SYNV 1: Potentials for NVs sensing magnetic phases, textures and excitations

Time: Monday 13:30–16:15 Location: Audimax 2

Invited Talk SYNV 1.1 Mon 13:30 Audimax 2

Harnessing Nitrogen Vacancy Centers in Diamond for Next-Generation Quantum Science and Technology — •Chunhui Du — University of California, San Diego, California, United State

Advanced quantum systems are integral to both scientific research and modern technology enabling a wide range of emerging applications. Nitrogen vacancy (NV) centers, optically active atomic defects in diamond, are directly relevant in this context due to their single-spin sensitivity and remarkable functionality over a broad temperature range. In this talk, I will present our recent efforts on developing NV-based quantum sensing and imaging techniques and their potential to address the challenges in both condensed matter physics and quantum science and technologies. Specifically, we have achieved: 1) electrical control of coherent spin rotations of NV spin qubits in NV-magnon based hybrid systems, 2) nanoscale imaging of magnetic flux and magnetization of a topological superconductor by NV wide-field microscopy, and 3) local non-invasive measurements of thermal environment of Mott insulators by NV centers. Our results illustrate the unique capability enabled by NV centers in exploring the exotic spin, heat, and charge transport in emergent quantum materials. The demonstrated coupling between NV centers and magnons in hybrid quantum devices further points to the possibility to establish macroscale entanglement between distant spin qubits and paves the way for developing transformative NV-based quantum computer.

Invited Talk SYNV 1.2 Mon 14:00 Audimax 2

Nanoscale imaging of spin textures with single spins in diamond — •Patrick Maletinsky — Department of Physics, Basel University, Switzerland

Quantum two-level systems offer attractive opportunities for sensing and imaging at the nanoscale. Since its inception, this idea [1] has advanced from proof of concept [2] to a mature quantum technology [3], which finds applications in condensed matter physics, materials science and engineering. In this talk, I will discuss our approach to realizing such quantum sensors [4] and highlight some particularly rewarding applications in the imaging of nanoscale spin textures.

Specifically, I will discuss how we employ single electronic spins in diamond for nanoscale probing of antiferromagnetic systems [5,6] and high-resolution imaging of atomically thin van der Waals magnets [7]. For both, the combination of sensitivity, spatial resolution and quantitative imaging enables unprecedented insights into nanoscale domains and domain-walls down to the atomic monolayer limit.

I will conclude with an outlook of future developments of single spin magnetometers for extreme conditions, such as high magnetic fields, mK temperatures or high-frequency sensors to probe the dynamics of nanomagnetic systems.

[1] B. Chernobrod et al., J. Appl. Phys. 97, 014903 [2] G. Balasubmaranian et al., Nature 455, 644 [3] P. Appel et al., Rev. Sci. Instr. 87, 063703 [4] N. Hedrich et al. Phys. Rev. Appl. 14, 064007 [5] P. Appel et al., Nano Lett. 19, 1682 [6] N. Hedrich et al., Nature Phys. 17, 574 [7] L. Thiel et al., Science 364, 973

Invited Talk SYNV 1.3 Mon 14:30 Audimax 2

Spin-based microscopy of 2D magnetic systems — •Jörg Wrachtrup — 3rd Physics Institute, University of Stuttgart, Stuttgart, Germany

The investigation of magnetic order in 2D materials requires dedicated probes. While conventional probes of magnetism with nanoscale resolution, like Lorenz microscopy or MFM fail for few layer- or monolayer samples, STM requires dedicated sample preparation. NV-based magnetic probes on the other hand are very well suited to provide quantitative data with a few ten nm spatial resolution and sufficient sensitivity, even for monolayer samples. In the talk I will describe experiments on CrBr3 which show the domain structure of the material [1]. Upon imaging material with different number of layers we gained insight into interlayer coupling and it impact on magnetic order. We also measure magnetic order over a wide range of temperatures and derive information on the physics of the phase transition of CrBr3. In addition, I will show measurements on CrI3 samples of different thickness and relative orientation where we find signatures of Moiré patterns in twisted multilayers [2].

[1] Qi-Chao Sun et al. Magnetic domains and domain wall pinning in atomically this CrBr3 revealed by nanoscale imaging, Nature Comm. 12, 1989 (2021) [2] Qi-Chao Sun et al. Direct visualization of magnetic domains and moiré magnetism in twisted two-dimensional magnets, submitted (2021)

15 min. break

Invited Talk SYNV 1.4 Mon 15:15 Audimax 2

Exploring antiferromagnetic order at the nanoscale with a single spin microscope — •Vincent Jacques — Laboratoire Charles Coulomb, Université de Montpellier and CNRS, 34095 Montpellier, France

Experimental methods allowing for the detection of single spins in the solid-state, which were initially developed for quantum information science, open new avenues for the development of highly sensitive quantum sensors. In that context, the electronic spin of a single nitrogen-vacancy (NV) defect in diamond can be used as an atomic-sized magnetometer, providing an unprecedented combination of spatial resolution and magnetic sensitivity under ambient conditions [1]. In this talk, I will illustrate how scanning-NV magnetometry can be used as a powerful tool for exploring condensed-matter physics, focusing on chiral spin textures in antiferromagnetic materials [2,3].

References: [1] L. Rondin et al., Rep. Prog. Phys. 77, 056503 (2014) [2] I. Gross et al., Nature 549, 252 (2017) [3] A. Finco et al., Nat. Comm. 12, 767 (2021)

Invited Talk SYNV 1.5 Mon 15:45 Audimax 2

Nanoscale magnetic resonance spectroscopy with NV-diamond quantum sensors — •Dominik Bucher — Technical University of Munich, Physical Chemistry, Garching, Germany

Recently, optically probed nitrogen-vacancy (NV) point defects in diamond have emerged as a new class of quantum sensors allowing the detection of magnetic fields on unprecedented length scales. This technique allows the measurement of magnetic resonance signals on the nanoscale down to a single electronic or nuclear spin. In the first part of this talk, I will introduce the concept of quantum sensing with NV-centers, in particular, the detection of oscillating magnetic fields, important for magnetic resonance spectroscopy applications. In the second part, I will report on recent progress on probing thin films and 2D materials with this technique. In the concluding part, possible applications in sensing magnetic phases, textures and excitations will be discussed.