Investigating individual spins on surfaces by electron paramagnetic resonance in a scanning tunneling microscope

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Scanning tunneling microscopy (STM) is a versatile tool that enables the study of surfaces and individual surface adsorbates. Additionally, it provides access to the energy resolved local conductance by tunneling spectroscopy. The latter has an energy resolution that is limited by the electronic temperature. On the other hand, electron paramagnetic resonance (EPR) is commonly used to characterize the magnetic properties of molecules and dopants in solid state materials. Recent advances combined STM and EPR to bring the superior energy resolution of resonant techniques to the atomic scale.[1] EPR-STM provides a powerful platform that enables coherent control of individual spin qubits and provides access to their interactions with the local environment. Furthermore, artificial quantum systems can be assembled atom by atom using in-situ atom manipulation to study their behavior.[2]
In this seminar, I will give an introduction to EPR and STM, review the recent developments in the field of EPR-STM and summarize the current understanding of the driving and readout mechanisms, as well as other requirements that facilitate EPR-STM measurements.[3] We will apply this knowledge in the demonstration that Alkali metal dimers on ultrathin MgO substrates can be studied by EPR-STM, expanding the class of available systems to beyond 3d transition metals and organic complexes thereof.[4]

References:

1. Baumann et al., Electron paramagnetic resonance of individual atoms on a surface. *Science* **350**, 417–420 (2015).
2. Chen et al., Harnessing the Quantum Behavior of Spins on Surfaces, *Advanced Materials,* 2107534 (2022)
3. Seifert et al., Longitudinal and transverse electron paramagnetic resonance in a scanning tunneling microscope, *Science Advances* **6**, 40 (2021)
4. Kovarik et al., Electron Paramagnetic Resonance of Alkali Metal Atoms and Dimers on Ultrathin MgO, *Nano Letters* **22**, 4176-4181 (2022)