Plenarvortrag PV I Mo 8:30 3A

Ultrakalte Atome - verdünnte Gase mit starken Wechselwirkungen — •Wolfgang Ketterle — MIT, Cambridge, USA

Atomkühlung in den Nanokelvin-Temperaturbereich hat die Atomphysik revolutioniert. Bei solch tiefen Temperaturen bestimmen die schwachen Kräfte zwischen den Atomen die Eigenschaften des Gases und führen zu neuen Formen von korrelierter Materie. Ultrakalte Fermionen zeigen Verhalten, das analog ist zu Elektronen in Supraleitern. Eine neue Form von Hochtemperatur-Superfluidität wurde beobachtet. Ultrakalte Atome in periodischen Licht-Potentialen zeigen Eigenschaften von Flüssigkeiten oder Isolatoren. Für die Zukunft planen wir, ultrakalte Atome zu verwenden, um neue Designer-Materie zu erzeugen, d.h. neue Materie-Formen, die als Modellsysteme für Vielteilechnphysik diskutiert werden, aber nicht in der Natur beobachtet worden sind.

Plenarvortrag PV II Di 8:30 3A

Electronic and vibrational spectroscopy of cold, gas-phase biological ions — •Thomas Rizzo — Laboratoire de chimie physique moléculaire, Ecole Polytechique Fédérale de Lausanne, CH-1015 Lausanne

The spectroscopic study of small neutral biological molecules in supersonic free jets has provided a wealth of information on their energy landscapes and represents an important means to test the reliability of structure calculations. In such studies, the spectral simplification afforded by the cooling in a supersonic expansion is essential for being able to extract useful information.

Many, if not most, biological molecules exist in the form of closed-shell molecular ions in solution, however, and one would like to have the same degree of spectral simplification for such species as for neutrals. Toward this end, we have constructed a tandem mass spectrometer with a linear 22-pole ion trap that can be cooled down to ~6K. Ions produced by nanospray are mass selected, injected into the trap and cooled through collisions with helium. We then irradiate the cold ions with different combinations of UV and IR laser pulses and measure spectra by detecting fragments that are produced after photon absorption.

In this talk I will present our most recent results on the electronic and vibrational spectroscopy of protonated amino acids, small protonated peptides as well small clusters of these species with a controlled number of solvent molecules. If time permits, I will discuss our preliminary results on multiply-charged oglionucleotides.

Plenarvortrag PV III Di 9:15 3A

Atoms and Molecules in Extreme Electromagnetic Fields: From Atto- to Femtoseconds — •Joachim Ullrich — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Highly-charged ions at velocities close to the speed of light, available at GSI in Darmstadt, generate extremely strong (I $\sim 10^{15}$ – 10^{23} W/cm^2), attosecond ($\sim 10^{-18}$ s) electromagnetic pulses when passing target atoms, molecules or clusters. Modern Ti:Sa laser systems deliver femtosecond ($\sim 10^{-15}$ s) optical pulses at power densities exceeding 10^{15} with records up to 10^{22} W/cm^2. The VUV **F**ree electron **Las**er at **H**amburg (FLASH), the first world-wide, provides coherent 20 fs radiation pulses at 10^{14} W/cm^2 and photon energies as high as 100 eV.

How do such super-strong electromagnetic fields couple to matter, to single atoms or molecules on these very different, though ultra-short time scales? What are the dynamic mechanisms of atto- or femtosecond single and multiple electron removal occurring e.g. with mega barn cross sections for the ejection of all 18 electrons from an Ar atom in a single collision with a heavy ion? Can we trace and possibly control the correlated femto- or sub-femtosecond quantum dynamics of electrons and ions in such fields? Might we be able to have a glimpse on the attosecond bound-state correlated motion in many-electron atoms or molecules?

Using "Reaction-Microscopes", i.e. many-particle imaging spectrometers, such questions can now be explored in unprecedented detail at heavy-ion accelerators, at optical as well as free electron lasers and will be elucidated in the talk.

Plenarvortrag PV IV Mi 8:30 3A

A Passion for Precision — •Theodor W. Hänsch — Max-Planck Institut für Quantenoptik, Garching, and Department of Physics, Ludwig-Maximilians-Universität, München, Germany

Optical frequency combs from mode-locked femtosecond lasers can link optical and microwave frequencies in a single step, and they provide the long missing clockwork for optical atomic clocks. By extending the limits of time and frequency metrology, they enable new tests of fundamental physics laws. Precise comparisons of optical resonance frequencies of atoms, ions or molecules with each other or with the microwave frequency of a cesium atomic clock are establishing sensitive limits for possible slow variations of fundamental constants. Optical high harmonic generation is extending frequency comb techniques into the extreme ultraviolet, opening a new spectral territory to precision laser spectroscopy. Frequency comb techniques are also providing a key to attosecond science by offering control of the electric field of ultrafast laser pulses.

Plenarvortrag PV V Mi 10:30 3A

The art of building small, from molecular switches to molecular motors — •Ben Feringa — University of Groningen, Stratingh institute for Chemistry, Nijenborgh 4, 9747 AG Groningen, The Netherlands

The fascinating structures and complex functions present in biological systems offer a great challenge to develop synthetic nanostructured materials with functions controllable at the molecular level. In our body a fascinating collection of ingenious molecular motors make it possible that our cells divide, that we can use our muscles and that the consumption of ATP can be used to generate force and mobility. A billion times larger than these nanoscale protein motors in Nature are the plethora of macroscopic motors that power the cars and machinery in daily life. Inspired by Natural we design molecular systems in which the control of molecular dynamics is coupled to specific functions. Toward the bottom up construction of photo- and electro-active systems the focus is on photo- or electro-chemical switching and control of motion. In this lecture molecular switches for data storage, molecular electronics and nanomechanical devices are presented. Molecular motors stand out among the most challenging goals in nanoscience and will provide the heart of future molecular level machinery. Both linear and rotary motors are shown as well as the principle of a chemical powered molecular motor. Progress in the construction of an artificial nanoscale *windmill park* powered by light and the application of molecular motors to perform useful functions is discussed.

Abendvortrag PV VI Mi 20:00 3A

Moderner Lasereinsatz in Medizin, Umwelt und Life Science — •Peter Hering — Institut für Lasermedizin, Universität Düsseldorf, Universitätsstrasse 1, D-40225 Düsseldorf und Forschungszentrum caesar, Ludwig-Erhard-Allee 2, D-53175 Bonn

Am Institut für Lasermedizin der Universität Düsseldorf und bei caesar (center of advanced european studies and research) in Bonn werden moderne neue lasergestützte Verfahren entwickelt für Medizin, Umweltforschung und Life Science. Mit höchstempfindlicher Spurengasanalytik (Cavity Ring Down Spektroskopie) werden der menschliche Atem und atmosphärische Gase untersucht. Neue holographische Methoden der Gesichtsprofilvermessung mit ultrakurzen Laserpulsen für komplizierte Operationsplanungen, forensische Anwendungen und Vermessung und Dokumentation von archäologischen Funden werden vorgestellt. Ein weiteres Thema sind neue Lasermethoden für die Hartgewebeablation (Laser Knochensäge), mit denen ultrafeine tiefe Schnitte in Knochengewebe ohne thermische Schädigung gemacht werden können. Mit Hilfe der 3D Planung können diese Schnitte mit Navigationshilfen Submilimeter genau durchgeführt werden. Es werden exemplarisch konkrete Anwendungsbeispiele mit Animationen gezeigt.

Plenarvortrag PV VII Do 8:30 3A

Dielectric Surface Flashover Under Pulsed RF and Unipolar Excitation* — •Andreas Neuber — Texas Tech University, Pulsed Power Laboratory, Lubbock TX 79409-3102

Flashover along insulators or insulating support structures has to be carefully addressed in the design of any dc, ac, or pulsed high voltage device. Although there is a large body of data on unipolar surface flashover in the atmosphere, which has led to empirical design rules primarily for the power distribution industry, the physics of the involved processes is widely unknown. The major limiting factor in the transmission of High Power Microwaves (HPM) into the atmosphere has been the vacuum-air interface. Both the unipolar and HPM surface flashover cases have been studied under vacuum conditions and have been found to have the same dominant mechanisms. Similarities between HPM window flashover on the air side and unipolar flashover are observed in an atmospheric environment as well. Pulsed unipolar and HPM surface flashover in the gaseous and vacuum environment will be discussed and recent progress on modeling flashover along insulators will be presented.

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Plenarvortrag PV VIII Do 9:15 3A

Relativistic Optics a New Route to Attosecond Physics and Relativistic Engineering — •Gérard A. Mourou — Laboratoire d'Optique Appliquée, ENSTA, France

Ultra high intensity lasers can produce high-energy photons (x-ray, γ-ray) electrons and protons. They are the direct consequence of the relativistic character of the electrons driven by the very large laser fields associated to laser pulse intensities higher than 10^{18}W/cm^2. In the λ^3 regime the pulses are only few optical periods in duration, focused over one wavelength. In this condition, all the pulse's electromagnetic field is contained within an irreducible volume of few lambda cubed. The laser-matter interaction in the λ^3 relativistic regime as shown in PIC simulation clearly indicates a new route to the efficient generation of isolated attosecond pulses of UV and EUV photons as well as synchronized attosecond MeV electron bunches. The manifestation of the relativistic behavior has recently been observed experimentally through the relativistic deflection of the optical pulse. Also a new process based on coherent Thomson scattering is predicted to produce EUV or even X-ray with extremely efficiency close to unity. Because the relativistic interaction occurs in the micrometer volume we can talk about a new field that we would call Relativistic Engineering that would include Relativistic Micro-electronics and Relativistic Micro-optoelectronics. We will also show that the efficient relativistic compression and deflection encountered in the λ^3 regime could lead toward intensities close to the Schwinger intensity with relatively compact systems, opening the exciting possibility to use the vacuum as the main nonlinear medium.

Plenarvortrag PV IX Do 10:30 3A

Gefangen und gekühlt: neue Entwicklungen und Anwendungen der Massenspektrometrie — •H.-Jürgen Kluge — Gesellschaft für Schwerionenforschung (GSI), 64291 Darmstadt — Universität Heidelberg, 69120 Heidelberg

Die Massenspektrometrie hat mit der Entwicklung und Anwendung von effizienten Speicherverfahren, vielfältigen Kühlmethoden, empfindlichen Nachweistechniken für einzelne Ionen und neuartigen Kalibrierverfahren, die zu absoluten Massenbestimmungen gegen die Einheit der Masse im mikroskopischen Bereich führen, eine neue Qualität in Hinsicht auf Genauigkeit, Empfindlichkeit und Anwendungsbreite gewonnen. Der Vortrag gibt einen Überblick über hochgenaue massenspektrometrische Verfahren, bei denen die Ionen in einem Schwerionen-Speicherring oder einer Penningfalle gespeichert sind. Weiter werden Anwendungen diskutiert, die für aktuelle Fragestellungen in vielen Bereichen der Physik wichtig sind. Diese reichen von der Festlegung von Einheiten über die Bestimmung von Fundamentalkonstanten und Tests des Standardmodells bis hin zur Überprüfung fundamentaler Symmetrien.

Plenarvortrag PV X Fr 8:30 3A

Komplexe Plasmen: Kräfte und dynamische Vorgänge — •Alexander Piel — IEAP, Christian-Albrechts-Universität, Kiel

Komplexe (staubige) Plasmen haben der Physik eine Reihe von neuen Impulsen gegeben, wie Plasmakristallisation, nicht-reziproke Kräfte, Windkräfte oder neue Einsichten in Wellenphänomene, die in diesem Vortrag erläutert werden. Die Coulombstreuung von Ionenströmungen an Staubteilchen ist gleichermaßen verantwortlich für die Bildung staubfreier Bereiche und für anziehende Kräfte zwischen gleichgeladenen Staubteilchen. Diese Kräfte haben wir mit Experimenten im Labor und auf Parabelflügen unter Schwerelosigkeit studiert. Ein zweiter Schwerpunkt unserer Untersuchungen sind zwei- und dreidimensionale Partikelsysteme in Plasmafallen. Diese Partikelwolken können in flüssigen und kristallinen Phasen auftreten. Wir haben entdeckt, dass in sphärischen Fallen, in denen wir die Schwerkraft durch theromophoretische Kräfte balancieren, Yukawa-Balls erzeugt werden können. Diese besitzen eine außergewöhnliche Kristallstruktur aus ineinander verschachtelten Schalen. Die elastischen Eigenschaften dieser zwei- und dreidimensionalen Systeme untersuchen wir anhand der Dispersion von Gitterwellen bzw. von Staub-Dichtewellen. Kürzlich konnten wir den direkten experimentellen Nachweis führen, dass transversale Wellen in flüssigen Phasen auftreten, wenn die Wellenlänge mit dem Interpartikelabstand vergleichbar wird. Dies ist ein gutes Beispiel, in dem komplexe Plasmen ein Modellsystem für reale Flüssigkeiten bilden, in denen eine Untersuchung auf der atomaren Skala nicht direkt möglich ist.

Plenarvortrag PV XI Fr 9:15 3A

Probing the electron EDM with cold molecules — •EA Hinds, JJ Hudson, HT Ashworth, MR Tarbutt, and BE Sauer — Centre for Cold Matter, Imperial College London

New elementary particle physics (beyond the standard model) is needed at the 1 TeV energy scale to understand the origin of mass and to explain why we see more matter than antimatter in the universe. This same new physics is expected to give the electron a permanent electric dipole (EDM) in the range of $10^{-26} - 10^{-30}$ e.cm. Thus the search for an electron EDM is the search for new particle physics.

We are measuring the electron EDM using a beam of cold YbF. This molecule benefits from a large amplification of the electric dipole interaction, as do several other heavy, polar molecules (E.A. Hinds, Physica Scripta T70, 34 (1997)). In our experiment this amplification factor is roughly a million. The present version of our experiment has the statistical sensitivity to make a measurement at the level of a few times 10^{-28} e.cm. and this is in progress.

In the next version of the experiment, our 600 m/s beam will be decelerated to increase the coherence time. This, together with several other upgrades now in preparation, will give a further tenfold improvement in sensitivity. Ultimately it will be possible to trap YbF molecules, perhaps for several seconds. The combination of large enhancement factor together with long coherence time promises to bring the uncertainty in the electron EDM into the 10^{-30} range. I will discuss the present status of this programme.