Colloquium on Solid-State Physics

Department of Physics
WS 2022/23

Thursday, 8st December 2022, 17.15 h
Lecture Hall III, Department of Physics, Garching

Accessing Non-equilibrium States at the Atomic Scale

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Abstract:

While scanning probe microscopy (SPM) has revolutionized our understanding of the atomistic world it is usually too slow to capture non-equilibrium excitation processes. Two complementary approaches that allow accessing non-equilibrium phenomena with SPM will be presented. Accessing ultra-fast phenomena is enabled by combining lightwave electronics with scanning tunneling microscopy (STM), allowing for combined femtosecond and sub-angstrom resolution in observing matter [1]. Lightwave STM can not only be used to merely observe, but it also provides combined femtosecond and sub-angstrom access in the control of matter by utilizing localized electric fields to exert atom-scale femtosecond forces [2].

Another approach gives us access to intermediate timescales that are relevant for spin precession and relaxations. We exploit the high sensitivity of atomic force microscopy (AFM) to perform scanning tunneling microscopy (STM) and spectroscopy on molecules in absence of any conductance of the underlying substrate. Thereby, we gain access to out-of-equilibrium charge states that are out of reach for conventional STM [3]. Extending this technique by electronic pump-probe spectroscopy, we measured the triplet lifetime of an individual pentacene molecule on an insulating surface [4] and lifetime quenching by nearby oxygen molecules. Combined with radio-frequency magnetic-field driving we introduce AFM-based electron spin resonance and spin manipulation showing long spin coherence in single molecules.

References:
[1] T. L. Cocker et al., Nature 539, 263 (2016).
[2] D. Peller et al., Nature 585, 58 (2020).
[3] L. L. Patera et al., Nature 566, 245 (2019).
[4] J. Peng et al., Science 373, 452 (2021).

There will be coffee, tea, and cookies in front of the lecture hall at 17.00 h

gez:
Christian Back (Host)