Plenary Talk PV I Mon 9:00 e415

"Atomic physics" with diatomic molecules — •David DeMille — Yale University, New Haven, CT, USA

Our group is extending the methods of modern atomic physics to the more complex system of diatomic molecules. Though the vibrational and rotational degrees of freedom of molecules make them more difficult to control, they also provide new features of broad use for "atomic physics"-type experiments. I will discuss two ongoing experiments of this type. In one, we have used a molecule to dramatically amplify the observable effect of an electric dipole moment (EDM) of the electron. This allowed us to search for the electron EDM with sensitivity sufficient to test theories, such as weak-scale supersymmetry, where new particles and interactions appear at the TeV energy scale. In a second experiment, we are applying the technique of laser cooling to diatomics. I will describe recent results demonstrating magneto-optical trapping of SrF molecules at temperatures as low as 400 μK.

Plenary Talk PV II Mon 9:45 e415

Processing of transparent materials by ultrashort laser pulses: fundamentals and applications — •Stefan Nolte — FSU Jena, Institute of Applied Physics, Jena, Germany — Fraunhofer IOF, Jena, Germany

Ultrashort laser pulses have shown tremendous advantages for precise microstructuring. This is especially true for metals, where ablation with minimal thermal and mechanical damage became possible. However, apart from simple ablation additional structuring options become possible when processing transparent materials. Especially, the realization of three-dimensionally localized modifications within the bulk of transparent materials has attracted increasing interest in the past years. When the intense ultrashort pulses are tightly focused into the transparent material, the intensity in the focal volume can become high enough to initiate nonlinear absorption processes. This localized energy deposition results in permanent structural changes inside the sample without affecting the surface. Depending on the processing parameters, either isotropic refractive index changes, self-organized sub-wavelength structures leading to form birefringence or microvoids can be generated in the focus. In this talk, the fundamentals of internal processing of glasses with ultrashort pulses will be reviewed. The detailed understanding allows to control and tailor the interaction process in order to enable fascinating new applications. Some of them will be highlighted, ranging from the cutting of hardened glass for smartphones, the fabrication of artificial birefringent devices or specialized Bragg gratings up to localized femtosecond laser welding.

Prize Talk PV III Mon 11:15 e415

Chiral Quantum Networks with Photons and Atoms — •Peter Zoller — Institute for Theoretical Physics, University of Innsbruck — Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences, Innsbruck, Austria — Laureate of the Herbert-Walther-Prize

Recent experiments have achieved trapping of atoms close to photonic nanostructures. A unique feature of such setups is the chiral character of emission of photons by atoms into the waveguide, i.e. broken left-right symmetry due to spin-orbit coupling of light. This chirality of photon exchange between atoms, and corresponding photon-mediated interactions between the atoms give rise to a novel quantum optical many-body system. We discuss from a theory perspective the quantum optics of such "chiral quantum circuits of photons and atoms" as a laser driven-dissipative quantum many-body system. This includes a discussion of novel non-equilibrium quantum phases, and new opportunities for implementation of quantum information protocols.

Prize Talk PV IV Mon 11:45 e415

Gedankliche Lawinen — •Nina Wentz und •Ingo Wentz — Gesamtschule Hennef Meiersheide, 53773 Hennef, Germany — Träger des Georg-Kerschensteiner-Preises

Wie begeistert man junge Menschen langfristig für Physik? In dieser Frage sind Problem und Lösung bereits enthalten. Das Problem ist die Langfristigkeit. Es reicht eben nicht, mit feurigen Explosionen einen kurzfristigen Wow-Effekt zu generieren, wie er in vielen Sendungen und Shows gezeigt wird. Erst der Biss etwas wirklich wissen zu wollen, ein Experiment zu durchdringen, zu hinterfragen und weiterzuentwickeln hat langfristige Wirkung. Biss bedeutet jedoch Arbeit. Diese extrinsische Notwendigkeit muss mit einer intrinsischen Motivation verknüpft werden. Die Lösung hierfür ist die Begeisterung. Um Begeisterung zu entfachen, also gedankliche Lawinen auszulösen, muss man an der richtigen Stelle eine Schneeflocke fallen lassen. Wie das gelingen kann, berichten Nina und Ingo Wentz von der Gesamtschule Hennef Meiersheide.

Plenary Talk PV V Tue 9:00 e415

The first operation of the superconducting optimized stellarator fusion device Wendelstein 7-X — •Thomas Klinger — Max-Planck-Institut für Plasmaphysik, Greifswald — Ernst-Moritz-Arndt Universität, Greifswald

The confinement of a high-temperature plasma by a suitable magnetic field is the most promising path to master nuclear fusion of Deuterium and Tritium on the scale of a reasonable power station. The two leading confinement concepts are the tokamak and the stellarator. Different from a tokamak, the stellarator does not require a strong current in the plasma but generates the magnetic field by external coils only. This has significant advantages, e.g. better stability properties and inherent steady-state capability. But stellarators need optimization, since ad hoc chosen magnetic field geometries lead to insufficient confinement properties, unfavourable plasma equilibria, and loss of fast particles. Wendelstein 7-X is a large (plasma volume $30\,\mathrm{m}^3$) stellarator device with shaped superconducting coils that were determined via pure physics optimization criteria. After 19 years of construction, Wendelstein 7-X has now started operation. This talk introduces into the stellarator concept as a candidate for a future fusion power plant, summarizes the optimization principles, and presents the first experimental results with Helium and Hydrogen high temperature plasmas. An outlook on the physics program and the main goals of the project is given, too.

Plenary Talk PV VI Tue 9:45 e415

Stimulated Raman Adiabatic Passage (STIRAP): a concept conquering new territory. — •Klaas Bergmann — Fachbereich Physik and OPTIMAS research center, Technische Universtität Kaiserslautern, Germany

The essential elements (theory and experiments) of the STIRAP concept for lossless transfer of population between quantum states were presented some 25 years ago. STIRAP was initially designed for use in AMO physics and praised for its robustness, i.e. for the insensitivity of the transfer efficiency to small variations of most experimental parameters. That concept has more recently enjoyed very wide spread application in many fields of physics, chemistry and e.g. optical technology that reach far beyond the initial expectations. After briefly presenting the essential ingredients of the physics that are the basis for the success of STIRAP some highlights from recent applications of STIRAP will be discussed. These include recent progress in the formation of ultra-cold ensembles of molecules, the control of excitation in superconducting circuits, and even the option for transfer of vibrational energy between mechanical oscillators, to name just a few. Furthermore, STIRAP-inspired work, such as the coherent coupling and robust transfer of light between waveguides or to a set of waveguides and even new concepts for wireless energy transfer will be mentioned.

Plenary Talk PV VII Wed 9:00 e415

Smoking guns of Anderson localization — •Dominique Delande — Laboratoire Kastler-Brossel, Universite Pierre et Marie Curie et Ecole Normale Superieure, Paris, France

Because their internal as well as their external degrees of freedom can be very well controlled, cold atoms make it possible to experimentally study a number of fundamental physical processes for quantum disordered systems or few/many-body interacting systems, such as ballistic/diffusive transport, and phenomena due to quantum interference between multiple scattering paths, such as weak localization, coherent back-scattering and strong (a.k.a. Anderson) localization. In traditional disordered systems such as electrons in solid state samples, localization properties are probed by measuring a transport coefficient such as conductivity. In cold atomic samples, usually not at thermal equilibrium, other tools must be used. I will show how signatures or "smoking guns" of Anderson localization can be observed with cold atoms and which relevant physical information can be extracted from these signatures.

Plenary Talk PV VIII Wed 9:45 e415

Organic chemistry in space and the challenge of searching for life beyond Earth — •Pascale Ehrenfreund — http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10329/510_read-14467/

Astrobiology connects space and Earth science to answer fundamental questions about the origin and evolution of life in our Solar System and possibly elsewhere. Carbonaceous compounds in the gas and solid state, refractory and icy are identified by astronomical observations in our Solar System, our and distant galaxies. Among them are a large number of molecules that are essential in prebiotic chemistry and used in contemporary biochemistry on Earth. Laboratory measurements of the carbon fraction of carbonaceous meteorites reveal a variety of extraterrestrial organic compounds including amino acids, N-heterocycles, carboxylic acids as well as aliphatic and aromatic hydrocarbons. Since August 2014 the comet rendezvous mission Rosetta has monitored the evolution of comet 67P/Churyumov-Gerasimenko and observed numerous volatiles and complex organic compound on the cometary surface and in the coma. Small solar system bodies hold clues to processes that formed our solar system and probably contributed carbonaceous compounds during the heavy bombardment phase ~3.9 billion years ago to the young planets, a process which may have jump-started life*s origin on Earth. A fleet of robotic space missions currently targets planets, moons and small bodies to reveal clues on the origin of our solar system and life beyond Earth.

Evening Talk PV IX Wed 19:30 e415

Gravitationswellenastronomie: Neues von der dunklen Seite des Universums! — •Karsten Danzmann — Leibniz Universität Hannover, Max-Planck-Institut für Gravitationsphysik, Hannover

Vor 100 Jahren hat Albert Einstein vorausgesagt, dass als Konsequenz seiner Allgemeinen Relativitätstheorie beschleunigte Massen Dellen in Raum und Zeit erzeugen, Gravitationswellen, die sich mit Lichtgeschwindigkeit ausbreiten, und eine völlig neue Art der Astronomie ermöglichen werden.

Das Jahr 2016 verspricht für die Gravitationswellenastronomie sehr interessant zu werden, denn seit Oktober 2015 nehmen die Advanced LIGO Detektoren nach 4 Jahren Umbauzeit wieder Daten auf. Und am 3. Dezember 2015 ist die LISA Pathfinder Weltraummission gestartet,eine Vorläufermission für einen Gravitationswellendetektor im Weltraum. In diesem Vortrag werde ich über die ersten Ergebnisse beider Projekte berichten.

Plenary Talk PV X Thu 9:00 e415

Femtosecond x-ray induced dynamics of fullerenes using FELs and IR — •Nora Berrah — University of Connecticut, Storrs, CT, USA

The new class of intense-femtosecond vuv and x-ray lasers has opened up new opportunities to study AMO physics with atomic spatial resolution and femtosecond temporal resolution. The understanding of physical and chemical changes at an atomic spatial scale and on the time scale of atomic motion is crucial not only for AMO physics but also for a broad range of other scientific fields. X-rays produced at FELs have energies and intensities sufficient to access core electrons to probe matter. The element-specificity of x-ray absorption has the ability to target specific atoms within matter. We used these attributes to investigate the electronic and nuclear dynamics of fullerenes subjected to intense x-ray radiation from the linac coherent light source (LCLS) FEL.

We will report on the time-resolved photoionization and fragmentation dynamics of gas phase C60 using intense femtosecond LCLS x-ray pulses. In addition, we will discuss the photoionization dynamics of Ho3N@C80 carried out using both intense IR laser fields and x-rays from the LCLS.

Investigations of the ionization and fragmentation dynamics of nanosize fullerenes subjected to femtosecond strong x-ray lasers are important for understanding the mechanisms of matter under extreme conditions and radiation damage which will benefit the development of bio-imaging techniques.

Plenary Talk PV XI Thu 9:45 e415

Quantum gas of polar molecules — •Jun Ye — JILA, NIST and University of Colorado

Molecules cooled to ultralow temperatures provide fundamental insights for molecular interactions and chemical reactions in the quantum regime. Cold molecules also provide new experimental platforms to study strongly correlated quantum systems and facilitate precision test of basic laws of nature. Complete control of molecular interactions by producing a molecular gas at very low entropy and near absolute zero has long been hindered by their complex energy level structure. Recently, a range of scientific tools have been developed to enable the production of molecular quantum gases, where collisions and reactions are controlled by quantum statistics of the molecules at the lowest collision channels. Furthermore, molecules can be confined in reduced spatial dimensions and their interactions can be precisely manipulated via external electromagnetic fields. The long-range dipolar interaction between spatially trapped molecules presents an interconnected spin system where correlated many-body dynamics can be explored.

Plenary Talk PV XII Fri 9:00 e415

Quantum Computing to advance Artificial Intelligence: Where do we stand? — •Hartmut Neven — Google, 340 Main Street, Venice CA 90291

In this talk I will describe two processor architectures that the Quantum AI team at Google is currently experimenting with: quantum annealers and quantum circuits. Quantum annealers are a promising tool to find good solutions to hard combinatorial optimization problems. In recent tests we were able to show that in the D-Wave 2X quantum annealer multi-qubit tunneling does play a computational role. For crafted benchmark problems the D-Wave runs significantly faster than purely thermal annealing that does not employ tunneling. I will discuss the implications of these experiments for the design of next generation quantum annealers. With quantum circuits we implemented what could be described as a quantum neural network. In a first application we used this circuit to calculate the energy surface of molecular hydrogen to chemical precision. Emerging quantum processors offer interesting opportunities to advance machine intelligence. I will describe the example of machine learning from very noisy data.

Plenary Talk PV XIII Fri 9:45 e415

Polaritons in two dimensional semiconductors — •Atac Imamoglu — ETH Zurich

Reversible coupling of excitons and photons in intrinsic semiconductor quantum wells embedded inside a microcavity has been used to study non-equilibrium condensation and superfluidity of cavitypolaritons. In this talk, I will present a new paradigm for polariton physics consisting of a charge tunable transition metal dichalcogenide monolayer embedded in an open fiber-cavity structure. Thanks to ultralarge exciton binding and the associated strong cavity coupling, this system exhibits robust polariton modes even in the presence of a two dimensional electron gas. As the electron density is increased from zero, the oscillator strength determined from polariton splitting is gradually transferred from the exciton transition to the trion transition. The lineshape of the lower and upper trion-polaritons as well their dispersion deviate substantially from a simple coupled oscillator model that is applicable to the exciton transition. Our system constitutes a new regime for mobile quantum impurity problem and paves the way for investigation of polariton-electron Bose-Fermi mixtures.