

# Scanning magnetoresistance microscopy of atom chips

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Surface based geometries of microfabricated wires or patterned magnetic films can be used to magnetically trap and manipulate ultracold neutral atoms or Bose-Einstein condensates. We have investigated the magnetic properties of such atom chips using a scanning magnetoresistive (MR) microscope with high spatial resolution and high field sensitivity [1]. By comparing MR scans of a permanent magnetic atom chip to field profiles obtained using ultracold atoms [2], we show that MR sensors are ideally suited to observe small variations of the magnetic field caused by imperfections in the wires or magnetic materials which ultimately lead to fragmentation of ultracold atom clouds. Measurements are also provided for the magnetic field produced by a thin current-carrying wire with small geometric modulations along the edge. Comparisons of our measurements with a full numeric calculation of the current flow in the wire and the subsequent magnetic field show excellent agreement. Our results highlight the use of scanning MR microscopy as a convenient and powerful technique for precisely characterizing the magnetic fields produced near the surface of atom chips.

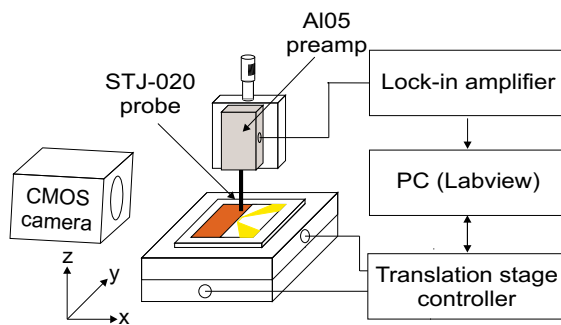


Figure 1: Schematic of the scanning magnetoresistance microscope. The sample is placed on a computer controlled  $x - y$  translation stage. The magnetoresistive probe is connected to a preamplifier and the signal is filtered and digitized by a lock-in amplifier. A CMOS camera is used to determine the distance between the sensor tip and the sample.

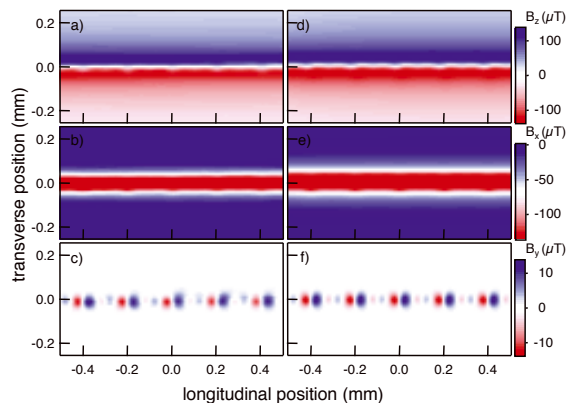


Figure 2: a to c measured out-of-plane component  $B_z$  and reconstructed in-plane components  $B_x$ ,  $B_y$  of the magnetic field above the current-carrying wire atom chip. d to f corresponding results of the numerical simulation of the current distribution and the associated magnetic field, based on the geometric dimensions of the wire structure.

## References

- [1] M. Volk, S. Whitlock, C.H. Wolff, B.V. Hall and A.I. Sidorov, *Rev. Sci. Instrum.* **79**, 1 (2008).
- [2] S. Whitlock, B.V. Hall, T. Roach, R. Anderson, M. Volk, P. Hannaford and A.I. Sidorov, *Phys. Rev. A* **75**, 043602 (2007).