

Toward Cavity-Enhanced Optically Pumped Magnetometry in a Microfabricated Cesium Vapor Cell

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Optically Pumped Magnetometers (OPMs) exploit the magneto-optical properties of alkali atoms like rubidium and cesium to detect magnetic fields with extremely high sensitivity. They rely on optically induced spin polarization, where magnetic fields modify the polarization state of light interacting with the vapor. Efforts to miniaturise microfabricated cells to mm size have opened the doors to new applications in biosensing such as magnetoencephalography (MEG), or magnetocardiography (MCG). To date, mm-sized miniaturised OPMs have enabled $10 \text{ fT}/\sqrt{\text{Hz}}$ sensitivity [1] [2]. Further miniaturisation down to $100\mu\text{m}$ scales and beyond will enable exploration of new regimes in these applications. However, the reduced sensing volume comes at the cost of a reduced sensitivity due to the smaller optical path length. Multipass configurations have proven to be a useful technique to enhance sensitivity, but they become increasingly hard to implement in miniaturised set-ups. To overcome these limitations, we propose the use of optical cavities to effectively extend the optical path length of microfabricated OPMs and improve signal readout. Towards this goal, I will first show the fundamental sensitivity enhancement provided by an optical cavity over optimal photon shot noise-limited single-pass measurements. The following detection schemes will be studied: side-of-fringe, PDH, homodyne/heterodyne detection and Faraday rotation. Furthermore, I will report previous work implementing a PDH scheme to a mm-sized OPM to detect the behaviour of magnetotactic bacteria under a magnetic field [3]. Finally, I will show experimental progress towards optimal cavity enhancement in the sub-mm regime using microfabricated cesium vapor cells.

[1] H. Raghavan *et al.* *Phys. Rev. Appl.* **22**, 044011 (2024).

[2] D. Sheng *et al.* *Appl. Phys. Lett.* **110**, 031106 (2017).

[3] M. H. Ruiz *et al.* *EPJ Quantum Technol.* (2026)