PhD Thesis 2016

Radio-Frequency Scanning Tunneling Microscopy and -Spectroscopy

Starting from: immediate

Background: The investigation of single spins in individual single atoms and molecules is crucial for many current fields of science and technology, since they determine chemical reaction pathways in catalysis, biology and medicine, mediate energy transfer in photosynthetic routes crucial for light harvesting, enable avian magneto-reception, control the transport and recombination of charge carriers in sensors and devices, act as sensitive local probes of molecular structure and for chemical identification, and play the central role in novel molecular (quantum) spintronics applications. To benefit from both, the high spatial resolution (~Å) of scanning tunneling microscopy (STM) and the exceptional energy resolution (< μeV) of magnetic resonance spectroscopy, we have recently pioneered a novel and worldwide unique spectroscopic technique based on a radio frequency (rf) STM system at 5 K. It enables the detection and excitation of mechanical as well as spin degrees of freedom in individual single atoms and functional molecules adsorbed on a surface with sub-nanometer spatial resolution. Our recently successful showcases of rf-STM based spectroscopy include the concerted mechanical oscillations of single molecules in the 100 MHz regime as well as the resonant excitation of single nuclear and electronic spin transitions up to 4 GHz in individual molecular quantum dots. After these successful demonstrations, to date, still many open questions remain, concerning both fundamental physics as well as technological problems.

Topic of thesis: The work addresses unsolved problems of microscopy and spectroscopy by rf-STM. Our current research topics include the effect of nano-mechanical excitations, intramolecular spin chemical probing, underlying physical mechanism, resonant rf pulses for controlled single spins switching.

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