Tuned Micro-Cavity Magnetometer

LDRD
LABORATORY DIRECTED RESEARCH & DEVELOPMENT

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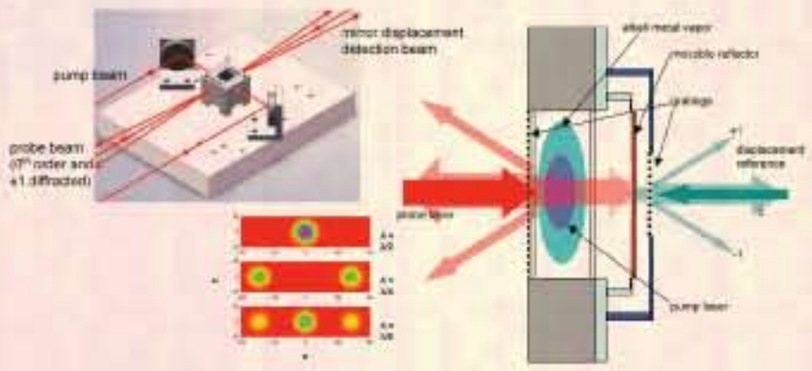
Problem

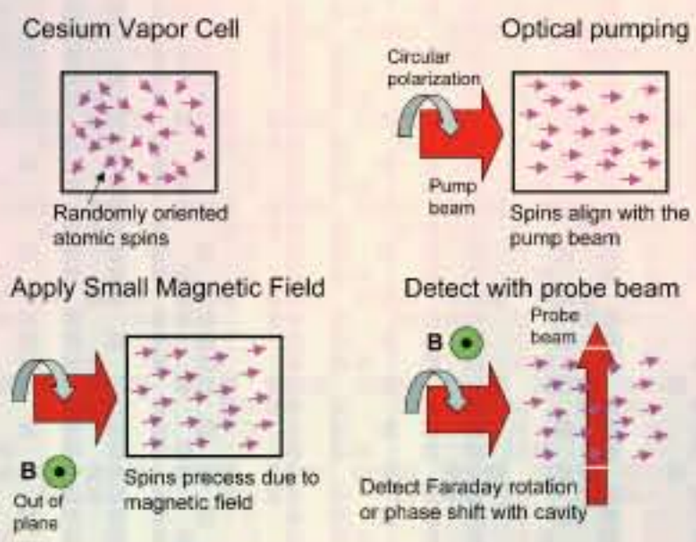
- Ultra-high sensitivity (<1 picoTesla) magnetic field measurements are critical for applications such as unexploded ordnance detection, underground structure mapping, ASW, neural activity monitoring (MEG).
- Atomic magnetometers have the potential to provide such sensitivity levels in a miniaturized format without the need for cryogenic cooling (liquid helium is required for SQUIDs).

Approach

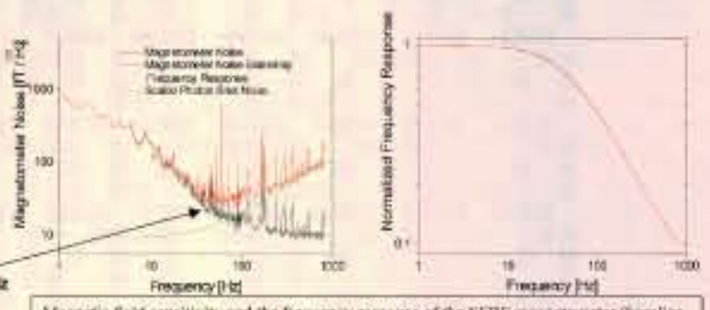
- We are building a miniaturized atomic magnetometer that utilizes a tuned path-length cavity and interferometric detection of index change (due to the imposed B field) inside the vapor cell.



Magnetometer Fundamentals: Low-Field Alkali Magnetometer

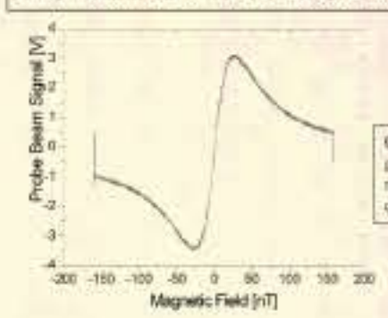


Baseline Magnetometer Measurements



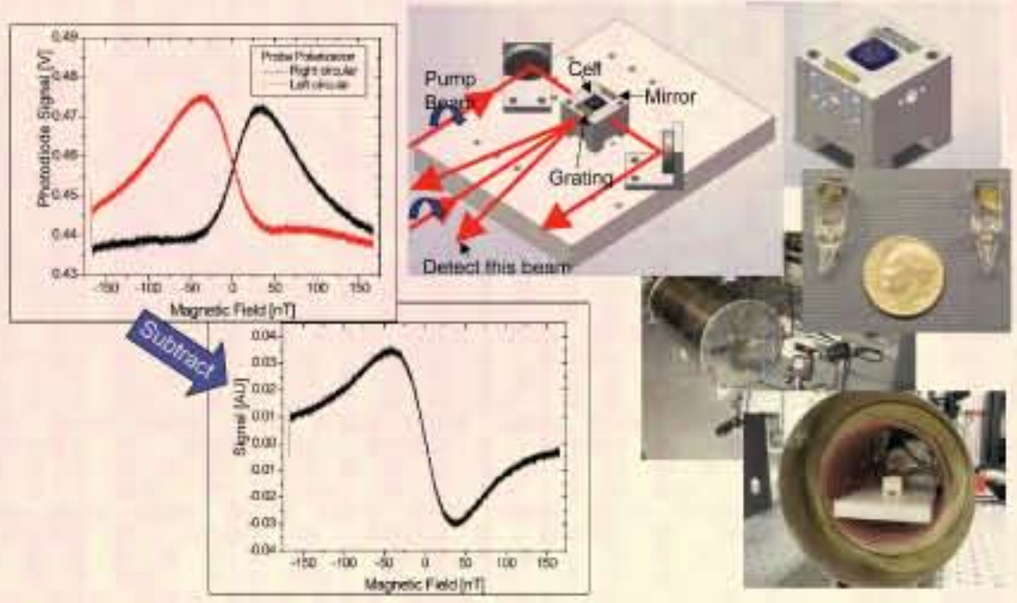
Baseline SERF magnetometer sensitivity of **30 femtoTesla/√Hz** at 50Hz

Magnetic field sensitivity and the frequency response of the SERF magnetometer (baseline configuration). The scaled noise (red trace) gives the sensitivity of the device.



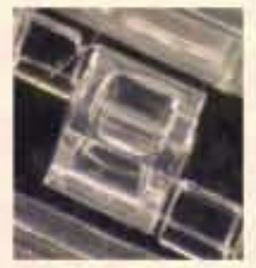
Optical response observed in the probe beam going through the vapor cell as the bias magnetic field is varied inside the shielded chamber.

First Cavity Measurements



Tuned Cavity Components

close-up image of the grating-only test structure (integrated into microcavity configuration)



Prototype vapor cell

Fill station for filling and sealing microcells with anodic bonding

boron nitride vapor cell / cavity assembly (heaters assembled)

actuatable reflector/grating

Significance

- Miniaturized highly sensitive magnetometers have potential applications in satellite systems, navigation, basic sciences, and unexploded ordnance/explosives detection.
- 3D array-based detection has significant possibilities in imaging type applications.
  - Neural currents (MEG), underground explosives and structures, low-field MRI.
- Miniature MEMS-based magnetometers have potential to reduce the cost of high-sensitivity magnetometry through wafer-level production.

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