Plenary Talk PV I Mon 8:30 Audimax

Imaging the quantum world in real space — •Tilman Pfau — 5. Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany

To observe matter waves optical microscopy is a standard tool. As long as the temperature is lower than the kinetic energy change caused by a single scattered photon the matter wavelength can be resolved in real space. In this ultracold regime in situ images allow for the observation of previously elusive new states of matter like the supersolid. Analyzing the fluctuations in hundreds of such images the structure factor can be mapped out, that reveals elementary excitations like sound or so called roton modes.

Optical techniques can also resolve single atoms via their fluorescence. This technique is used as readout for quantum computers or simulators. In optical quantum gas microscopes stunning pictures of e.g. antiferromagnetic order or the Pauli hole have been reported. An alternative microscope for ultracold single atoms is based on fast photoionization of atoms. An ion microscope combined with an ultracold atom setup recently allowed for the spatially resolved observation of a molecular ion bound by a previously unknown mechanism. Based on these images the bond length and the alignment of the molecule could be determined.

With the help of such ever improving imaging techniques we will continue to gain new insights into the two, few- and many-body quantum physics of synthetic materials.

Plenary Talk PV II Mon 9:15 Audimax

Introducing the All-Optical Attoclock — •Uwe Morgner — Institute of Quantum Optics and Cluster of Excellence PhoenixD, Hannover, Germany

Theoretical physics and extensive computer simulations reveal the dynamic interaction of atoms and molecules with strong laser fields on attosecond time- and Angstrom length scales. However, experimental access is quite limited to indirect methods such as high-harmonic or electron spectroscopy.

Now, a novel method is introduced: The Optical Attoclock. After ionization, the free electron is accelerated in the strong field of the light pulse; its exact trajectory depends on the field profile of the laser pulse, on the dynamic details of the tunnel ionization process, and on the local charge distribution in the atomic environment. The accelerated electrons emit light, the Brunel radiation, located in the VIS/UV spectral range. A precise analysis of this radiation opens up a novel window of access into the interaction dynamics of atoms, molecules, and solids.

The lecture introduces the theoretical and experimental state-of-the-art for exploring a topical area of today's physics.

Prize Talk PV III Mon 10:30 Audimax

High resolution laser mass spectrometry in isotope physics applications - balancing selectivity against sensitivity and vice versa — •Klaus Wendt — Institut für Physik, Johannes Gutenberg-Universität, D-55099 Mainz — Laureate of the Robert-Wichard-Pohl-Prize 2022

Based entirely on historical atomic physics technologies, as developed by J.J. Thomson and F. Atkins much more than 100 years ago in the Cavendish laboratories and few others, mass spectrometry (MS) has delivered a significant part of our understanding of the nature of matter, specifically allocating individual elements and their isotopes. Since then, numerous MS methods were developed and have revolutionized investigations in analytics, e.g., in chemistry, biology and medicine. Similarly, our knowledge in fundamental atomic, quantum, nuclear and particle physics has been put forward tremendously by ion manipulation and storage based on MS techniques. On one side MS is severely limited by isobaric interferences caused by the variety of stable and radioactive isotopes of all the elements of the Periodic Table, on the other side, the specific investigation of rare isotopes and the prevention of this effect is of high relevance for a variety of research fields. As will be discussed, the use of resonant laser light for element- and isotope-selective ionization not only opens up new perspectives for MS far beyond routine applications, but represents an independent research tool for precision, atomic and nuclear structure physics, where MS is just used as a background free and sensitive detection unit.

Plenary Talk PV IV Tue 8:30 Audimax

Reduce, Reuse, 'Restore'. GHG Emissions from the Viewpoint of a Rock Physicist — •Frank R. Schilling — Technische Petrophysik (AGW), KIT, Karlsruhe, Germany

To reduce the anthropogenic contribution of greenhouse gases on global warming, different perspectives are debated. In this contribution, three major strategies and their potentials are discussed: To reach the goal set by COP21* in Paris (2015) by reducing GHG in the Earth's atmosphere, some 100 billion tonnes of CO_2 will have to be reduced, reused or (re)stored by the end of the century.

In view of this great challenge, different potentials will be discussed. The focus will be the underground storage option for CO_2. What are the potentials, how safe is storage, what are possible trapping mechanisms (structural, chemical, physical) in the underground, and why caverns seem no option for long-term storage. Insights from the first European Onshore Project and recent developments will be used to address some hurdles that need to overcome in the next decades if some hundred million tons of GHG should be (re)stored underground safe and secure.

*COP21: United Nations Climate Change Conference 2015. The key result of the 196 parties was an agreement to set a goal of limiting global warming to 'well below 2 °C' compared to pre-industrial levels.

Plenary Talk PV V Tue 9:15 Audimax

Chirality differentiation and manipulation using tailored microwave fields — •Melanie Schnell — DESY, Hamburg, Germany — CAU Kiel, Germany

Chirality is ubiquitous in nature and involved in many aspects of life, making it an important phenomenon to understand. The enantiomers of chiral molecules have identical physical properties (despite the predicted small contributions due to parity-violating weak interactions), while their chemical and biochemical properties can differ dramatically. Due to these different behaviors, the development of sensitive spectroscopic methods that can differentiate and/or separate molecules of opposite handedness, particularly in complex sample mixtures, are of utmost importance.

In recent years, there is tremendous development in chiral molecule research. Powerful methods to analyse and control chirality in the gas phase have been developed, up to the attosecond range. In my group, we focus on characterizing, controlling, and manipulating chirality using microwave radiation. Using a coherent, non-linear, and resonant microwave three-wave mixing approach, we can differentiate enantiomeric pairs of chiral molecules using tailored microwave pulses. The technique is uniquely mixture-compatible and allows for enantiomer separation, as will be discussed.

Plenary Talk PV VI Wed 8:30 Audimax

Topology meets strong-field physics — •Dieter Bauer — Institute of Physics, University of Rostock, 18051 Rostock, Germany

Strong-field physics was developed to describe the non-perturbative interaction of intense laser pulses with atoms and molecules in the gas-phase and led to the discovery of prominent phenomena such as above-threshold ionization and high-harmonic generation, including the creation of attosecond pulses. About ten years ago, strong-field physics in condensed matter started to attract more and more attention. In particular, it was found that intense laser fields can be used to steer ultrafast currents in solids and that high-harmonic generation offers an attractive approach to "image" condensed matter non-invasively on ultrashort time scales (without destroying the target). As modern condensed matter physics involves topological effects to a large extent, natural questions are "How do topological effects manifest in typical strong-field observables?" and "How can topological effects be created with lasers in the first place?" In my talk, I will give an introduction into topological strong field physics, discuss recent advances, and address the above questions.

Plenary Talk PV VII Wed 9:15 Audimax

Quantum simulation of dissipative collective effects on noisy quantum computers — •Sabrina Maniscalco[1,2,4], Marco Cattaneo[1,4], Matteo Rossi[2,3], Guillermo Garcia Perez[1,2], and Roberta Zambrini[4] — [1]QTF Centre of Excellence, Department of Physics, University of Helsinki, P.O. Box 43, FI-00014 Helsinki, Finland — [2]Algorithmiq Ltd, Kanavakatu 3C 00160 Helsinki, Finland — [3]Instituto de Fisica Interdisciplinar y Sistemas Complejos (IFISC, UIB-CSIC), Campus Universitat de les Illes Balears E-07122, Palma de Mallorca, Spain — [4]QTF Centre of Excellence, Department of Applied Physics, School of Science, Aalto University, FI-00076 Aalto, Finland

I will present the first fully quantum simulation of dissipative collective effects on a near-term quantum computer. We employ a recently introduced algorithm based on a collision model to implement the superradiant and subradiant dynamics of two qubits on a near-term quantum device.

Our experimental outcomes successfully display the emergence of dissipative collective effects on a near-term device. Furthermore, full process tomography allows us to compare different figures of merit for the gate errors. We show that a common procedure broadly employed in the literature to estimate the experimental average gate fidelity, namely randomized benchmarking, may not always be reliable. In addition, rigorous computation of the gate errors shows that the thresholds for fault-tolerant computation are still orders of magnitude away in near-term devices.

Prize Talk PV VIII Wed 19:00 Audimax

Amazing light that brightens our research — •Jun Ye — JILA, National Institute of Standards and Technology and University of Colorado — Laureate of the Herbert-Walther-Prize 2022

Increasingly precise control of light-matter interactions has enabled breakthroughs in science and technology over centuries. Recent innovations in quantum and laser technologies are providing emerging opportunities for fundamental discovery and practical application. We are probing matter with novel spectroscopy to develop new sensing tools, testing fundamental laws to search for new physics, and exploring quantum complexity to harness its power.

Plenary Talk PV IX Thu 8:30 Audimax

Time-resolved coherent spectroscopy of dilute samples — •Frank Stienkemeier — Institute of Physics, University of Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

In the infrared to visible spectral range, coherent nonlinear spectroscopy is an important concept for the real-time study of ultrafast dynamics in complex quantum systems, and has been a driving force for the understanding of biological light harvesting and opto-electronics. The technique exploits the wave properties of matter detecting interference phenomena, in this way obtaining fine details of the probes. However, corresponding experiments on dilute atomic or molecular systems on the one hand, and on XUV or X-ray wavelength on the other hand, have been hindered by severe experimental challenges. In this talk recent progress will be presented, demonstrating unprecedented sensitivity for dilute samples and sub-cycle phase stability even at XUV and soft X-ray wavelength, entering the attosecond domain for corresponding interferometric experiments.

Plenary Talk PV X Thu 9:15 Audimax

Secure Communications using Quantum Continuous Variables. — •Philippe Grangier — Laboratoire Charles Fabry, Institut d'Optique, CNRS, Université Paris-Saclay, Palaiseau, France

During the last 20 years Quantum Continuous Variables have emerged as a valid and interesting alternative to the usual qubits for quantum information processing. We will briefly review these developments, and focus on continuous variable (CV) quantum key distribution (QKD) [1-2], which is much closer to standard optical telecommunication techniques than discrete variable (DV) QKD. In particular, CVQKD does not use photon counters, but coherent (homodyne or heterodyne) detections, which are now very usual in high-speed commercial telecom systems. In addition, using a truly local oscillator allows one to simplify security issues, and to eliminate potentially unsecure side channels. We will present recent developments in CVQKD using Probabilistic Constellation Shaping, also related to recent security proofs [3], and to hardware improvement [4]. This talk will illustrate the potential of CVQKD, and of CV in general, for a widespread use in secure communication networks.

[1] F Grosshans, G V Assche, J Wenger, R Brouri, N J Cerf and P Grangier, Nature 421, 238 (2003). [2] P Jouguet, S Kunz-Jacques, A Leverrier, P Grangier and E Diamanti, Nat. Photonics 7, 378 (2013). [3] A Denys, P Brown, A Leverrier, Quantum 5, 540 (2021). [4] F Roumestan, A Ghazisaeidi, J Renaudier, L Trigo Vidarte, E Diamanti, P Grangier, ECOC 2021, Bordeaux, France. doi:10.1109/ECOC52684.2021.9606013t

Evening Talk PV XI Thu 19:00 MVL

Max-von-Laue Lecture: Risikokompetenz – informiert und entspannt mit Risiken umgehen — •Gerd Gigerenzer — Direktor des Harding-Zentrums für Risikokompetenz an der Universität Potsdam — Direktor emeritus des Forschungsbereichs „Adaptive Behavior and Cognition“ (ABC) am Max-Planck-Institut für Bildungsforschung, Berlin

In dieser Welt ist nichts gewiss, außer dem Tod und den Steuern – so schrieb Benjamin Franklin vor mehr als 200 Jahren. Dennoch suchen noch heute Menschen nach Gewissheiten die nicht existieren und vertrauen auf Horoskope und Marktvorhersagen. Statt der Illusion der Sicherheit und dem Wunsch nach Nullrisiko braucht eine lebendige Demokratie Menschen, die kompetent und entspannt statt ängstlich und verunsichert mit Risiken umgehen können. Risikokompetenz kann man lernen – und darüber geht dieser Vortrag.

Risikokompetenz ist die Fähigkeit, die Gefahren und Möglichkeiten einer technologischen Welt zu verstehen statt diese zu verdrängen, und mit Unsicherheit emotional entspannt leben zu lernen. Unsere Gesellschaft ist von einem rationalen Umgang mit Risiken noch weit entfernt, ein Zustand, der jedes Jahr beträchtliche finanzielle Mittel, Ängste und das Leben von Bürgern kostet. In diesem Vortrag berichte ich über die mangelnde Fähigkeit von Ärzten, Richtern, Journalisten und Politikern, Risiken zu verstehen und zu kommunizieren. Dann zeige ich anhand meiner Forschung, wie man mit nachhaltigen Methoden diese allgemeine Konfusion in Einsicht verwandeln kann.

Plenary Talk PV XII Fri 8:30 Audimax

Photonic graphene and beyond - topological features of optically created artificial matter — •Cornelia Denz and Haissam Hanafi — Institute of Applied Physics, University of Muenster

Graphene with its hexagonal band structure of the energy spectrum has been celebrated in the past years as a wonder material due to its intriguing features. Among them, its topological phases are attributed to singular points in the band structure, the so-called Dirac points, and flat bands. Varying the lattice structure beyond graphene extends these topological phases of matter, leading for example to topological insulation. While condensed matter systems are difficult to adapt, optically created artificial dielectric photonic lattices represent an ideal testbed for these 2d materials. This has led to the area of topological photonics, an emerging field in which geometrical and topological concepts are implemented to design and control the behavior of complex light. In our contribution, we summarize fabrication techniques of photonic lattices with structured light based on additive femtosecond laser machining in fused silica or on optical induction in nonlinear photonic crystals. We demonstrate topological features of artificially created 2d graphene and twisted bilayer materials and showcase first realizations of photonic borophene, the optical equivalent of the new rising star of solid-state physics, and fractal lattices. Further, we demonstrate numerous fascinating topological effects ranging from light localization in flat bands to robust edge-mode transport and nonlinear light localization in higher-order topologies.

Plenary Talk PV XIII Fri 9:15 Audimax

The KATRIN experiment: latest results and future perspectives — •Susanne Mertens — Max Planck Institute for Physics and Technical University Munich

From the discovery of neutrino oscillations we know that at least two neutrino mass eigenstates have a nonzero rest-mass. However, the absolute scale of the neutrino masses cannot be assessed from oscillation experiment. A direct way to probe the absolute neutrino mass scale is via the single beta decay, where the neutrino mass manifests itself as a small spectral distortion close to the endpoint. The Karlsruhe Tritium Neutrino (KATRIN) experiment is designed to measure the effective electron anti-neutrino mass with a sensitivity of 0.2 eV at 90% confidence level. The talk will focus on the latest KATRIN result, which reaches for the first time in the history of direct neutrino mass experiments a sub-eV sensitivity, and limits the neutrino mass to less than 0.8 eV (90% confidence level). Moreover, new results on sterile and relic neutrino searches with KATRIN will be presented. The presentation will conclude with an outlook to upcoming data sets and future perspectives of KATRIN.