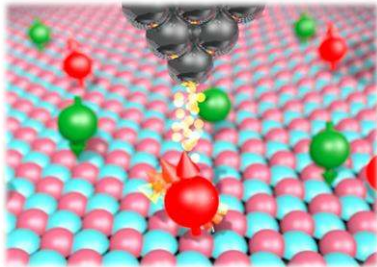


Einladung zum Physikalischen Kolloquium



24.04.2026 Philip Willke, Karlsruher Institut für Technologie
»Quantum Science with Single Atoms and Molecules on Surfaces«
Einführung: J. Schmalian



The quantum nature of a physical system often emerges from its fundamental building blocks and demands a deep understanding to leverage its benefits for future quantum technologies. In this talk, I introduce how spin systems on surfaces can act as a new platform for coherent quantum control. In particular, I show how the combination of electron spin resonance (ESR) with scanning tunneling microscopy (STM) enables the detection, control, and manipulation of individual spin centers with atomic spatial resolution and extremely high energy sensitivity. Building on the first demonstrations of ESR on single atoms on surfaces [1], I will introduce the basic principles of this technique and show how it allows quantum systems to be investigated one atom at a time. As examples, I discuss high-resolution magnetic sensing that resolves magnetic dipole interactions as well as hyperfine coupling between single electron and nuclear spins [2,3]. Beyond sensing, these spin systems can be coherently driven and engineered as prototype quantum bits.

I will highlight current research directions in the field and in my group, including the extension of coherent control from single atoms to individual molecules [4,5] as well as spin defects on surfaces. Finally, I will discuss recent developments that connect this platform to new experimental techniques, such as atomic force microscopy, and to new material systems, including superconductors.

- [1] S. Baumann *et al.*, *Electron paramagnetic resonance of individual atoms on a surface*, **Science** **350**, 417–420 (2015).
- [2] P. Willke *et al.*, *Magnetic resonance imaging of single atoms on a surface*, **Nature Physics** **15**, 1005–1010 (2019).
- [3] P. Willke *et al.*, *Hyperfine interaction of individual atoms on a surface*, **Science** **362**, 336–339 (2018).
- [4] X. Zhang *et al.*, *Electron spin resonance of single iron phthalocyanine molecules and role of their non-localized spins in magnetic interactions*, **Nature Chemistry** **14**, 59–65 (2022).
- [5] W. Huang *et al.*, *Quantum spin-engineering in on-surface molecular ferrimagnets*, **Nature Communications** **16**, 5208 (2025).

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