Plenary Talk PV I Mon 9:00 E 415

Prospects for Superconducting Qubits — •David DiVincenzo — RWTH Aachen and Forschungszentrum Juelich

I will give a review of the steady progress in achieving high-fidelity superconducting qubits. As with any "Moore's law" phenomenon, this progress has not been the result of any one breakthrough, but rather from a continual increase in the understanding of the physics and engineering of the field. I will discuss the next steps of scaling this system, and the role that the surface code could play in this.

Plenary Talk PV II Mon 9:45 E 415

Spectroscopic signatures of quantum-coherent energy transfer — •Elisabetta Collini — Dept. of Chemical Sciences, University of Padova, via Marzolo 1, 35131 Padova (Italy)

One of the most surprising and significant advances in the study of the photosynthetic light-harvesting process is the discovery that the electronic energy transfer might involve long-lived electronic coherences, also at physiologically relevant conditions. This means that the transfer of energy among different chromophores does not follow the expected classical incoherent hopping mechanism, but that quantum-mechanical laws can steer the migration of energy. The implications of such quantum transport regime, although currently under debate, might have a tremendous impact in our way to think about natural and artificial light-harvesting. Central to these discoveries has been the development of new ultrafast spectroscopic techniques, in particular two-dimensional electronic spectroscopy, which is now the primary tool to obtain clear and definitive experimental proof of such effects. This talk aims to provide an overview of the experimental techniques developed with the purpose of attaining a more detailed picture of the coherent and incoherent quantum dynamics relevant to energy transfer processes, not limited to the two-dimensional electronic spectroscopy. With the idea of summarizing the experimental and theoretical basic notions necessary to introduce the field, the connection between experimental observables and coherence dynamics will be analysed in detail for each technique, highlighting how electronic coherences could be manifested in different experimental signatures.

Plenary Talk PV III Tue 9:00 E 415

Testing quantum gravity speculations with classical experiments — •Eric Adelberger — University of Washington, Seattle WA, USA

Theoretical attempts to unify gravity with the other fundamental forces and develop quantum theory of gravity suggest new phenomena that can be tested with sufficiently sensitive experiments. I will discuss two of the possible experimental signatures, violation of Einstein's equivalence principle (EP) and of Newton's inverse-square law (ISL). The leading candidate for a unified approach, string or M-theory, predicts remarkable features that have to be hidden from normal investigations–extra space dimensions and hundreds of nominally massless particles with gravitational- strength" couplings–but can lead to small, but detectable, violations of either the EP or the ISL or both.

At present, the most sensitive probes for these new phenomena are provided by classical techniques–torsion balances and lunar laser ranging. I will review these techniques, summarize their remarkable results and discuss some of their implications.

Plenary Talk PV IV Tue 9:45 E 415

How quantum coherence assists photosynthetic light harvesting — •Klaus Schulten — Dept. Physics, U. Illinois at Urbana-Champaign, Beckman Institute, Urbana, IL 61801, USA

This lecture examines how hundreds of pigment molecules in purple bacteria cooperate through quantum coherence to achieve remarkable light harvesting efficiency. Quantum coherent sharing of excitation, which modifies excited state energy levels and combines transition dipole moments, enables rapid transfer of excitation over large distances. Purple bacteria exploit the resulting excitation transfer to engage many antenna proteins in light harvesting, thereby increasing the rate of photon absorption and energy conversion. The lecture highlights how quantum coherence comes about and plays a key role in the photosynthetic apparatus of purple bacteria. The apparatus absorbs light and generates a membrane potential that drives many cellular processes energetically. The atomic level structure of the apparatus, which spreads over the entire bacterial cell, has been deduced from crystallography, electron microscopy, atomic force microscopy and computational modeling. The core function is carried out by photosynthetic reaction centers (RCs) that convert electronic excitation energy of pigments through electron transfer into the membrane potential. The RCs are fed electronic excitation energy through light harvesting complexes exhibiting circular geometries adapted to their function of absorbing sun light and transferring its energy among themselves and the RC with little loss. The apparatus might be the first cellular organelle described on the whole at an electronic and atomic level.

Plenary Talk PV V Wed 9:00 E 415

One, two, three, many: Exploring quantum systems one atom at a time — •Selim Jochim — Physikalisches Institut, Universität Heidelberg, 69120 Heidelberg, Germany

Experiments with ultracold gases have been extremely successful in studying many body systems, such as Bose Einstein condensates or fermionic superfluids. These are deep in the regime of statistical physics, where adding or removing an individual particle does not matter.

For a few-body system this can be dramatically different. This is apparent for example in nuclear physics, where adding a single neutron to a magic nucleus dramatically changes its properties. In our work we deterministically prepare generic model systems containing up to ten ultracold fermionic atoms with tunable short range interaction.

In our bottom-up approach, we have started the exploration of such few-body systems with a two-particle system that can be described with an analytic theory. Adding more particles one by one we enter a regime in which an exact theoretical description of the system is exceedingly difficult, until the particle number becomes large enough such that many-body theories provide an adequate approximation.

Plenary Talk PV VI Wed 9:45 E 415

Imaging attosecond multi-electron dynamics — •Misha Ivanov — Max Born Institute, Berlin, Germany

I will cover several topics related to our work on trying to follow and understand multi-electron dynamics in atoms and molecules, triggered by one-photon or multi-photon ionization. First, I will touch upon the question of how long does it take to remove an electron from an atom or a molecule by light. I will focus on the role of electron-electron interaction in introducing time-delays in this process. Using an example of an excited Helium atom, I will describe a very simple physical picture of how electron-electron interaction can delay one-photon ionization.

Second, I will explain why it may take much less time to absorb many photons then one. Multi-photon absorption in strong laser fields is often viewed as tunnelling. I will discuss our recent results on the role of electron-electron correlation during laser-induced tunnelling, and how these effects manifest themselves in photo-electron or high harmonic spectra.

Third, I will discuss applications of high harmonic spectroscopy to tracking core rearrangement dynamics induced by one-photon ionization, including high harmonic spectroscopy of the Auger-like processes. Finally, I will show how strong laser fields can control the hole dynamics on a femtosecond time-scale, and how this control manifests itself in the high harmonic response.

Evening Talk PV VII Wed 20:00 E 415

Die neue Vermessung der Welt - mit Quanten und Relativität — •Jürgen Müller — LUH, Institut für Erdmessung u. QUEST

Spektakuläre Forschungsergebnisse in der Physik, sei es im Bereich der Quantentheorie oder der Relativitätstheorie, eröffnen nicht nur die Möglichkeit, vielleicht einen Nobelpreis zu erhalten, sie dienen in exzellenter Weise auch so profanen Dingen wie die Vermessung der Welt mit ganz neuen Technologien u. Konzepten. Es lassen sich lokale und globale Deformationen der Erdfigur und Veränderungen der Schwerkraft der Erde mit ungeahnter Genauigkeit und räumlicher Auflösung bestimmen. Variationen liegen unterschiedliche geophysikalische Prozesse zugrunde, die sich über Minuten (Erdbeben), Monate (Monsunregen) oder Jahrtausende (nacheiszeitliche Landhebung) erstrecken. Deren präzise Erfassung liefert wichtige Beiträge zum Verständnis des globalen Wandels. Exemplarisch seien Eismassenverluste in Grönland und der Antarktis und resultierender Meeresspiegelanstieg genannt, oder Änderungen im globalen Wasserhaushalt, z.B. bei zu umfangreicher Bewässerung in Indien oder durch Tauprozesse im Sibirischen Permafrost. Es werden neue Sensor- und Messkonzepte unter Nutzung der Quantenstruktur der Materie und Berücksichtigung der Relativität in der Raum-Zeit-Beschreibung vorgestellt. Sie erstrecken sich von der μm-genauen Abstandsmessung zwischen Satelliten mittels Laserinterferometrie, über die Messung des Schwerefeldes mit Hilfe der Interferenz frei-fallender Atome bis hin zur Nutzung von genauesten

Atomuhren zur Erfassung von Unterschieden des Schwerepotentials. Der Einsatz der neuen Techniken wird für die Erdmessung illustriert.

Plenary Talk PV VIII Thu 9:00 E 415

Capturing Reaction Intermediates with Cryogenic Ion Spectroscopy — •Mark Johnson — Yale University

We will describe the characterization of catalytic reaction intermediates by combining electrospray ionization with cryogenic mass spectrometry. This technique uses a cold (10-30K) RF ion trap to rapidly cool reaction partners and freeze the intermediates into well-defined structures. After mass-selection, these species occur as isomers at a particular mass, and we isolate the spectra of each using a photochemical hole burning scheme involving three stages of mass selection and two independently tunable pulsed infrared lasers. The table-top lasers yield highly resolved vibrational fingerprints of the cold chemical species in a linear action regime, which can be directly compared with theory to recover the structures at play. We will focus on a biomimetic synthetic peptide catalyst (developed at Yale) to carry out stereoselective bromination of a biaryl compound. In this case, the catalyst is first isolated and sharp features associated with particular C=O groups are identified using site-specific isotopic substitution. The catalyst is then docked to the substrate, and the geometry of the host-guest complex is unravelled, again using isotope-dependent vibrational spectrosocpy to follow how specific functional groups are attached in the non-covalent interaction. Applications of this methodology to a variety of systems, including larger peptides and organometallic homogeneous catalytic intermediates, will also be presented.

Plenary Talk PV IX Thu 9:45 E 415

Entanglement, Interference and Tunneling - Multiparticle Coincidence Experiments of Molecular Fragmentation — •Reinhard Dörner, Lothar Schmidt, Till Jahnke, Markus Schöffler, and Jian Wu — Goethe Universität, Frankfurt am Main, Germany

COLTRIMS Reaction Microscopes today allow measuring the correlations between all fragments (electrons and ions) from ionization processes of atoms and molecules. We will show synchroton, laser and ion beam based experiments, where this technique is used to explore fundamental quantum phenomena such as entanglement, double slit interference and tunneling.

One of the examples we will show is the realization of Einsteins Gedankenexperiment on double slit interference where he proposed that measuring the momentum transfer to a double slit would unveil through which of the two slits the quantum particle had passed.

Plenary Talk PV X Fri 9:00 E 415

Efficient coupling of single photons and single molecules — •Vahid Sandoghdar — Max Planck Institute for the Science of Light and Alexander Friedrich University, Erlangen, Germany

Many pioneering experiments have explored the coupling of single quantum mechanical emitters such as atoms and ions to photons. Recently, we showed theoretically that in the linear excitation regime, an atom can block a freely-propagating light beam by up to 100% if it is confined to an area comparable with its scattering cross section. In this talk I present an overview of the recent experimental work on the efficient interaction of light and single emitters with an emphasis on organic molecules. We will see that a single molecule can attenuate, transmit, amplify or phase-shift a focused laser beam. Furthermore, I will report on the first direct long-distance communication of two quantum emitters via single photons. I will then discuss strategies for the optimization of the interaction between photons and emitters by using plasmonic and dielectric antennas.

Plenary Talk PV XI Fri 9:45 E 415

100 Years of Mass Spectrometry: From Thomson to Modern Methods and Applications — •Lutz Schweikhard — Institut für Physik, Ernst-Moritz-Arndt-Universität Greifswald

In 1913 J.J. Thomson reported on experiments with "Rays of positive electricity": Ion beams, as we would call them today, were deflected by electric and magnetic fields and, thus, were dispersed into separate parabolas on a photographic plate. In retrospect, this finding marked the birth of mass spectrometry which was immediately recognized as an ideal method of chemical analysis with highest sensitivity. In addition, Thomson indicated the discovery of a new isotope of neon, i.e., more generally speaking, of a new nuclide. Soon after, the so-called mass defect of atomic nuclei was discovered which gives direct access to the binding energy of atomic nuclei. Over the decades spanning its first century and still today, more and more mass-spectrometry methods were invented and refined while along with these developments the range of applications was expanded. The talk will give an overview of the techniques and will touch upon a couple of examples in physics research.