**Plenary Talk** PV I Mon 8:30 H 0105

**The Interior of Single Molecules** — •Wilson Ho — Department of Physics, University of California, Irvine, CA 92697-4575

Spatially resolved inelastic electron tunneling with a low temperature scanning tunneling microscope (STM) has led to new understanding into a broad spectrum of molecular properties, including particularly, the revelation of variations in the coupling of different parts of a single molecule to external particles, such as electrons and photons. Examples of such spatially resolved inelastic tunneling are vibrational excitation, vibronic spectroscopy, vibrationally resolved fluorescence, and light driven phenomena. The STM makes it possible to inject or remove an electron from a specific point $\mathbf{r_0}$ of the molecule at t=0, i.e. setting up an initial, nonstationary state $\Psi(\mathbf{r_0},0)$, and measure the influence of the chosen $\mathbf{r_0}$ on the molecule's properties. Such experiments lead to spatial control of the properties and functions of molecules in isolation and in aggregates, as well as providing direct visualization of nanoscale phenomena and removing ensemble averaging in the measurement. It is now possible to study the interior of single molecules in real space, and literally visualize their inner machineries in various processes such as energy transfer, conformational changes, diffusion, electron transport, bond formation and dissociation, electron transfer, chemical sensing, and responses of the molecule to light. These studies provide the link between the interior excitations and motions with the macroscopic molecular properties.

**Plenary Talk** PV II Mon 13:00 H 0105

**Computing with Quantum Knots: Non-Abelian Anyons and Topological Quantum Computation** — •Sankar Das Sarma — Condensed Matter Theory Center, University of Maryland, US

Ordinary quantum computation uses simple quantum two level systems (e.g. electron or nuclear spins, atomic hyperfine states, etc.) as quantum bits ('qubits') with one- and two-qubit unitary operations serving as universal quantum gates. The main problem is quantum decoherence, the inevitable continuous dephasing of a quantum state due to its interaction with the environment. A revolutionary alternative idea is to build a quantum computer which is topologically immune to quantum decoherence. Such an inherently fault tolerant topological quantum computer is completely protected from any local perturbation induced by the environment and uses the time-space braiding (i.e. creating suitable quantum knots) of non-Abelian anyonic quasiparticles for quantum computation. Prospects for topological quantum computation will be discussed in this talk from a combined experimental and theoretical perspective. I will discuss a number of physical systems, mostly the fractional quantum Hall states in high-mobility two-dimensional semiconductor structures, but also chiral p-wave superconductors, p-wave fermionic superfluids, cold atom optical lattices, frustrated quantum magnetic systems, Josephson junction arrays, rotating BEC systems, etc. where the possibility for doing topological quantum computation has been theoretically discussed in the recent literature. I will also provide an elementary introduction to the concepts of topological phase, anyons, and non-Abelian braiding statistics, discussing how the interdisciplinary subject of topological quantum computation brings together topology, conformal field theory, fractional quantum Hall effect, Chern-Simons-Witten theory, and materials science.

Further reading: Charles Day, Physics Today, October 2005; Graham Collins, Scientific American, April 2006; Sankar Das Sarma, Michael Freedman, and Chetan Nayak, Physics Today, July 2006; Sankar Das Sarma, Michael Freedman, Chetan Nayak, Steven Simon, and Ady Stern, http://www.arxiv.org/abs/0707.1889 (to appear in Reviews of Modern Physics 2008).

**Evening Talk** PV III Mon 20:00 Urania

**Reaktionen an Festkörper-Oberflächen: Vom Atomaren zum Komplexen** — •Gerhard Ertl — Fritz-Haber-Institut der Max-Planck-Gesellschaft, 14195 Berlin

Reaktionen an Oberflächen von Festkörpern bilden u.a. die Grundlagen der heterogenen Katalyse und lassen sich mithilfe physikalischer Methoden bis ins atomare Detail studieren. Unter bestimmten Bedingungen beobachtet man Phänomene der raumzeitlichen Selbstorganisation, die als Modelle für vielfältige ähnliche Erscheinungen in der Natur dienen können.

**Plenary Talk** PV IV Tue 8:30 H 0105

**How hearing happens** — •James Hudspeth — Rockefeller University, New York, USA

Our hearing is remarkable for its physical capabilities. We can discern sounds at frequencies up to 20 kHz, a bandwidth one-thousandfold that of our vision. At the auditory threshold, our ears detect vibrations of only 0.3 nm, an atomic dimension. Finally, our hearing responds over twelve order of magnitude in intensity, a range unmatched by other sensory systems or indeed by manmade detectors. Uniquely among vertebrate sensory receptors, the ear's mechanoreceptive hair cells amplify their inputs by means of an active process that increases responsiveness to sound, sharpens frequency selectivity, and compresses the dynamic range of hearing. An overly exuberant active process can even cause the spontaneous emission of sound from an ear! Each hair cell uses its hair bundle, an elaborate array of tiny biological strain gauges, both to transduce mechanical stimuli and to implement the active process. Application of the fluctuation-dissipation theorem confirms that a hair bundle can contribute energy to its inputs. Mechanical amplification is accomplished through the interaction of negative hair-bundle stiffness with the activity of the motor protein myosin-1c. The operation of the active process near a Hopf bifurcation explains many of the characteristics of our hearing.

**Prize Talk** PV V Tue 13:00 H 0105

**Quantum tunnelling and coherence in magnetic molecule and ions** — •Bernard Barbara — Institut Néel, CNRS, Grenoble, France — Träger des Gentner-Kastler-Preises

The search for quantum tunnelling in complex magnetic systems, started with domain walls, continued with nano-particles and really succeeded with Single Molecule Magnets. A SMM is a complex object containing several magnetic ions coupled by robust super-exchange interactions and having an energy barrier against spin reversal. The so-called Mn12-ac system is the archetype of SMMs. Despite a huge Hilbert space, resonant tunnelling between its ground-state spin components S= 10 and -10 could be observed, leading to large quantum steps in the classical magnetization-field hysteretic loop. This quantum/classical coexistence can be controlled by temperature (populating energy states closer to the top of the barrier) or applied transverse field Ht (increasing the tunnel splitting D ˜exp-aS, where a represents the ratio of longitudinal/transverse terms of the Hamiltonian), allowing an exploration of nanomagnetism between the quantum and classical limits (where D is large or null, respectively). The discovery of quantum tunnelling in Mn12-ac, later extended to other SMMs, led to a multidisciplinary research on incoherent tunnelling of large magnetic objects. Coherent spin dynamics, observed only recently at the solid-state (e.g. rare-earth ions in crystalline matrices) will now be extended to SMMs for the study of decoherence in complex systems and also for the future implementations of 2D networks of SMM qubits.

**Plenary Talk** PV VI Wed 8:30 H 0105

**Graphene: Exploring Carbon Flatland** — •Andre Geim — University of Manchester

When one writes with a pencil, thin flakes of graphite are left on the surface making a dark trace. Some of these flakes turn out to be only one atom thick and can be viewed as individual atomic planes pulled out from bulk graphite. These planes look like a chicken wire made from carbon atoms. Despite being literally right before our eyes for centuries, this thinnest possible material in our universe called graphene was presumed not to exist until it was discovered by our group in 2004. Now graphene is a bright and still rapidly rising star on the horizon of materials science and condensed matter physics, revealing a cornucopia of new physics and potential applications. I will overview our experimental work on graphene concentrating on its exotic electronic properties that are governed by Dirac-like equations rather than the standard Schrödinger equation and speculate about future applications.

**Plenary Talk** PV VII Wed 9:15 H 0105

**The new paradigm of electron microscopy – on the way to the ultimate limits of optics** — •Knut Urban — Institute for Solid State Research and Ernst Ruska Centre for Microscopy and Spectroscopy with Electrons, Helmholtz Research Centre Jülich, and Chair for Experimental Physics IVE, RWTH Aachen University

Seventy years after its invention by Ernst Ruska (Nobel laureate 1987) transmission electron microscopy has entered a dramatic phase of development and has set out to quest for the ultimate limits of microscopies. The key to this is the recent introduction of aberration-corrected electron optics opening up the way to atomic-resolution electron microscopy in the sub-Angström range. Since the images obtained this way are based on quantum physics their content can only be understood quantitatively on the basis of a comparison with proper solutions of the Schrödinger equation. This way novel investigations on defect structures e.g. in oxides, superconductors and ferroelectrics have become possible in which one not only can determine the local oxygen content on the atomic level but also one can measure atomic displacements at an accuracy of a few picometers. Furthermore instruments equipped with electron monochromators and spectrometers allow to study and measure related electron states at an energy resolution better than 100 meV. The lecture will provide an introduction to this exciting field and elaborate on the foreseeable limits given by the width of the electron wave function.

**Evening Talk** PV VIII Wed 20:00 Urania

**Vom Riesenmagnetowiderstand zur Computerfestplatte** — •Peter Grünberg — Institut für Festkörperforschung, Forschungszentrum Jülich GmbH, 52425 Jülich

**Plenary Talk** PV IX Thu 8:30 H 0105

**Forces and Conformational Dynamics in Biomolecular Nanomachines** — •Helmut Grubmueller — Max-Planck-Institute for Biophysical Chemistry, Am Fassberg 11, 37077 Göttingen, Germany

Many proteins are molecular 'nano machines'; their conformational plasticity and dynamics determines their function. Molecular dynamics force probe experiments enable one to simulate and predict such conformational motions at the atomic level and permit comparison with single molecule experiments [1-4].

Three examples shall highlight the role of conformational protein motions and their theoretical description [7,8]:

(1) Aquaporins are highly selective water channels. Molecular dynamics simulations of multiple water permeation events correctly predict the measured rate and explain why these membrane channels are so efficient, while blocking other small molecules, ions, and even protons [5].

(2) Primary ATP synthesis steps in F1-ATP synthase were studied with molecular dynamics simulations. By enforced rotation of the gamma-'stalk', as in vivo caused by protonmotive Fo-rotation, a time-resolved atomic model for the mechano-chemical energy transfer to the ATP synthesis sites is obtained [6].

(3) Importins and exportins bind cargo proteins and facilitate their transport across nuclear pores. Our molecular dynamics simulations predict the unbound highly flexible importin structures, explain the exportin 'loaded spring' dynamics, and thus resolve previous energetic and kinetic puzzles. [4]

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**Prize Talk** PV X Thu 13:00 H 0105

**Quantum information processing with single spins in diamond** — •Fedor Jelezko — University of Stuttgart, 3. Physical Institute, Stuttgart, Germany — Träger des Walter-Schottky-Preises

Quantum computers promise to increase substantially the efficiency of solving certain computationally demanding problems like searching databases and factoring large integers. One of the greatest challenges now is to implement basic quantum computational elements in a physical system and to demonstrate that they can be reliably controlled. Single spins in semiconductors, in particular associated with defect centers, are promising candidates for practical and scalable implementation of quantum computing even at room temperature . This presentation reports an implementation of quantum logic elements with single spins in a solid. As quantum bits a single electron spin and a single 13C nuclear spin of a single nitrogen vacancy defect center in diamond are used. Owing to long decoherence and relaxation times the systems meets the requirements of hardware for quantum computation. Another important application of single spin manipulation is of more fundamental character. Experiments with single spins are suitable for experimental test of quantum mechanics. Projective measurements of single spins can be used as a test of the quantum Zeno effect and Bell's inequalities.

**Special Talk** PV XI Thu 19:00 H 0105

**Die Debatte um den Klimawandel – Wissenschaftliche Fakten und Handlungsnotwendigkeiten** — •Hartmut Grassl — Max-Planck-Institut für Meteorologie, Hamburg — von Laue Lecture

Der erhöhte Treibhauseffekt der Atmosphäre und die kontinentweite Trübung der Luft haben globale Klimaänderungen angestoßen, die mindestens für die kommenden Jahrhunderte zu einer mittleren Erwärmung und stark steigendem Meeresspiegel führen werden. Je nach zukünftigem Verhalten der Menschheit, vor allem bei der Energiebereitstellung, ist eine Erwärmung über alle Erfahrungen des homo sapiens hinaus sehr wahrscheinlich. Eine die Vorgaben der Rahmenkonvention der Vereinten Nationen zu Klimaänderungen einhaltende Klimapolitik muss den Übergang zu kohlenstofffreien Energieträgern organisieren. Wie schnell dies zu bewerkstelligen ist, soll im Vortrag anhand eines Szenarios, das die mittlere globale Erwärmung unter zwei Grad hält, gezeigt werden.

**Plenary Talk** PV XII Fri 8:30 H 0105

**Multiferroic and Magnetoelectric Materials** — •Wolfgang Kleemann — Angewandte Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany

Recently magnetoelectric (ME) materials with a bilinear magnetic and electric free energy contribution, $F_{me}$= - $\alpha H \cdot E$, have become of utmost interest in view of both fundamental understanding and novel desirable applications (Fiebig, 2005). Multiferroic materials with simultaneous polar and magnetic long-range order are expected to optimize the crosslinked responses, *viz.* magnetization excited by electric fields and electric polarization induced by magnetic ones (Eerenstein *et al.*, 2005). We discuss the occurrence of single phase multiferroicity and of bilinear magnetoelectricity in various systems. Surprisingly most promising applications in spintronics are at present proposed for *non*-ME multiferroics like $BiMnO_3$ (Gajek *et al.*, 2007), and for *non*-multiferroic magnetoelectrics like $Cr_2O_3$ (Chen *et al.*, 2006). Best performing ME multiferroics are stress-strain coupled heterophase systems like $BaTiO_3/CoFe_2O_4$ (Ren *et al.*, 2005). Since recently two extensions of the conventional multiferroic scenario have been under debate. Ferromagnetic-ferroelastic multiferroics as realized by $Ni_2MnGa$-like magnetic shape memory alloys (Ullacko *et al.*, 1996) complement the framework of ferroics involved. Even multiglass systems are envisaged. Mn-doped quantum paraelectric $(Sr,Mn)TiO_3$ shows both long-range dipolar and spin-glass ordering and is subject to higher order ME coupling (Bedanta *et al.*, 2007).

**Prize Talk** PV XIII Fri 9:15 H 0105

**Multivalued Fields in Condensed Matter, Electrodynamics, and Gravitation** — •Hagen Kleinert — Institute for Theoretical Physics, FU Berlin, Germany — Träger des Max-Born-Preises

An introduction is is given into the theory of multivalued fields and their important applications in phase transitions of many physical systems, such as superfluids, superconductors, crystals, and confined charges.

**Special Talk** PV XIV Fri 13:15 H 0105

**The US Missile Defense and Its European Components – Implications for European Security** — •Theodore Postol — Science, Technology and Global Security Working Group, MIT, 77 Massachusetts Avenue, Building E51-163, Cambridge, MA 02139

During 2007 the United States has been presenting briefings and other documents to the European allies that extensively describe the Bush Administration's plans to deploy missile defenses aimed at defending Europe from postulated long-range ballistic missile attacks from Iran. The US plan proposes to deploy a large X-band radar called the EMR (European Midcourse Radar) in the Czech Republic, a launch site of 10 Ground-Based Interceptors, modified from 3-stages to 2, and a Forward Based X-Band Radar (FBX) at some as yet undisclosed location near Iran.

A serious scientific and technical assessment of the US plan leads to the conclusions that:

(1) The technology being used in the European missile defense will never be able to reliably tell the difference between warheads and decoys, which means that the system will have little or no defensive capability in any real combat environment.

(2) The United States has been systematically making false technical statements about the plan to its European allies and to Russia that

have significant policy implications for European security.

(3) Using the Missile Defense Agency's own questionable assumptions about system performance, it can be shown that there are alternative defense-configurations that would *theoretically* give better defense coverage of Europe and would be more robust and reliable relative to the currently proposed missile defense.

(4) Unlike the currently proposed US missile defense, these alternative defense-configurations would be unambiguously pointed at Iran, rather than Russia.

This talk will describe the scientific and technical facts that lead to the above conclusions