High-bandwidth optical magnetometry via phase retrieval

Chris Perrella[1], Kyle Netz[1], Rujie Li[1], Andre Luiten[1]

[1] Institute for Photonics and Advanced Sensing, School of Physical Sciences, University of Adelaide, Adelaide, SA 5005 Australia

We merge together two techniques to demonstrate broadband, high-bandwidth magnetic field measurements from DC to above 100kHz for magnetometers based on nonlinear magneto-optical rotation (NMOR). We extend upon the first technique that measures instantaneous phase evolution of the optical polarisation rotation in the temporal domain that enabled quantitative measurements of modulated magnetic fields above 100kHz [1]. We show that this instantaneous phase evolution can be extracted directly from the polarimeter measurements through a balancing of the absorption and polarisation rotation of the probe light. This is seen in Figure 1 (left) which shows the two polarimeter outputs are phase shifted by 90° allowing the instantaneous phase to be calculated. We combine this first technique with a second method that employs phase sensitive detection and active feedback techniques to track magnetic field fluctuations up to 100kHz, nearly 4-orders of magnitude larger than the passive bandwidth [2]. 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 preliminary measurement that combine these two techniques with the measured magnetic noise floor shown in Figure 1 (right) and demonstrate that NMOR magnetometers are able to offer a high-bandwidth and broadband field measurements for oscillating fields from DC to above 100kHz.

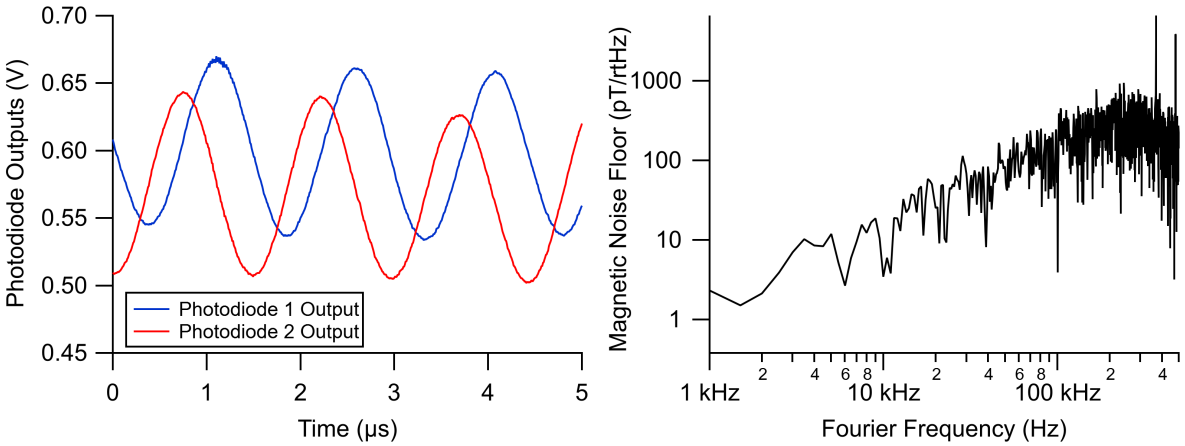

Figure 1. Left: Output of the polarimeter showing a 90° phase shift between the two outputs/polarisation components of the probe light. Right: Preliminary power spectral density of the magnetic noise floor using this technique.

[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).