TT 14 Symposium Molecular Electronics

Time: Tuesday 09:30–12:15 Room: HSZ 02

Invited Talk TT 14.1 Tue 09:30 HSZ 02

Single-Molecule Transistor — •Hongkun Park — Department of Chemistry and Department of Physics, Harvard University, 12 Oxford Street, Cambridge, MA 02138, USA

In this presentation, I will describe the fabrication of three-terminal devices (transistors) incorporating individual molecules and discuss their utility in probing the coupling between the electronic motion and other molecular degrees of freedom. Examples that will be discussed include (1) the excitation of the internal vibrational motion of a molecule induced by single-electron hopping, (2) the Kondo resonance in single-molecule transistor caused by correlated spin screening, (3) the spin-level structures in the Mn12O12 cluster, a prototypical single-molecule magnet, and (4) electroluminescence from individual CdSe nanorods caused by inelastic electron scattering.

Invited Talk TT 14.2 Tue 10:00 HSZ 02

Three-terminal transport through molecular junctions — •Herre van der Zant — Kavli Institute of Nanoscience, Lorentzweg 1, 2628 CJ Delft, The Netherlands

With electrochemical etching and electromigration, nanogaps on an aluminum gate have been made and small organic molecules of different lengths have been trapped between the electrode pairs. Temperature-dependent transport measurements as a function of gate voltage show that the molecules are weakly coupled to the leads. Samples with the same molecule share common features. For some molecular systems, we find that at low temperatures smaller molecules are worse conductors than longer ones. Asymmetric junctions with a sulphur-gold bonding only on one side, exhibit current-voltage characteristics with steps that are absent for symmetric ones. Coulomb blockade measurements on OPV-3 and OPV-5 show excited states and Kondo behavior. The excitations are associated with vibrational modes and a very good correspondence with Raman spectra is found. Excitations in the single-molecule magnet Mn-12 (S = 10 ground state) are related to non-degenerate spin states. Negative differential resistance and complete current suppression at low bias are explained by a new kind of spin blockade.

Keynote Talk TT 14.3 Tue 10:30 HSZ 02

Transport through single molecules: vibrational and magnetic excitations — •Maarten Wegewijs, Christian Romeike, Herbert Schoeller, and Walter Hofstetter — Institut fuer theoretische Physik A RWTH-Aachen

We discuss the effects of vibrational and magnetic excitations localized on a molecule on the electron tunneling transport.

In the limit of weak tunnel coupling, we show that a distortion of the vibrational potential shape induced by the charging leads to marked transport signatures. Quantum interference of the mechanical motion of the molecule shows up as a suppression of the transport current. Secondly, we show that quantum-tunneling of the magnetic moment in a single molecular magnet leads to oscillations of the transport current and shot-noise. These molecules exhibit a large ground state spin S and a magnetic anisotropy barrier. The weak quantum tunneling effects do not affect the electron addition spectrum but nevertheless lead to visible non-equilibrium shifts of current and noise resonances.

In the limit of strong tunnel coupling we investigate Kondo-tunneling through single-molecular magnets. We show that the quantum-tunneling of the magnetic moment induces a Kondo effect in the electron transport.

— 15 min. break —

Keynote Talk TT 14.4 Tue 11:15 HSZ 02

Novel quantum transport effects in single-molecule junctions — •Felix von Oppen — Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin

Single-molecule junctions differ from more conventional nanstructures such as quantum dots due to the coupling between the electrons and few, well-defined vibrational modes. In this talk, I show that this coupling can lead to transport in the form of a self-similar hierarchy of avalanches of many electrons as well as to tunneling of electron pairs. Self-similar avalanche transport occurs in the regime of strong electron-phonon coupling when the current drives the molecular vibrations out of thermal equilibrium. Tunneling of electron pairs dominates transport when the polaronic renormalization leads to a negative effective charging energy of the molecule.

This work was done in collaboration with Jens Koch (Berlin) and M.E. Raikh (Utah)

Keynote Talk TT 14.5 Tue 11:45 HSZ 02

Electron Transport through Single Molecules — •Heiko B. Weber[1], Daniel Secker[1], Rolf Ochs[2], Mark Elbing[2], Ferdinand Evers[2], Max Köntopp[2], and Marcel Mayor[2,3] — [1]Universität Erlangen-Nürnberg, Lehrstuhl für Angewandte Physik, D-91058 Erlangen — [2]Forschungszentrum Karlsruhe, Institut für Nanotechnologie, D-76021 Karlsruhe — [3]Universität Basel, Dep. of Chemistry, St. Johanns-Ring 19, CH-4056 Basel

We will report on experiments with single molecule junctions, performed with the mechanically controlled break-junction technique. A review is given on the capabilities of the technique and the results obtained so far. The importance of the molecular structure, the local environment, the contacts, and the electronic polarizability will be elucidated.

As a particular example, we will present a redesigned Aviram-Ratner experiment [1] with a molecule that was designed to form a single-molecule diode when contacted from two sides. Indeed, the IVs show a pronounced asymmetry, whereas a blind experiment with symmetric molecules resulted in symmetric IVs. A closer analysis of the data, involving theoretical models, suggests that the bias-dependent charge reconfiguration of the electronic structure is responsible for the diode-like characteristics.

[1] M. Elbing, R. Ochs, M. Köntopp, M. Fischer, C. von Hänisch, F. Weigend, F. Evers, H. B. Weber, M. Mayor: *A single-molecular diode.* In: Proc. Natl. Acad. Sci. USA (2005), Nr. 102, S. 8815 - 8820.