Magnetic Microscopy with an Ultracold Quantum Fluid

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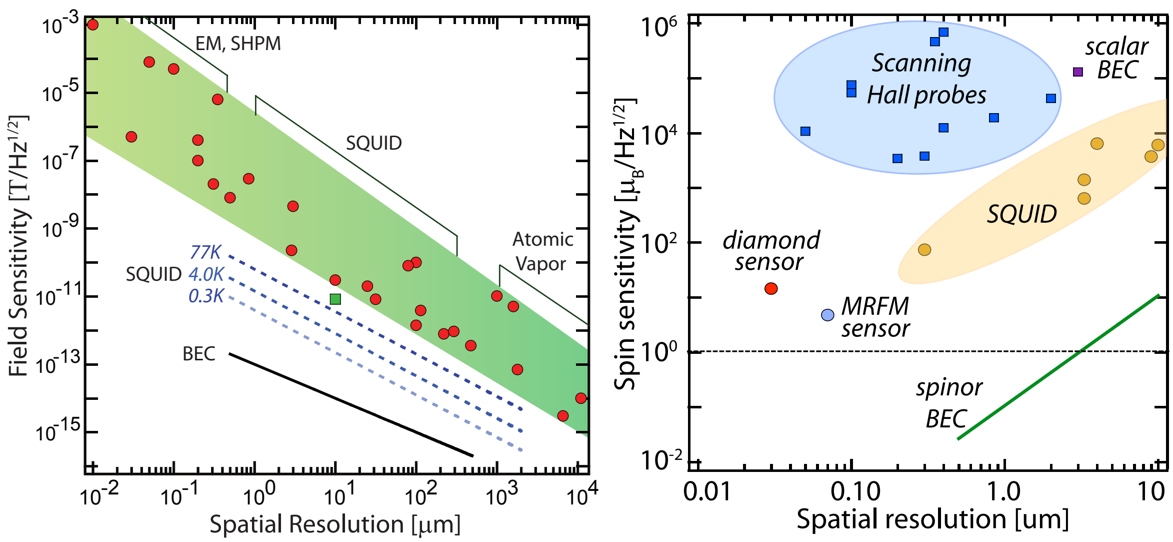
Precision magnetometers find applications in biomagnetic imagining, studying condensed matter systems and exploring fundamental symmetries of Nature. We propose a novel approach to precision magnetic microscopy, which is based on the detection of Larmor precession of a Bose-Einstein Condensate. A recent proof-of-principle demonstration of this concept has resulted in a field sensitivity of 8.3 pT/Hz$^{1/2}$ over a measurement area of 120 μm^2. As indicated in Figure 1 this is on par with the current state-of-the-art. We present methods to improve upon this performance by three orders of magnitude, thus heralding a new regime of magnetic microscopy.



This unprecedented combination of field sensitivity and spatial resolution makes this Quantum Fluid Magnetic Microscope (QFMM) an ideal device for electronic spin detection. We estimate a shot noise limited spin sensitivity of 0.1 $\mu_B/\sqrt{Hz}$ with a spatial resolution of 1 micron. This implies the nondestructive detection of a single electronic spin within 10 ms. As shown in figure 2 this spin sensitivity decidedly improves upon existing techniques for electron spin detection such as the MRFM sensors and diamond magnetometers.