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Chip-Scale Atomic Magnetometers

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Atomic magnetometers have reached sensitivities rivaling those of superconducting quantum interference devices (SQUIDs) in some frequency ranges [1]. A major advancement in atomic magnetometry was made possible by implementing interrogation schemes that suppress spin-exchange collisions between the alkali atoms [2]. Good signal-to-noise can be achieved by operation at very high alkali densities. At the same time, it introduces the challenge to create uniform spin-polarization and monitor the atomic precession about the magnetic field in atomic vapors with large optical densities. Off-resonant detection of the polarization rotation rather than the absorption is essential to operate in this regime. By use of microfabrication methods, we are miniaturizing such atomic magnetometers. They consist of miniature vapor cells with volumes of a few cubic millimeters integrated with micro-optical components. We present the advancement in sensitivities of such devices over nearly four orders of magnitude [3]. This allows for small low-power room-temperature devices with sensitivities that get close to those of SQUIDs in the frequency range around 100 Hz. We outline the current performance of chip-scale atomic magnetometers and the major challenges. Apart from efficient pumping and probing at high optical densities, these include magnetic noise caused by several sensor components and environmental factors, noise on the light fields, as well as magnetic fields from current-carrying parts, such as heaters, lasers, and photodetectors.

[1] Allred et al., Phys. Rev. Lett. 89, 130801 (2002)
[2] Happer and Tam, Phys. Rev. A 16, 1877 (1977)
[3] Griffith et al., Appl. Phys. Lett 94, 023502 (2009)