across a potential energy surface determined by the occupation of electronic states as a function of nuclear coordinates. A key goal of structural dynamics is therefore to record a "molecular movie" of the atom positions. Ultrafast photo-induced phase transitions provide a test case for how the forces and resulting nuclear motion along the reaction coordinate originate from a non-equilibrium population of excited electronic states. Moreover, small changes of nuclear positions in solids can correlate with dramatic electronic structure changes (e.g. conductivity). In this talk I discuss recent advances in time-resolved spectroscopy allowing for direct probing of the underlying fundamental steps of ultrafast non-equilibrium dynamics of solids and surfaces like ultrafast phase transitions, coherent lattice excitations or chemical reactions at surfaces. Utilizing photoemission with femtosecond XUV laser pulses (trARPES), we obtain direct access to the transient electronic structure during the ultrafast phase transition in indium nanowires on Si(111) and lay out a detailed reaction pathway. Experiments at the X-ray free electron laser LCLS performed with time-resolved resonant inelastic x-ray scattering (trRIXS) provide direct insight into chemical bond formation in ultrafast surface reactions. Finally I will discuss recent attempts to access the space-time limit in surface dynamics using time-resolved scanning probe techniques.

Plenary Talk — PLV XII — Thu 14:00 — H1

Quantum computing - progress towards applications — •Heike Riel — IBM Research, Rüschlikon, Switzerland

For nearly 70 years the microelectronics industry built increasingly powerful programmable systems with performance and economics driven by Moore's Law and enabling some of the seminal breakthroughs of the twentieth century. Today one of the most exciting new frontiers of information technology is quantum computing. In the recent years rapid progress in development of quantum technologies has been achieved. Quantum computers promise to outperform conventional computers in certain types of problems such as, e.g., combinatorial optimization, algebraic algorithms, machine learning, and computation of complex many-body physical systems. In this presentation our recent developments towards a scalable quantum computing platform using superconducting Qubit technology integrated into an end-to-end ecosystem will be discussed. Furthermore, technological progress towards tackling practical applications with potential advantage on near-term quantum computing hardware will be highlighted. In that regard an error mitigation technique to obtain zero-noise estimates of expectation values that require no additional quantum resources is introduced.

Plenary Talk — PLV XIII — Thu 14:00 — H2

The Physics of Inference and Community Detection — •Cristopher Moore — Santa Fe Institute

There is a deep analogy between statistical inference and statistical physics. Just as a block of iron suddenly loses its magnetic field when it reaches a critical temperature, data can suddenly become impossible to analyze if it becomes too noisy or too incomplete. I'll focus on the case of finding communities in social and biological networks, and the "detectability transition" beyond which we cannot classify nodes better than chance, or even tell whether community structure really exists. We'll see how physics both helps us locate these phase transitions, and gives us optimal algorithms that succeed all the way up to this point. Along the way, I will visit ideas from computational complexity, random graphs, and spin glass theory.

Plenary Talk — PLV XIV — Fri 8:30 — H1

Soft Matter: Topological constraints do matter — •Kurt Kremer — Max-Planck-Institut für Polymerforschung

Most biological systems and a huge class of everyday products ranging from simple plastics to complex functional systems and to most foods are made of soft matter. Its generic properties are mostly governed by the statistical mechanics of strongly fluctuating huge molecules, such as polymers. For this the plain fact that polymer chains cannot cross through each other introduces significant constraints and is of central importance, e.g. for polymer rheology where entanglements dominate the dynamics or for chromosome territories in the cell nucleus in biophysics, where topology induced repulsion plays a role. Such constraints can be permanent (quenched), as for gels and networks or ring polymers or temporary (annealing) but long lived as in polymer melts or for chromosome organization in the cell nucleus. By manipulating entanglements new non-equilibrium materials can be made. Currently there is no comprehensive analytic theory, which links topological constraints to material properties. The talk will give an overview of recent developments and point to some challenging opportunities based on advances in computational physics of soft matter and experiment.