High-bandwidth optical magnetometry via phase retrieval

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We demonstrate broadband, high-bandwidth magnetic field measurements from DC to above 1MHz with a magnetometer based on nonlinear magneto-optical rotation (NMOR). This is achieved through measurement of the instantaneous phase evolution of the optical polarisation rotation in the temporal domain. We theoretically show that this instantaneous phase evolution can be extracted directly from polarimeter measurements through balancing the absorption and polarisation rotation of the probe light. Under these conditions, the two outputs of the polarimeter are phase shifted by 90° allowing the instantaneous phase to be calculated. We combine the instantaneous phase measurements [1] with phase sensitive detection and active feedback techniques [2] to track magnetic field fluctuations over long timescales resulting in broadband, high-bandwidth magnetic field measurements from DC to above 1MHz, nearly 4-orders of magnitude larger than the passive bandwidth. This technique achieved a sensitivity of 200fT/$\sqrt{\text{Hz}}$ around 8Hz and 1nT/$\sqrt{\text{Hz}}$ at 100kHz, for a bias field of 50μT [2]. We present bandwidth and signal-to-noise ratio (SNR) measurements, Figure 1, and demonstrate that NMOR magnetometers are able to offer high-bandwidth and broadband field measurements for oscillating fields from DC to above 1MHz. Practical and physical limitations to the technique will be discussed.

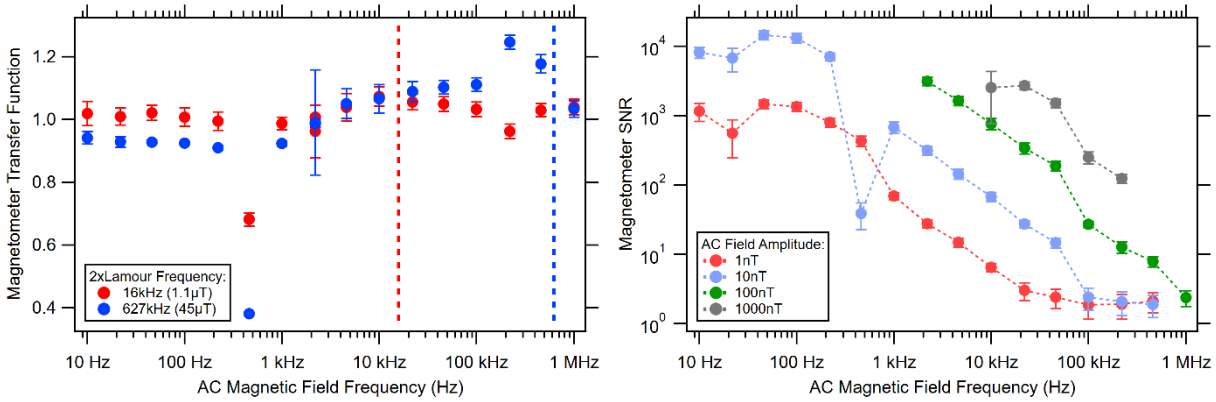

Figure 1: Left - Transfer function of the instantaneous phase retrieval technique. Vertical dashed lines represent twice the Lamour frequency, the polarization rotation modulated frequency. Right – SNR measurements for a range of magnetic field strengths.

References

[1] N. Wilson, C. Perrella, R. Anderson, A. Luiten, and P. Light, Phys. Rev. Res. **2**, 1 (2020).

[2] R. Li, F. N. Baynes, A. N. Luiten, and C. Perrella, Phys. Rev. Appl. **14**, 064067 (2020).