PHYSIKALISCHES KOLLOQUIUM

Wintersemester 2025/2026

Das Kolloquium findet (soweit nicht anders angegeben) **jeweils montags um 14:15 Uhr im Röntgen-Hörsaal** des Physikalischen Instituts, Hubland Campus Süd, Universität Würzburg **und online via Zoom statt**.
Zugangsdaten siehe https://www.physik.uni-wuerzburg.de/aktuelles/veranstaltungen-aus-der-physik/physikalisches-kolloquium/

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Non-equilibrium at atomic scales: shaken or stirred… and scanned

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 subangstrom resolution in observing matter (1). Lightwave STM also provides access in the control of matter by utilizing localized electric fields to exert atom-scale femtosecond forces (2). Further, we show how lightwave STM can be extended to its ultrafast spectroscopy variant (3). The corresponding ultrafast and atomically resolved tunnelling spectra reveal transient energy shifts of a single selenium vacancy in a WSe_2 monolayer on gold.
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 outof-equilibrium charge states (4,5) that are out of reach for conventional STM. Extending this technique by electronic pump-probe spectroscopy, we measured the triplet lifetime of individual molecules and its quenching by nearby oxygen molecules (6). Combined with

radio-frequency magnetic-field driving we introduce AFM-based electron spin resonance and spin manipulation showing long spin coherence in single molecules (7).

An overview of our recent activities related to the aforementioned two approaches—metaphorically 'shaken' and 'stirred'—will be presented. For example, we will highlight the challenges and solutions involved in bringing LW-STM towards laser transients with carrier waves in the near-infrared spectral range to boost the temporal resolution. This way, tunneling-time windows below one femtosecond can be achieved, while maintaining the atomic-scale spatial resolution of STM.

References:

(1) T. Cocker et al., Nature 539, 263 (2016).
(2) D. Peller et al., Nature 585, 58 (2020).
(3) C. Roelcke et al., Nature Photonics 18, 595 (2024).
(4) L. L. Patera et al., Nature 566, 245 (2019).
(5) L. Sellies et al., Nature Nanotechnology 20, 27 (2024).
(6) J. Peng et al., Science 373, 452 (2021).
(7) L. Sellies et al., Nature 624, 64 (2023).

Für die Dozentinnen bzw. Dozenten der Fakultät

Prof. Dr. Palffy-Buß, Prof. Dr. Klembt, Dr. Hammer, Hr. Baumbach, Fr. Schleicher