Evening Talk PLV I Sun 18:30 HSZ 01

Was müssen wir wissen, um glauben zu dürfen? — •Joachim Treusch — Bremen

Das Gehirn des Menschen ist von der Evolution zu enormen Leistungen hin entwickelt worden, es hat aber auch systembedingte Schwächen: Da es aus pragmatischen Gründen von erfahrungsgeprägten Vorurteilen lebt, öffnet es damit die Tür für Manipulationen, sei es durch Medien, Statistiken, Wirtschaft, Wissenschaft oder Politik. Einige einfache Maßnahmen zur Abwehr dieser Gefahr werden in den Themenfeldern Verkehr und Umwelt, Gesundheit, Information und Künstliche Intelligenz anhand von aktuellen Beispielen geschildert. Zum Schluss wird in diesem Kontext ein kurzer Blick auf die derzeitige Weltpolitik geworfen. Die Folgerungen aus all diesen Beispielen und Überlegungen lauten: 1. Da niemand alles wissen kann, bedarf es immer eines gewissen Vertrauens des Informationsempfängers in den Informationsgeber, und 2. es gibt Grundrezepte, wie man sich die Vertrauenswürdigkeit auf der Senderseite erwerben und wie man sie auf der Empfängerseite - jedenfalls ansatzweise - prüfen kann.

Plenary Talk PLV II Mon 8:30 HSZ 01

Bicontinuous Structures in Charged Polymer Blends — •Timothy Lodge — University of Minnesota, Minneapolis, MN, USA

Nanostructured materials with co-continuous structures, in which each discrete domain is independently interconnected, can simultaneously achieve orthogonal properties such as rapid ion transport and excellent mechanical strength. Potential applications include porous membranes, fuel cells, and rechargeable metal batteries. A promising route involves blending an AB diblock copolymer with the constituent A and B homopolymers, leading to a disordered bicontinuous microemulsion (BuE) state. We have shown that charge-free ternary AB/A/B polymer blends universally self-assemble into the thermodynamically stable BuE phase, albeit with carefully designed molecular weights and compositions. The BuE is found in a narrow window near the location of an isotropic Lifshitz point predicted by mean-field theory, and is presumably stabilized by fluctuations. The interesting question that arises is whether this phase can also be accessed in blends containing charge, where in general the intermolecular interactions are stronger and more long-ranged. We are exploring this issue in two cases: an AB/A/B ternary system with added salt, and an AB/A/B system in which one of the polymers is ionomeric. Surprisingly, in both cases an even wider BuE channel occurs for symmetric compositions (equal volumes of A and B), despite huge asymmetries in the binary blend phase diagram for the same system.

Plenary Talk PLV III Mon 14:00 HSZ 01

Functional Three Dimensional Mesostructures as Bioelectronic Interfaces — •John Rogers — Northwestern University, Evanston, IL, USA

Complex, three dimensional (3D) assemblies of nanomaterials provide sophisticated, essential functions in even the most basic forms of life. Compelling opportunities exist for analogous 3D structures in manmade devices, but existing design options are highly constrained by comparatively primitive capabilities in fabrication and growth. A recent collection of advanced concepts in thin film physics, materials science and mechanical engineering provide broad access to diverse, highly engineered classes of 3D architectures in diverse classes of functional materials and devices, with characteristic dimensions that range from nanometers to centimeters and over areas that span square centimeters or more. The approach relies on geometric transformation of preformed two dimensional (2D) precursor micro/nanostructures and/or devices into extended 3D layouts by controlled processes of substrate-induced compressive thin film buckling, where the bonding configurations, thickness distributions and other parameters control the final configurations. This talk reviews the key physics concepts associated with this scheme, and focuses on the most recent developments with example applications at the bio-interface.

Plenary Talk PLV IV Mon 14:00 HSZ 02

Operando Nanocatalysis — •Beatriz Roldan Cuenya — Fritz Haber Institute of the Max Planck Society

Tailoring the chemical reactivity of nanomaterials at the atomic level is one of the most important challenges in catalysis research. However, in order to achieve this elusive goal, we must first obtain fundamental understanding of the structural and chemical properties of these complex systems. In addition, the dynamic nature of the nanoparticle (NP) catalysts and their response to the environment must be taken into consideration. Despite the significant progress in experimental tools for NP characterization and theoretical NP modeling approaches, understanding the relation between intriguing properties of metal NPs and their structure and surface composition is still a challenging task. The intrinsic complexity and heterogeneity of NPs, their interactions with the support, ligands and adsorbates, strong static disorder and anharmonic effects at NP surface, or in situ transformations of their structure pose significant difficulties both for theoretical modeling and for the interpretation of experimental data. I will address some of these issues by bridging theoretical modeling and experiments via machine learning methods. Experimentally I will take advantage of a variety of cutting-edge complementary experimental methods (EC-AFM, EC-TEM, TPD, NAP-XPS, XAFS, MS/GC) to gain new insights into the thermal hydrogenation and electrocatalytic reduction of the greenhouse gas CO2 over supported metal NPs. Our results will open up new routes for the reutilization of CO2 through its direct conversion into valuable chemicals and fuels such as ethylene, methanol and ethanol.

Plenary Talk PLV V Tue 8:30 HSZ 01

Thousands of New Worlds: How to characterize Habitable Worlds and find signs of life — •Lisa Kaltenegger — Carl Sagan Institute Cornell University, Ithaca, NY, USA

The detection of exoplanets orbiting other stars has revolutionized our view of the cosmos. First results suggest that it is teeming with a fascinating diversity of rocky planets, including those in the habitable zone. Even our closest star, Proxima Centauri, harbors a small planet in its habitable zone, Proxima b.

With the next generation of telescopes, we will be able to peer into the atmospheres of rocky planets and get a glimpse into other worlds. Using our own planet and its wide range of biota as a Rosetta stone, we explore how we could detect habitability and signs of life on exoplanets over interstellar distances. Current telescopes are not yet powerful enough to characterize habitable exoplanets, but the next generation of telescopes that is already being built will have the capabilities to characterize close-by habitable worlds.

This talk will present and discuss the latest results, the challenges of how to identify and characterize such habitable worlds, and how near-future telescopes will revolutionize the field. For the first time in human history, we have developed the technology to detect potentially habitable worlds. Finding thousands of exoplanets has taken the field of comparative planetology beyond the Solar System.

Plenary Talk PLV VI Tue 17:00 HSZ 01

Rydberg Excitons in Cuprous Oxide — •Manfred Bayer — Experimentelle Physik 2, TU Dortmund, D-44227 Dortmund, Germany

Excitons determine the optical properties of semiconductors and recently have attracted strong renewed interest because of novel materials with exciton binding energies exceeding by far the thermal energy at ambient conditions. Excitons were demonstrated first in cuprous oxide with a binding energy of about 90 meV, showing also that the hydrogen model provides a reasonable description of the exciton series. In 2014, high-resolution laser spectroscopy combined with high crystal quality allowed the observation of the hydrogen-like series up to the principal quantum number n=25 in cuprous oxide, corresponding to huge wave function exciton extensions in the micrometer range. This demonstration has formed the basis for taking unprecedented insights into exciton physics, for which several examples will be given: (a) Applying a magnetic field not only gives concise understanding of the exciton levels, but also allows to enter the regime of quantum chaos with surprising features like breakdown of all anti-unitary symmetries. (b) Similar to Rydberg atoms, the huge exciton size leads to giant interaction effects such as the Rydberg blockade, where injection of a single Rydberg exciton blocks the resonant excitation of another Rydberg exciton in a micrometer-sized surrounding. Recent studies suggest that the underlying interaction is of Van der Waals-type. This demonstration could lead to implementations of quantum technologies in an application-friendly, engineerable semiconductor environment.

Plenary Talk PLV VII Wed 8:30 HSZ 01

Physics of Morphogenesis — •Stephan Grill — Max Planck Institute of Molecular Cell Biology and Genetics, Dresden — Cluster of Excellence Physics of Life, TU Dresden

One of the most remarkable examples of self-organized structure formation is the development of a complex organism from a single fertilized egg. With the identification of the molecules that participate in this process, attention has now turned to capturing the physical principles that govern the emergence of biological form. The movements inside cells and tissues that give rise to patterns and shape reflect the action of physical forces. However, the biochemical systems that guide morphogenesis are tightly intertwined with active mechanical processes. How such coupled mechanical and chemical systems self-organize, and how these self-organized modules are guided by genetic programs is not well understood. In this presentation, I will give an overview of how mechanical processes couple to regulation and biochemistry in living biological matter. I will discuss examples of mechanochemical coupling that we have been working on on the scales of molecules, cells and organisms, and present a theory of guided mechanochemical self-organization we have used to investigate morphogenetic events in the development of a nematode worm and a flour beetle.

Plenary Talk PLV VIII Wed 14:00 HSZ 01

Revealing the topological nature of transport at mesoscopic scales with quantum interferences — Anil Murani, Alik Kasumov, Alexandre Bernard, Meydi Ferrier, Richard Deblock, Bastien Dassonneville, Sophie Guéron, and •Hélène Bouchiat — Laboratoire de Physique des Solides CNRS Université Paris Saclay

A mesoscopic conductor is characterized by its size smaller than the phase coherence length of electronic wave-functions (typically one micrometer at low temperature). Mesoscopic electronic transport depends strongly on the nature of interferences between these wave functions determined by the scattering disorder potential which tends to localize electronic states at low dimension. Moreover, these interferences can be modulated by a magnetic flux through the Aharonov-Bohm effect giving rise to orbital persistent currents in ring geometries. These interferences also determine the Josephson supercurrent of a mesoscopic normal conductor when connected to superconducting electrodes. We show that these basic fundamental properties of mesoscopic quantum interferences can be used to reveal the existence and the physical location of 1d protected states in topological insulators. This method is illustrated in the case of crystalline bismuth nanowires which were found to belong to a class of newly discovered higher order topological insulators with helical ballistic hinge states coexisting with trivial bulk and surface diffusive states. In particular we discuss SQUID like periodic magnetic oscillations observed in Bi based Josephson junctions.

Plenary Talk PLV IX Wed 14:00 HSZ 02

Stochastic thermodynamics: Concepts and applications — •Udo Seifert — Universität Stuttgart

For the macroscopic world, classical thermodynamics formulates the laws governing the transformation of various forms of energy into each other. Stochastic thermodynamics extends these concepts to micro- and nano-systems embedded or coupled to a heat bath where fluctuations play a dominant role. Examples are colloidal particles in time-dependent laser traps, single biomolecules manipulated by optical tweezers or AFM tips, and transport through quantum dots. For these systems, exact non-equilibrium relations like the Jarzynski relation, fluctuation theorems and, most recently, a thermodynamic uncertainty relation have been discovered. First, I will introduce the main principles and show a few representative experimental applications. In the second part, I will discuss the universal trade-off between the thermodynamic cost and the precision of any biomolecular, or, more generally, of any stationary non-equilibrium process. By applying this thermodynamic uncertainty relation to molecular motors, I will introduce the emerging field of "thermodynamic inference" where relations from stochastic thermodynamics are used to infer otherwise yet inaccessible properties of nano-scale systems. I will close with recent insights into the minimal requirements for creating coherent oscillations at finite temperature.

Evening Talk PLV X Wed 20:00 HSZ 01

Farbrestaurierung einer Gemäldeserie von Mark Rothko durch Licht eines digitalen Projektors — •Jens Stenger — Zürich, Schweiz

1962 schuf Mark Rothko eine Serie von Leinwandgemälden für einen Empfangsraum an der Harvard Universität. Diese Arbeiten, heute bekannt unter dem Namen Harvard Murals, waren 15 Jahre lang extremer Einwirkung von Tageslicht ausgesetzt, der das Pigment Litholrot in Rothkos Farben nicht standhielt. Da diese Ausbleichung nicht mit herkömmlichen Methoden restauriert werden kann, wurde ein neuer Ansatz zur Wiederherstellung der ursprünglichen Farbe mittels Licht eines digitalen Projektors erprobt. Ein Kamera/Projektor-System charakterisiert die Reflektionseigenschaften der bemalten Leinwandoberfläche sowie die Kennlinien des Projektors. Der Vergleich mit einem digitalen Bild der Gemälde im originalen, noch nicht verbleichten Zustand ermöglicht die Berechnung eines Kompensationsbildes, das dann auf die ausgebleichte Leinwand projiziert wird. Durch diesen Augmented-Reality-Ansatz erscheint der Gemäldezyklus in seiner ursprünglichen Farbe, ohne dass materiell etwas geändert wurde.

Plenary Talk PLV XI Thu 8:30 HSZ 01

THz-ARPES band structure movies of Dirac surface currents — •Ulrich Höfer — Fachbereich Physik, Philipps Universität Marburg, Germany

Time-resolved photoelectron spectroscopy combines femtosecond pump-probe techniques with angle-resolved photoelectron spectroscopy (ARPES). New opportunities for this powerful technique arise in combination with THz excitation. As an example, I will explain how THz-ARPES can be used to measure electron transport in the Dirac surface state of a three-dimensional topological insulator in a contact-free fashion and with femtosecond time resolution. We induce electrical currents in these states with the carrier wave of strong THz transients, and we directly access their dynamics in momentum space with subcycle time resolution. As a result of spin-momentum locking, the accelerated spin-polarized electrons reach ballistic mean free paths of several hundreds of nanometers.

Subcycle THz-ARPES not only provides a way of observing carrier transport in k-space. The method may well herald a new era of time-domain investigations of new materials and phenomena. I will briefly discuss perspectives and experimental challenges of the technique.

Plenary Talk PLV XII Thu 14:00 HSZ 01

Pico-Photonics: what can be seen with extreme confinement of light — •Jeremy Baumberg — NanoPhotonics Centre, Cavendish Laboratory, University of Cambridge

Recent advances in using noble metals to confine light to the sub-nm3 scale through advanced plasmonics is opening up a new realm of *picoscopy*. I will show how a wide range of dynamic motions of atoms and molecules can be studied on microsecond timescales under ambient conditions, vital for nanoscale applications at interfaces that have been inaccessible.

I will show how simple nano-architectures enable such trapping of visible light, and how elastic and inelastic light scattering reveal detailed spectral information about extremely small volumes of space [1-3]. I will also show how this can generate optical forces sufficient to move individual atoms, molecules, and nanoparticles, and develop the new area of molecular optomechanics. Using nano-composites of plasmonic nanoparticles and thermos-responsive polymers I will demonstrate the utility of the nN forces produced at sub-μs speeds, for creating new types of active nanomachinery.

References: [1] Nature Materials 18, 668 (2019); [2] Nature 535, 127 (2016); [3] Science 354, 726 (2016)

Plenary Talk PLV XIII Thu 14:00 HSZ 02

A Path Towards Room Temperature Superconductivity? — •Mikhail Eremets — Mikhail Eremets, Max-Planck-Institut fur Chemie, Hahn-Meitner Weg 1, 55128 Mainz, Germany

Room-temperature superconductivity is one of the most challenging and long-standing problems in condensed-matter physics. In 2014, we discovered superconductivity at 203 K in H_3S at high pressure, breaking archaic paradigms on conventional superconductivity. Last year, with the advancement of the field, T_c of 250 K was reached in a superhydride LaH_{10}. The mechanism governing these exceptional superconductors is the conventional electron-phonon coupling. Theoretically, predictions point out other compositions that could superconduct at temperatures as high as 470 K. These record-breaking superconductors are the result of chasing of a 50 years old prediction of high-temperature superconductivity in hydrogen. In this respect, we will discuss the most recent efforts on seeking for the superconducting phase of hydrogen. The progress towards room temperature superconductivity is likely to be related first to hydrides under pressure. I will summarize the talk with perspectives for high-temperature conventional superconductivity at moderate and ambient pressure which is expected from arrangements of atoms of light-elements.

Plenary Talk PLV XIV Fri 8:30 HSZ 01

Machine Learning meets Quantum Physics — •Klaus-Robert Müller — TU Berlin, Computer Science, ML Group, Berlin — Korea University, Anam, Seoul — MPII, Saarbrücken

The talk will first briefly introduce machine learning (ML) concepts, before applying them in Quantum chemistry and materials. This will include kernel-based learning methods and deep neural networks. A particular focus will lie on the challenge of interpreting nonlinear machine learning models. In other words, given that we have an excellent predictor of quantum chemical properties, how can we gain an understanding of the physics or chemistry that this learning machine has implemented? I will show selected examples of ML applied for predicting properties of small molecules and also for materials.