Physikalisches Kolloquium

Universität Konstanz

Di 16.5.17
15:15 Uhr
14:45 Uhr, Kaffee/Tee
R 513

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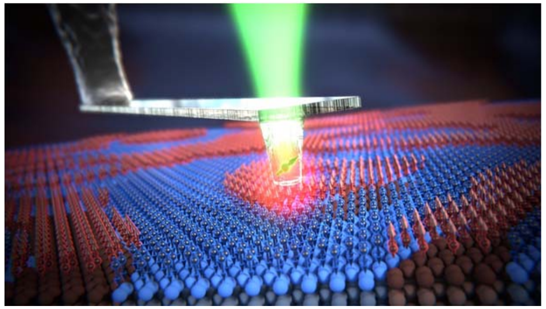
Single spin quantum sensing of superconductors and antiferromagnets



Electronic spins make for excellent nanoscale magnetometers [1,2] as they offer single spin sensitivities and nanoscale spatial resolution [3]. Such magnetometers based on Nitrogen-Vacancy (NV) electronic spins in diamond have proven particularly impactful over the last years, as they confer above benefits with quantitative sensing, imaging under ambient conditions and largely non-invasive operation. This combined performance is of particular significance for applications in nano-magnetism, where quantitative studies of ferromagnetic domains [4] and resonances [5] have recently been demonstrated with accessible sensing bandwidths up to several gigahertz [5,6]. Such quantum sensors now compete with the current state-of-the-art in classical magnetic sensing and imaging and thereby showcase the high potential of emerging quantum technologies in practical applications.
In my talk, I will present recent activities of the Quantum Sensing Group at Basel University in nanoscale NV magnetometry of condensed-matter systems. Specifically, I will describe our experimental approach to realising such quantum magnetometers [7] and discuss two classes of systems we currently investigate with them: antiferromagnets and superconductors. I will first focus on an experiment where we used scanning NV magnetometry to address magnetism in the magneto-electric antiferromagnet Cr_2O_3. This material is a main contender for realising future antiferromagnetic spintronic devices, including antiferromagnetic random access memories [9]. Our NV magnetometry experiments allowed us to study important material properties such as magnetic domain formation and magnetic moment densities in this antiferromagnet, both of which are key to future technological applications of Cr_2O_3.
I will then discuss a second line of experiments, where we promoted NV magnetometry to cryogenic operation for the first time and applied it to nanoscale studies of superconductors [10]. I will review our results of imaging individual vortices in the high-temperature superconductor $YBa_2Cu_3O_7$ and how they will enable future nanoscale studies of a broad class of mesoscopic systems under cryogenic conditions.
I will conclude with an outlook on further prospects of nanoscale NV magnetometry, including sensing of high-frequency dynamics in nanomagnetic systems and applications of NV magnetometers to exotic states of matter at sub-Kelvin temperatures.

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[4] J.P. Tetienne, et al., Nature Comm. 6, 6733
[5] T. Van der Sar, et al., Nature Comm. 6, 7886
[6] P. Appel, et al., New J. of Phys. 17, 112001
[7] P. Appel, et al., Rev. Sci. Instrum. 87, 063703, P. Maletinsky, et al., Nature Nanotech. 7, 320
[8] X. He, et al., Nature Mat. 9, 579
[9] T. Kosub, et al., Nature Comm. 8, 13985
[10] L. Thiel, et al., Nature Nano. 11 677