

An optically pumped magnetic gradiometer for the detection of human biomagnetism

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We realise an intrinsic optically pumped magnetic gradiometer based on non-linear magneto-optical rotation [1]. We show that our sensor can reach a gradiometric sensitivity of $18 \text{ fT/cm}/\sqrt{\text{Hz}}$ and can reject common mode homogeneous magnetic field noise with up to 30 dB attenuation. We demonstrate that our magnetic field gradiometer is sufficiently sensitive and resilient to be employed in biomagnetic applications. In particular, we are able to record the auditory evoked response of the human brain, and to perform real-time magnetocardiography in the presence of external magnetic field disturbances. Our gradiometer provides complementary capabilities in human biomagnetic sensing to optically pumped magnetometers, and opens new avenues in the detection of human biomagnetism [2].

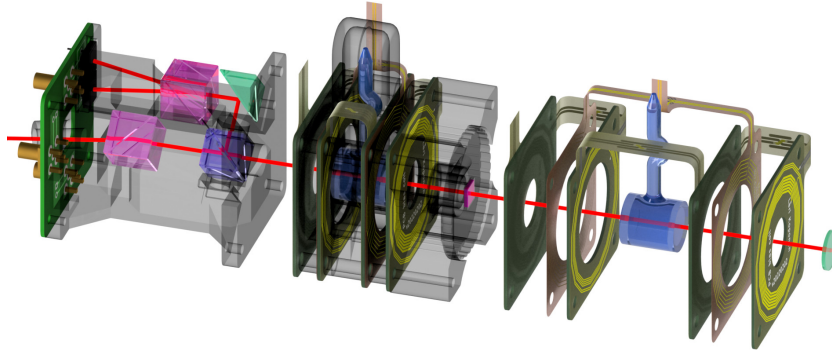


Figure 1. Sensor design. Two paraffin-coated vapour cells are interrogated by a single laser beam. This beam is delivered by a polarisation-maintaining fibre and after probing the atoms, the polarisation is measured with a balanced polarimeter. Around each cell two sets of coils are used: the first applies a magnetic bias field across the atoms, and the second heats the cell. A half-waveplate is placed between the cells to induce a π phase-delay on the lock-in signal.

[1] V. Acosta et al., Nonlinear magneto-optical rotation with frequency-modulated light in the geophysical field range, *Phys. Rev. A* **73**, 053404 (2006)

[2] H. Cook et al., An optically pumped magnetic gradiometer for the detection of human biomagnetism, *Quantum Sci. Technol.* **9** 035016 (2024).