High-bandwidth optical magnetometry

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Using two techniques that exploit phase-sensitive detection, we demonstrate broadband, high-bandwidth magnetic field measurements from DC up to 100kHz for magnetometers based on nonlinear magneto-optical rotation (NMOR). The first technique measures the instantaneous phase evolution of the optical polarisation rotation in the temporal domain which enabled quantitative measurements of modulated magnetic fields above 100kHz for a Larmor frequency of 15kHz, corresponding to a bias field of 2μT. This technique was used to measure arbitrarily-complicated modulation waveforms, see Fig. 1 (left). The second method 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, see Fig. 1 (right). This technique achieved a slew rate of 91.4nT/μs, and a sensitivity of 200fT/$\sqrt{\text{Hz}}$ around 8Hz and 1nT/$\sqrt{\text{Hz}}$ at 100kHz, for a bias field of 50μT. Both techniques are photon shot-noise limited above 100Hz. Our investigation shows that NMOR magnetometers are able to offer a high-bandwidth, broadband, and high-slew-rate field measurement for oscillating fields up to frequencies of 100kHz.

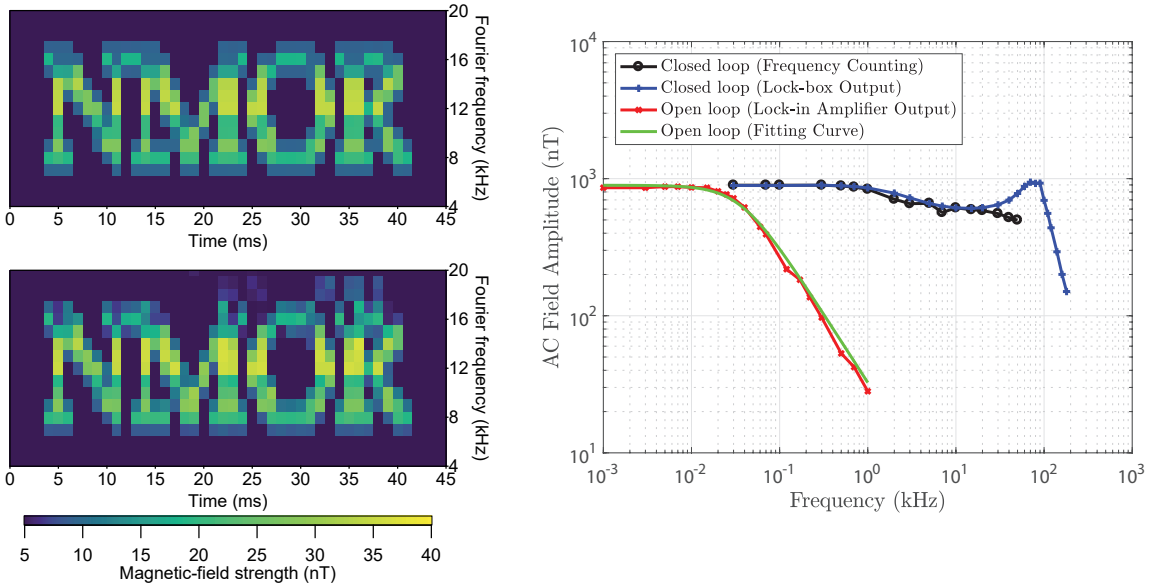

Figure 1. Left: Expected (top) and measured (bottom) spectrograms of the magnetometers response to magnetic-fields measured using the instantaneous phase extraction technique. Right: The amplitude response to AC fields when using phase sensitive detection and active feedback techniques.