Contribution ID: **78** Type: **Oral presentation**

High-resolution magnetic field imaging with a two-axis MEMS scanning mirror

Thursday 7 August 2025 11:20 (20 minutes)

We demonstrate high-resolution magnetic field imaging using a custom micro-machined cesium (Cs) vapor cell filled with nitrogen (N_2) buffer gas [1], incorporating automated spatial sampling via a two-axis MEMS scanning mirror. The cell utilizes advanced fabrication techniques that enable flexible and scalable geometries, making it well suited for a variety of applications, including magnetic imaging [2]. An optically pumped magnetometer (OPM) operating in the free-induction-decay (FID) protocol is employed. Renowned for its high accuracy and stability, this technique is also discussed in the context of portable sensor implementations used to detect space weather phenomena.

By resonantly pumping the Cs D_2 transition, near-unity spin polarization is achieved, maximizing signal amplitude. Spin-exchange effects are suppressed via light narrowing, which reduces the transverse relaxation rate (γ_2). Combined with an advanced optical pumping strategy, this results in sub-picotesla sensitivity across a broad dynamic range, supporting accurate and stable imaging in finite-field environments [3].

Spatial confinement provided by the buffer gas enables locally independent measurements within a single vapor cell. This capability is harnessed to image a variety of magnetic sources using a single-pixel FID-based sensor. Two-dimensional magnetic field images with high spatial and temporal resolution are generated which has significant implications for applications including battery diagnostics and electronic circuit quality assurance.

[1] S. Dyer *et al.*, J. Appl. Phys., vol. **132**, no. 13, 2022.
[2] D. Hunter *et al.*, Opt. Express, vol. **31**, no. 20, pp. 33582–33595, 2023.
[3] D. Hunter *et al.*, J. Opt. Soc. Am. B, vol. **40**, no. 10, pp. 2664–2673, 2023.

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Session Classification: OPM Development II