Plenary Talk PV I Mon 8:15 U Audimax

Quantum optics and information science in multi-dimensional photonics networks — •Christine Silberhorn — Integrated Quantum Optics, Department of Physics, University of Paderborn, Warburger Straße 100, 33098 Paderborn, Germany

Classical optical networks have been widely used to explore a broad range of transfer phenomena based on coherent interference of waves, which relate to different disciplines in physics, information science, and even biological systems. At the quantum level, the quantized nature of light gives rise to genuine quantum effects that can appear completely counter-intuitive.

Photonic quantum systems with many optical modes have been investigated intensively in various theoretical proposals over the last decades. However, their implementation requires advanced setups of high complexity, which poses a considerable challenge on the experimental side. The successful realization of controlled quantum network structures is key for many applications in quantum optics and quantum information science.

Here we present three differing approaches to overcome current limitations for the experimental implementation of multi-dimensional quantum networks: non-linear integrated quantum optics, pulsed temporal modes and time-multiplexing.

Plenary Talk PV II Mon 9:00 U Audimax

Interstellar radionuclides identified in deep-sea archives — •Anton Wallner — Department of Nuclear Physics, The Australian National University, Canberra

The Interstellar Medium (ISM) is continuously fed with new nucleosynthetic products. The solar system moves through the ISM and collects dust particles. Therefore, direct detection of freshly produced nuclides on Earth provides insight into recent and nearby nucleosynthetic activities. ISM radionuclides trapped in deep-ocean archives include ^{60}Fe ($t_{1/2}$=2.6 Myr), ^{26}Al (0.7 Myr) and ^{244}Pu (81 Myr). These nuclides can be measured with Accelerator Mass Spectrometry (AMS) with high sensitivity.

Recent measurements, which continued pioneering work at TU Munich, demonstrate a global ^{60}Fe influx and is evidence for exposure of Earth to recent ($\leq$10 Myr) supernova explosions. Unknown is still the site where the heaviest elements are made in nature. Very low concentrations measured for interstellar ^{244}Pu, however, disfavour supernovae as the predominant producing site for heavy-element nucleosynthesis.

I will present new results, measured for ^{60}Fe at the ANU and for ^{244}Pu at ANSTO with unprecedented sensitivity. These data provide new insights into their concomitant influx and their ISM concentrations over a time period of the last 11 Myr.

Plenary Talk PV III Tue 8:15 U Audimax

Exploring Exotic Elements - all about Astatine and Actinides as accessible from Laser Mass Spectrometry — •Klaus Wendt — Johannes Gutenberg-Universität Mainz

The UN has proclaimed 2019 as the International Year of the Periodic Table of Chemical Elements, celebrating the 150th anniversary of this significant discovery by Dmitry Mendeleev. Today the table with its broad implications in astronomy, biology, chemistry, geosciences, physics, and even medical research extends up to element 118. Nevertheless, for a number of elements listed, which either have no stable isotopes or are produced only artificially, still today fundamental relevant quantities have not been determined precisely or are entirely missing. These gaps concern atomic and nuclear structure, isotope and isomer effects, and include even basic parameters like ionization potential or electron affinity. Resonant laser mass spectrometry is the method of choice for investigations on rare species. In the range around proton numbers Z=85-95 a variety of results has been reported during the last years, not only filling these blanks but also enabling analytical lowest-level determination of radiotoxic contaminations.

Plenary Talk PV IV Tue 9:00 U Audimax

Light and cavity induced new states of matter: Quantum Electrodynamical Density Functional Theory (QEDFT) — •Angel Rubio — Max Planck Institute for the Structure and Dynamics of Matter, Luruper Chaussee 149, 22761 Hamburg, Germany — Center for Computational Quantum Physics (CCQ), The Flatiron Institute, 162 Fifth avenue, New York NY 10010, USA — Laureate of the Max-Born-Prize 2018

Computer simulations that predict the light-induced change in the physical and chemical properties of complex systems usually ignore the quantum nature of light. Recent experiments at the interface between materials science and quantum optics have uncovered situations where both the molecular system and the photon field have to be treated in detail. In this talk, we show how the effects of quantum-photons can be properly included in the newly developed quantum electrodynamics density-functional formalism (QEDFT). We provide an overview of how well-established concepts in the fields of quantum chemistry and material sciences have to be adapted when the quantum nature of light becomes important. We identify fundamental changes in Born-Oppenheimer surfaces, conical intersections, spectroscopic quantities, and quantum control efficiency. We also show how periodic driving of many-body systems allow to design Floquet states of matter with tunable electronic properties on ultrafast time scales (and cavity induced-topology). This work paves the road for the development of two new fields, namely QED-materials and QED-chemistry.

In collaboration with: H. Appel, M. Ruggenthaler, H, Hübener, U. de Giovannini, M. Sentef, J. Flick, C. Schafer, V. Rokaj, D. Welakuh

Lunch Talk PV V Tue 12:45 U A-Esch 1

TRUMPF - Arbeiten als Physiker in einem globalen, innovativen Familienunternehmen — •Malte Kumkar — TRUMPF Laser- und Systemtechnik GmbH, Ditzingen

Als Markt- und Technologieführer bei Werkzeugmaschinen und Lasern für die industrielle Fertigung hat TRUMPF das Bestreben auch über Softwarelösungen und mit Industrieelektronik Hochtechnologieprozesse zu ermöglichen. Mit rund 13.400 Mitarbeitern weltweit ist die TRUMPF Gruppe in fast allen europäischen Ländern, in Nord- und Südamerika sowie in Asien vertreten.

Bei uns sind Mut und Vertrauen keine Gegensätze, sondern Werte, die erst in ihrem Zusammenspiel die Faszination des Arbeitens bei TRUMPF ausmachen.

Bei TRUMPF arbeiten Physiker in verschiedenen Bereichen daran die Produktionstechnik weiter zu entwickeln, sie wirtschaftlich, präzise, zukunftssicher und vernetzt zu gestalten. Als Innovationsgarant kann das Unternehmen Mitarbeitern mit herausragendem ingenieurs- und naturwissenschaftlichem Profil vielfältige Aufgaben und ein attraktives Umfeld bieten.

Dr. Malte Kumkar wird im Lunch Talk seinen persönlichen Werdegang aufzeigen und einen Einblick geben, wie das Arbeitsumfeld eines Physikers bei TRUMPF aussieht. Eine Vorstellung von aktuellen Themen des Unternehmens und Informationen zu den Einstiegsmöglichkeiten runden den Vortrag ab.

Prize Talk PV VI Tue 15:00 U Audimax

Ultimate Rayleigh-Bénard and Taylor-Couette turbulence — •Detlef Lohse — Physics of Fluids Group, Max-Planck Center Twente for Complex Fluid Dynamics & JM Burgers Center, Department of Science and Technology, University of Twente, P. O. Box 217, 7500 AE Enschede, The Netherlands — Laureate of the Max-Planck-Medal

Rayleigh-Bénard flow - the flow in a box heated from below and cooled from above - and Taylor-Couette flow - the flow between two coaxial co- or counter-rotating cylinders - are the two paradigmatic systems in physics of fluids and many new concepts have been tested with them. While the low Reynolds number regime has been very well explored in the '80s and '90s of the last century, in the fully turbulent regime major research activity only developed in the last two decades. We will first briefly review this recent progress in our understanding of fully developed Rayleigh-Bénard (RB) and Taylor-Couette (TC) turbulence, from the experimental, theoretical, and numerical point of view and discuss transitions between different (turbulent) flow states. We will in particular focus on the so-called ultimate regime, in which the boundary layer has become turbulent, and which therefore has enhanced transport properties. In the last part of the talk we will discuss RB and TC turbulence with rough walls. There the results can be expressed in terms of the skin-friction factor, revealing analogy to turbulent flow in rough pipes.

Plenary Talk PV VII Tue 15:30 U Audimax

Taming Atomic Giants - How Rydberg atoms became veritable quantum simulators — •Matthias Weidemüller — Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany — University of Science and Technology of China, Shanghai Branch, Shanghai 201315, China

Due to their exaggerated properties, highly excited (Rydberg) atoms have fascinated physicists for more than a century. The study of these atomic giants is intimately connected to major advances in modern

quantum science. In the last years, quantum engineering of the atomic interactions on a mesoscopic scale has opened exciting perspectives for using Rydberg atoms to simulate quantum many-body systems, allowing one to address fundamental problems such as, e.g., magnetization relaxation in spin glasses or energy transport in photosynthetic complexes. These advances have promoted ultracold Rydberg atoms to one of the hottest candidates for large-scale quantum simulation. I will provide an introduction into this rapidly growing field of research and present prominent examples of recent achievements.

Prize Talk PV VIII Tue 16:30 U A-Esch 2

X-rays go quantum — •Adriana Pálffy — Max-Planck-Institut für Kernphysik, Heidelberg — Laureate of the Hertha-Sponer-Prize

More than fifty years ago, it was the invention of the laser that revolutionized atomic physics and laid the foundations for quantum optics and coherent control. With only optical frequencies available, the interaction of coherent light with matter was for a long time mainly restricted to atomic transitions. Only recently have novel high-frequency light sources rendered x-ray quantum optics possible. In this higher frequency regime, atomic nuclei rise as natural candidates for the interaction with coherent light creating a new bridge between atomic physics, quantum optics and nuclear condensed matter physics. Nuclei are very clean quantum systems, well isolated from the environment and benefiting from long coherence times.

Combining the advantages of x-rays and nuclei, a prominent incentive is to exploit x-rays as the future quantum information carriers or for novel probing technologies based on quantum effects. Furthermore, the control of nuclear transitions would open the possibility to use long-lived nuclear excited states as a compact and clean energy storage solution. The lecture will follow the developments on the emerging field of x-ray quantum optics and focus on the mutual control of coherent x-ray radiation and nuclear transitions in this new regime of laser-matter interactions.

Prize Talk PV IX Tue 17:00 U A-Esch 2

Laser filamentation and terahertz pulse generation — •Luc Bergé — CEA, DAM, DIF - 91297 Arpajon - France — Laureate of the Gentner-Kastler-Prize 2018

Laser filamentation is actively studied for its rich variety of applications, from supercontinuum generation to lightning control. In air, femtosecond filaments result from the self-focusing of ultrashort light pulses that couple to their own plasma channel and stay self-guided upon long distances at high intensity levels. Driven by strong nonlinearities, these optical structures are able to promote broadband terahertz (THz) radiation when using laser fields composed of two colors, e.g., a fundamental frequency and its second harmonic. Terahertz emitters have many promising applications in security screening, cryptography, material sciences, medical imaging, time-domain spectroscopy and remote detection. This plenary talk will recall the main mechanisms involved in both laser filamentation and laser-driven THz pulse generation, such as plasma generation and ponderomotive forces, photocurrents induced by air ionization, Kerr self-focusing and optical rectification by four-wave mixing, and their respective range of occurrence in terms of the optical pump intensity. The last part of the talk will be devoted to recent results on the THz spectroscopy of various solid materials based on air plasmas, obtained in the framework of the project ALTESSE involving German, Danish and French researchers.

Plenary Talk PV X Wed 8:15 U Audimax

The future of time: prospects for a redefinition of the SI second — •William D. Phillips — National Institute of Standards and Technology, Gaithersburg MD, USA

The reform of the International System of Units (the SI) in which the kilogram, ampere, kelvin, and mole are all defined by fixing the values of four fundamental constants of nature, gives us a measurement system in which all of the base units are defined in terms of natural constants. While one might have hoped that this reformed SI would serve us into the indefinite future, the SI unit of time, the second, remains in serious need of redefinition. This talk will describe the history and current status of the SI second, and speculate about a possible redefinition.

Plenary Talk PV XI Wed 9:00 U Audimax

Chemical Energy Storage: a Key Element for a Sustainable Energy Future — •Ferdi Schüth — Max-Planck-Institut für Kohlenforschung, Mülheim an der Ruhr, Germany

Our energy systems are facing fundamental changes, caused by the depletion of fossil fuels and climate change. This requires increased use of renewable energy, which are typcially intermittent, such as solar radiation and wind energy. Storage of energy could thus become a key question in future energy systems, and methods for storage and different time and size scales are necessary. Chemical storage, including electrochemical systems such as batteries, have advantages compared to purely physical methods, since only chemical methods reach the required storage densities. The presentation will address the conditions, which future storage systems will have to meet and discuss different systems and their integration into the energy system. Main develeopment lines and the research needs associated with them will also be addressed.

Evening Talk PV XII Wed 18:30 U Audimax

Von essbaren Quanten und massiven Materiewellen — •Markus Arndt — Fakultät für Physik der Universität Wien, Boltzmanngasse 5, A-1090 Wien, Österreich — Laureate of the Robert-Wichard-Pohl-Prize

Kann man Quanten essen? Und was bleibt dabei von ihren Quanteneigenschaften übrig?

Ich werde Experimente aus unseren Labors an der Universität Wien diskutieren, in denen wir die Materiewellennatur einiger Grundbausteine der Biologie untersuchen. Wir werden uns fragen, wie man Vitamine und andere (Bio)Moleküle in einer geschützten Umgebung als intakte Teilchen mit all ihren Komponenten quantenmechanisch delokalisieren kann, warum das wissenschaftlich spannend ist aber im Körper keine bislang nachweisbare Rolle spielt.

Was bedeutet das für unsere Sicht auf die Welt? Ist es legitim von einer Quantenwelt neben unserer Alltagswelt zu sprechen? Wenn ja, durch welches Türchen wären sie verbunden? Gibt es aber nur eine Welt, wo und wie entsteht dann die gefühlte lokale Realität, die im mikroskopischen Quantenexperiment oft nicht definierbar ist?

Ich werde diskutieren, warum die Maschinen, die in Wien zur Untersuchung dieser Fragen gebaut werden, vor allem auch ausgezeichnete Kraftsensoren sind, die es erlauben, auf eine neue Weise und oft minimalinvasiv optische, elektrische, magnetische und somit auch strukturelle Eigenschaften komplexer Moleküle zu bestimmen.

Plenary Talk PV XIII Thu 8:15 U Audimax

Probing electronic processes in large molecules — •Francesca Calegari — Center for Free Electron Laser Science, DESY, Notkestrasse 85 22607 Hamburg Germany

Attosecond science is nowadays a well-established research field, which offers formidable tools for the realtime investigation of electronic processes [1]. In this context, we have recently demonstrated that attosecond pulses can initiate charge migration in aromatic amino-acids [2]. Still, there is a long path towards attochemistry and the full control of the molecule via electronic coherences.

In this talk I will first present a time-resolved study of photofragmentation of adenine. Our most intriguing observation is that a stable dication of the parent molecule can be produced if the probing NIR pulse is briefly delayed from the XUV pulse. Our findings indicate that this time is required for a shake-up process to occur. After shake-up, a second electron can be ionized and the molecule is ultimately stabilized.

In the second part of the talk I will show the results obtained in the C60 molecule. Here we have investigated delays in photoemission after exciting the Giant surface Plasmonic Resonance (GPR) around 20 eV. Clear signatures of the collective electron dynamics initiated by the XUV pulse can be extracted from the experimental data.

[1] F. Calegari et al., J. Phys. B 062001, 49 (2016) [2] F. Calegari et al, Science 346, 336 (2014)

Plenary Talk PV XIV Thu 9:00 U Audimax

Non-Markovian Dynamics: Correlations, Information Flow and Memory in Open Quantum Systems — •Heinz-Peter Breuer — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, D-79104 Freiburg

The dynamics of open quantum systems is conventionally modelled by means of a Markovian process in which the open system irretrievably loses information to its surroundings, expressing the memoryless nature of the dynamics. However, complex open systems out of equilibrium often exhibit a pronounced non-Markovian behavior which is characterized by a flow of information from the environment back to the open system. This information backflow implies the presence of memory effects and represents the key feature of non-Markovian quan-

tum dynamics. In addition to standard phenomena like dissipation of energy and relaxation to a thermal equilibrium or nonequilibrium stationary state, non-Markovian time evolution is distinguished by a revival of genuine quantum properties such as coherences, correlations and entanglement. In the talk I will discuss theoretical concepts developed in the past years in order to define, quantify and control quantum memory effects in open systems. In particular, I will explain the connections between memory in the quantum regime, the generation of system-environment correlations and the flow of information between the open system and its environment.

Evening Talk PV XV Thu 18:30 U Audimax

Max-von-Laue Lecture: 2100: A Climate-Space Odyssey — •Hans Joachim Schellnhuber — Potsdam-Institut für Klimafolgenforschung (PIK)

Vor über 50 Mio Jahren begann sich die Erde aufgrund mächtiger geologischer Prozesse abzukühlen, um schließlich vor etwa 2,5 Mio Jahren in den Eiszeitzyklus einzutreten, der aus einem subtilen Zusammenspiel von Gravitation und Strahlung entstand. Unter diesen heftig schwankenden Umweltbedingungen entwickelte sich der *Homo sapiens*, aber erst in der klimatisch besonders stabilen Warmzeit, die vor etwa 11 000 Jahren einsetzte, wurde die Zivilisation geboren.

Letztere erfuhr einen gewaltigen Schub durch die Industrialisierung, die ihre Energie immer noch vorwiegend aus fossilen Brennstoffen bezieht. Als unbeabsichtigter Nebeneffekt reichert sich die Erdatmosphäre seit dem 19. Jahrhundert mit CO_2 an, wodurch der natürliche Treibhauseffekt zunehmend verstärkt wird. Damit stellen sich grundlegende Fragen: Wie ändert sich der Charakter des Klimasystems durch diese anthropogene Störung? Was werden die Folgen für Natur und Kultur sein? Kann diese Entwicklung noch gebremst werden und was sind die technischen, wirtschaftlichen und gesellschaftlichen Voraussetzungen dafür?

Der Vortrag wird auf all diese Fragen eingehen. Insbesondere soll gezeigt werden, dass bei ungeminderten CO_2-Emissionen unser Planet um viele Millionen Jahre in der geologischen Zeit zurückverschoben würde und dass die Klimastabilisierung nur durch eine vollständige Dekarbonisierung der Weltwirtschaft in den nächsten drei Jahrzehnten gelingen könnte. Im Jahr 2100 wird die Menschheit dann endgültig wissen, auf welchen Kurs sie das Raumschiff Erde gebracht hat.

Plenary Talk PV XVI Fri 8:15 U Audimax

Universal dynamics far from equilibrium — •Jörg Schmiedmayer — Vienna Center for Quantum Science and Technology, Atominstitut, TU-Wien

We provide experimental evidence of universal dynamics far from equilibrium during the relaxation of an isolated one-dimensional Bose gas. Following a rapid cooling quench, the system exhibits universal scaling in time and space, associated with the approach of a non-thermal fixed point. The time evolution within the scaling period is described by a single universal function and scaling exponent, independent of the species of the initial state. Our results provide a quantum simulation in a regime, where to date no theoretical predictions are available. This constitutes a crucial step in the verification of universality far from equilibrium. If successful, this will lead to a comprehensive classification of systems far from equilibrium based on their universal properties similar to the universality classes in phase transitions. This can be the basis for a new type of quantum simulation that let us explore a large variety of systems at different scales.

This work was supported by the ERC (QuantumRelax) and the DFG/FWF SFB ISOQUANT.

S. Erne et al. Nature **253**, 225 (2018) arXiv:1805.12310.

For a similar experiment in a spin system see: M. Prüfer et al. Nature **253**, 217 (2018) arXiv:1805.11881

Plenary Talk PV XVII Fri 9:00 U Audimax

Controlling and imaging molecules inside helium nanodroplets with laser pulses — •Henrik Stapelfeldt — Department of Chemistry, Aarhus University, Denmark

Controlling and imaging molecules inside helium nanodroplets with laser pulses

I will show how laser pulses can align molecules embedded in helium nanodroplets and how the ability to place molecules in advantageous spatial orientations allows structural determination of molecular complexes. The talk will focus on the following topics:

1) Impulsive alignment with pulses much shorter than the molecular rotational periods focusing on understanding how rotational quantum coherence is influenced by the dissipative environment of the helium droplets.

2) Alignment induced by pulses that are turned-on on the time scale of molecular rotations. It will be shown how the 0.4 K temperature of the molecules inside the droplets enables unprecedented high degrees of alignment, in either one or three dimensions. The method applies to large, complex molecules and the alignment can be made field-free by rapidly switching off the alignment pulse.

3) Femtosecond-laser-induced Coulomb explosion imaging of the structure of molecular dimers and trimers created inside He droplets. Results for both small linear molecules, such as carbonylsulfide, and larger molecules, such as tetracene, are presented. Perspectives for time-resolved imaging of bimolecular reactions are discussed.