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Scanning SQUID microscopy with single electron spin sensitivity

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Superconducting interference devices (SQUIDs) have been traditionally used for studying fundamental properties of magnetic materials and superconductors. Although widely used in scanning magnetic microscopy, their progress towards detection of small magnetic moments was stagnating of late due to limitations imposed by conventional designs of planar SQUIDs and contemporary lithography techniques, restricting sample-to-sensor distance smaller than ~ 0.5 micron and SQUIDs diameters smaller than ~ 200 nm. These limitations were overcome by the invention of a SQUID-on-tip device [1], subsequent realization of a SQUID-on-tip microscope [2], and by creation of an ultra-small sensor with spatial resolution of 20 nm and sensitivity to a single electron spin per 1 Hz bandwidth [3]. In this talk I will describe the principles of scanning SQUID magnetometry, its applications to study superconductors and its potential for magnetic nano-scale imaging of novel materials.

[1] Self-aligned nanoSQUID on a tip. A. Finkler, Y. Segev, Y. Myasoedov, M. L. Rappaport, L. Ne'eman, D. Vasyukov, E. Zeldov, M. E. Huber, J. Martin and A. Yacoby, Nano Letters 10 (2010) 1046.
[2] Scanning superconducting quantum interference device on a tip for magnetic imaging of nanoscale phenomena. A. Finkler, D. Vasyukov, Y. Segev, L. Ne'eman, E. O. Lachman, M. L. Rappaport, Y. Myasoedov, E. Zeldov and M. E. Huber, Rev. Sci. Instrum. 83 (2012) 073702.
[3] A scanning superconducting quantum interference device with single electron spin sensitivity. D. Vasyukov, Y. Anahory, L. Embon, D. Halbertal, J. Cuppens, L. Ne'eman, A. Finkler, Y. Segev, Y. Myasoedov, M. L. Rappaport, M. E. Huber and E. Zeldov, Nature Nanotechnology 8 (2013) 639; Magnetic sensors: A tip for better sensing. D. Koelle, Nature Nanotechnology 8 (2013) 617.