Plenary Talk PV I Mo 11:00 E 415 und E 214

Quantum interference experiments with massive matter — •Markus Arndt — Faculty of Physics, University of Vienna , Boltzmanngasse 5, A-1090 Vienna

Matter wave interferometry with organic molecules and clusters is based on many achievements in quantum experiments with electrons, neutrons and atoms. We will therefore briefly review the state of the art in de Broglie-interferometry, i.e. in single-particle center-of-mass coherence.

We will then address in particular the new challenges and benefits to be expected in quantum experiments with internally highly complex and very massive objects.

We study the foundations of quantum physics, by visualizing the wave-particle duality and by exploring the potential or practical limits for the quantum delocalization of massive bodies.

We also discuss new ideas on how to turn de Broglie interferometry into a novel tool for sensing a variety of internal properties of clusters and molecules as well as for probing external force fields.

Plenary Talk PV II Mo 11:45 E 415 und E 214

Photostability of the Building Blocks of Life — •Wolfgang Domcke — Department of Chemistry, Technische Universität München

Stability with respect to photochemical destruction by ultraviolet light is a decisive property of biological molecules. Recent excited-state electronic-structure calculations and time-dependent quantum wavepacket calculations of the nuclear motion have revealed the role of conical intersections of electronic potential-energy surfaces in the highly efficient excited-state deactivation in biological molecules such as DNA bases, DNA base pairs, aromatic amino acids and peptides. Evidence has been found that specific electron-driven proton-transfer processes play a universal role in the photochemistry of biomolecules and biopolymers (DNA and proteins). These processes may be the origin of the exceptional photostability of these compounds which has lead to their selection at the very beginning of the biological evolution.

Plenary Talk PV III Tu 8:30 E 415 und E 214

Plasma physics - the scientific base for ITER — •Hartmut Zohm — Max-Planck-Institut für Plasmaphysik, D-85748 Garching, EURATOM Association

The large-scale fusion experiment ITER, currently under construction in Cadarache, France, is usually associated with high-temperature plasma physics typical for conditions under which fusion reactions occur. However, a large range of plasma physics phenomena plays a role in optimising the ITER design and preparing its operation, involving also low temperature plasma physics, dust in plasmas or materials under steady state and transient high power load. The talk will give an overview of critical areas for the ITER design and point out the contribution of different areas of plasma science to their resolution.

Plenary Talk PV IV Tu 9:15 E 415 und E 214

Fundamental tests in Cavity Quantum Electrodynamics — •Serge Haroche — Laboratoire Kastler Brossel, Ecole Normale Superieure, 24 rue Lhomond, 75231, Paris, France — Collège de France, 11 Place Marcelin Berthelot, 75005, Paris, France — Laureate of the Herbert-Walter-Award

At the dawn of quantum physics, Einstein and Bohr had the dream to confine a photon in a box and to use this contraption in order to illustrate the strange laws of the quantum world. Cavity Quantum Electrodynamics, a field to which Herbert Walther has made essential contributions, has now made this dream real, allowing us to actually achieve in the laboratory variants of the thought experiments of the founding fathers of quantum theory. In our work at Ecole Normale Supérieure, we use a beam of Rydberg atoms to manipulate and probe non-destructively microwave photons trapped in a very high Q superconducting cavity. We realize ideal quantum non-demolition (QND) measurements of photon numbers, observe the radiation quantum jumps due to cavity relaxation and prepare non-classical fields such as Fock and Schrödinger cat states. Combining QND photon counting with a homodyne mixing method, we reconstruct the Wigner functions of these non-classical states and, by taking snapshots of these functions at increasing times, obtain movies of the decoherence process. These experiments open the way to the implementation of quantum feedback procedures aimed at preserving over long time intervals the quantum coherence of non-classical states of radiation in a cavity.

Prize Talk PV V Tu 11:00 E 415 und E 214

Von Otto Sterns Molekularstrahlmethode zum COLTRIMS-Reaktionsmikroskop — •Horst Schmidt-Böcking — Goethe-Universität Frankfurt am Main, Institut für Kernphysik, Max-von Laue-Str.1, 60438 Frankfurt — Träger der Stern-Gerlach-Medaille

Ausgehend von seiner Habilitationsarbeit über die kinetische Theorie des Dampfdrucks einatomiger fester Stoffe, die er 1913 bei Einstein in Zürich ablieferte, hatte der junge Stern die brilliante Idee, wie man an kollimierten Molekularstrahlen die äusseren und inneren Eigenschaften von einzelnen Atomen vermessen konnte. In wenigen Jahren von 1919 bis zu seiner Vertreibung aus Deutschland in 1933 gelangen ihm mit Hilfe dieser Methode eine Reihe von grundlegenden Pionierexperimenten der Atom- und Kernphysik, darunter zusammen mit Walther Gerlach 1922 in Frankfurt das berühmte Stern-Gerlach-Experiment, wo er Sommerfelds Hypothese der Raumquantisierung bestätigen konnte und 1932 in Hamburg die Messung des magnetischen Momentes des Protons und Deuterons. Auf seiner Methode aufbauend haben Rabi (nuclear magnetic resonance), Lamb (lambshift), Ramsey (Atomuhr), Townes (maser) und viele andere die vielleicht wichtigste Säule der modernen experimentellen Physik des 20.Jahrhunderts errichtet (ca. 20 Nobelpreise). In jüngster Zeit ist es gelungen, einzelne Atome oder Moleküle im Molekularstrahl z.T. vollständig zu fragmentieren und mit Hilfe des COLTRIMS-Reaktionsmikroskopes (Bubble Chamber der Atomphysik) Elektronendynamik im wenigen Attosekundenbereich fast „Live“ zu beobachten und neue Einblicke in die Vielteilchen-Coulombwechselwirkung zu gewinnen.

Plenary Talk PV VI We 8:30 E 415 und E 214

Attosecond electron dynamics in high harmonic generation and laser induced tunneling ionization — •Ursula Keller — ETH Zurich, Physics Department, 8093 Zürich, Switzerland

Tunneling theories are the standard approach to intense-field ionization and have successfully described high harmonic generation (HHG), quantum path interference (QPI) in HHG, laser-induced electron tunneling and diffraction. We have observed for the first time the interference between the two shortest quantum paths contributing to the harmonic emission. By varying the laser intensity, we change their interference and thus demonstrate a control of the paths on an attosecond time scale. Furthermore, it is typically assumed that electrons can escape from atoms through tunneling when exposed to strong laser fields, but the timing of the process has been controversial, and far too rapid to probe in detail. We have used attosecond angular streaking to place an intensity-averaged upper limit of 12 attoseconds on the tunneling delay time in strong field ionization of a helium atom in the non-adiabatic tunneling regime. This is the fastest process that has been measured directly in the time domain and the different theoretical interpretations of this result is still controversal.

Plenary Talk PV VII We 9:15 E 415 und E 214

Tunable Quantum Gases in Optical Lattice Potentials — •Hanns-Christoph Nägerl — Universität Innsbruck, Technikerstrasse 25, A-6020 Innsbruck, Austria

I will review our recent experiments with atomic and molecular quantum gases in optical lattices. I will first show how one can produce quantum gases of rovibronic ground state molecules with full control over all internal and external quantum degrees of freedom [1]. For the case of atomic quantum gases, for which one can tune the interaction parameter, I will discuss the preparation of an exotic many-body, highly-correlated quantum phase in 1D geometry known as the super-Tonks-Girardeau (sTG) gas [2]. In contrast to the well-known case of the Tonks-Girardeau (TG) gas, interactions are strongly attractive for the sTG gas. Finally, I will report on the observation of the superfluid-to-Mott-insulator (SF-MI) phase transition for a strongly-interacting 1D gas. For sufficiently strong interactions, the insulating state is induced by an arbitrarily week lattice, in striking contrast to the SF-MI transition observed for weakly-interacting 3D gases. [1] Quantum gas of rovibronic ground-state molecules in an optical lattice, J.G. Danzl et al., arXiv:0909.4700 (2009). [2] Realization of an excited, strongly correlated quantum gas phase, E. Haller et al., Science 325, 1224 (2009).

Evening Talk PV VIII We 20:00 E 415 und E 214

Schwerkraftwellen – Sphärenmusik tatsächlich hören! — •Bernard Schutz — Max-Planck-Institut für Gravitationsphysik, Albert-Einstein-Institut, Am Mühlenberg 1, 14476 Golm

Im kommenden Jahrzehnt werden Wissenschaftler ein neues Fenster zum Universum öffnen, wenn sie die Gravitationswellen nachweisen können, die vor einem Jahrhundert von Einstein vorausberechnet wurden. Aber anstatt durch dieses Fenster zu schauen, werden wir dem Universum zuhören, denn Gravitationswellen entsprechen in der Raumzeit den Klangwellen, und so sind unsere Detektoren unsere Mikrofone. In dieser Multimedia-Präsentation werden Sie den "Klängen" lauschen können, die massive Schwarze Löcher, kollidierende Neutronensterne, explodierende Supernovae und der Urknall selbst verursachen, und sie werden mehr darüber erfahren, wie sehr sich die Wahrnehmung unseres Universums verändern wird, wenn wir erst einmal die Technik der Gravitationswellenmessung beherrschen.

Plenary Talk PV IX Th 8:30 E 415 und E 214
Solar radiation management to limit climate change: An overview on proposed methods, their cooling potential, and possible side effects — •Hauke Schmidt — Max Planck Institute for Meteorology, Bundesstr. 53, 20146 Hamburg, Germany

There is increasing scientific evidence indicating that anthropogenic emissions of greenhouse gases (GHG) have a significant impact on Earth's climate, and that this climate change will be harmful for mankind. Consequently, there is a growing urgency to design new measures for limiting climate change to an acceptable level. To prepare for possible failure of emission reduction attempts through international agreements, currently there is an increasing debate in the public and scientific communities on the possibility of "geoengineering", or "the deliberate manipulation of the Earth system to manage the climatic consequences" (Schneider, 2001) of enhanced GHG concentrations. Two classes of proposed methods can be distinguished, such that aim on an actual removal of carbon dioxide from the atmosphere, and such that are frequently referred to as "solar radiation management". This presentation tries to provide an overview on the status of scientific research concerning the latter class of methods, their physical basis, global cooling potential, and possible side effects. Among these methods a special emphasis will be put on the suggestion to inject sulfur into the stratosphere and the question to what extent past volcanic eruptions may serve as an analog. Ethical and economical aspects of the discussion on geoengineering will be touched briefly.

Plenary Talk PV X Th 9:15 E 415 und E 214
"Molecular spectrometers" in the condensed phase: local THz-FIR response from femtosecond fluorescence — •Nikolaus P. Ernsting — Dept. of Chemistry, Humboldt-Universität zu Berlin

A molecular probe functions as a microscopic THz light source when its charge distribution is suddenly altered by femtosecond optical excitation. For example consider the zwitterionic molecule N-Methyl-Quinolone. Excitation at 400 nm reduces its dipole moment and the local electric field is switched down instantaneously. As the new field acts on nearby groups with partial charges, these reorient and collectively create the reaction field $R(t)$. The latter is reported by the polar probe molecule through an emission frequency which depends linearly on $R(t)$. The probe is therefore not only light source but also detector. Thus, by time- and frequency-resolving the fluorescence, a local THz-FIR spectrum can be obtained.

This concept is first demonstrated with aqueous solution of trehalose, a disaccharide which strongly influences water dynamics. Then we focus on the observation of low-frequency vibrational modes of DNA double helices. For this purpose, suitable probe molecules are linked and embedded into the supramolecular structure.

Plenary Talk PV XI Fr 8:30 E 415 und E 214
Transforming light with metamaterials — •Vladimir Shalaev — Purdue University, Wets Lafayette, Indiana, USA

One of the most unique properties of light is that it can package information into a signal of zero mass and propagate it at the ultimate speed. It is, however, a daunting challenge to bring photonic devices to the nanometer scale because of the fundamental diffraction limit. Metamaterials can focus light down to the nanoscale and thus enable a family of new nanophotonic devices. Metamaterials, i.e. artificial materials with rationally designed geometry, composition, and arrangement of nanostructured building blocks are opening a gateway to unprecedented electromagnetic properties and functionalities that are unattainable with naturally occurring materials. We review this exciting field and discuss the recent, significant progress in developing metamaterials for the optical part of the electromagnetic spectrum. Specifically, we report on our recent world's smallest nanolaser (collaborative work with Norfolk State University and Cornell), describe the phenomena of artificial magnetism across the whole visible and negative refractive indices in the optical range, and demonstrate a broadband cloaking in the visible based on tapered waveguides (collaboration with BAE and Towson University). Progress on developing negative-index metamaterials with no loss will be also presented. Finally, a new, powerful paradigm of engineering space for light with transformation optics, which can enable a family of new applications including a planar magnifying hyperlens and optical black hole, will be also discussed.

Plenary Talk PV XII Fr 9:15 E 415 und E 214
Two-Dimensional Electronic Spectroscopy: Coherence, Entanglement and Photosynthesis — •Graham Fleming — University of California Berkeley, 221 Hildebrand Hall, Berkeley, CA 94720

Two-dimensional (2D) electronic spectra contain information about the combined spatial, energetic and temporal landscapes of condensed phase systems. Because they are recorded at the amplitude level, they are directly sensitive to the presence of quantum coherence. In addition, differing sequences of polarizations of the four fields involved can suppress or enhance specific features in the spectra. An example is given by a sequence which reveals only peaks that have arisen through coherence transfer as opposed to population transfer. In this talk these ideas will be applied to natural photosynthetic light harvesting systems. These pigment-protein complexes contain chlorophyll molecules at very high spatial density, leading to delocalized excited states. The experiments reveal long-lived quantum electronic coherence and substantial coherence transfer leading to speculations about the physiological consequences of quantum effects, and the potential applications in quantum theory. New theoretical methods are required to address these questions and a formally exact, reduced hierarchy approach will be used to describe the experiments and explore more subtle quantum mechanical questions such as the presence of entanglement in natural systems.