Nanoscale physics

NanoSQUID on tip microscopy

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In recent years there is a growing interest in development of microSQUIDs for imaging and study of quantum magnetism. Imaging magnetic fields on a nanoscale is a major challenge in nanotechnology, physics, chemistry, and biology. One of the milestones in this endeavor is to achieve sensitivity sufficient for detection of the magnetic moment of a single electron. There are three main technological challenges: fabrication of a sensor with a high magnetic flux sensitivity, reducing the size of the sensor, and the ability to scan the sensor nanometers above the sample. We have developed a very simple self-aligned fabrication method which results in the smallest SQUIDs to date [1]. The SOT made of thin Pb film with the tips mounted on a rotatable liquid He cryostat display extremely low flux noise of $\Phi_n = 50\ n\Phi_0/Hz^{1/2}$ that corresponds to a spin sensitivity of 0.4 $\mu_B/Hz^{1/2}$ and are operable at 4.2 K in applied magnetic fields of up to 1.5 T. The SOTs are mounted on a stack of atto**cube** scanners and positioners that can scan an area 30 x 30 μm^2 and provide coarse positioning with a range of a few millimeters at 4.2 K. Using the feedback signal from a quartz tuning fork to which the SOT is touching, the SOT can scan a few nms above the surface of the sample. The combination of having the SQUID on the end of a needle-like tip (rather than on a flat substrate) plus its small diameter, high flux sensitivity, and ability to scan at such a small separation from the sample, opens the way to high resolution imaging and investigation of vortex matter with single vortex resolution. Scanning SOT magnetic images of vortices in a superconducting 50 nm-thick Pb film at 4.2 K in different applied magnetic fields will be presented revealing intriguing vortex static and dynamic phenomena.

1. *D. Vasyukov, Y. Anahory, L. Embon, D. Halbertal, J. Cuppens, L. Neeman, A. Finkler, Y. Segev, Y. Myasoedov, M. L. Rappaport, M. E. Huber, and E. Zeldov* A scanning superconducting quantum interference device with single electron spin sensitivity// Nature Nanotech.-2013.-**8**.-P. 639-644.