Quantum sensing with a hybrid rf-dc optically pumped magnetometer at Earth's magnetic field

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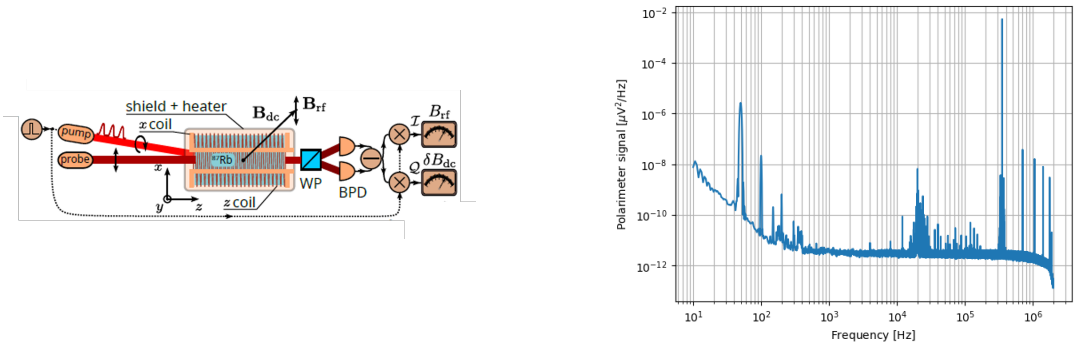
We describe progress toward quantum enhancement of a *hybrid optically pumped magnetometer* (hOPM) able to measure simultaneously the dc field component and one rf field component quadratures with a single atomic spin ensemble [1]. The hOPM operates at Earth's magnetic field on a moving platform, with consequent large fluctuations in background field strength and orientation. The experimental set-up of the hOPM is presented in figure 1a. The hOPM is a Bell-Bloom magnetometer, optically pumped in the same direction as the probe laser. The probe light is then detected with a balanced polarimeter and demodulated with respect to the optical pumping reference modulation signal. The power spectral density of the polarimeter signal is shown in figure 1b, where the strongest peak corresponds to the Earth's magnetic field signal. A high sensitivity hOPM at Earth field could be used in outside-the-lab applications, including underwater and underground magnetic communication [2, 3], and in planetary exploration. Sensitivity of this quantum noise limited instrument could be enhanced for both fields by including squeezed probing technique [4].



(a) (b)

Figure 1. a) Experimental setup of a Bell-Bloom optically pumped rf-dc magnetometer: shielded ^{87}Rb cell through which pass the probe and the pump beams. The polarization rotation of the probe is captured via a Wollaston prism (WP) and a balanced photodetector (BPD). b) Power spectral density of the signal measured at Earth's magnetic field.

[1] M. Lipka, A.Sierant, C. Troullinou, and M. Mitchell, (2023) 10.48550/arXiv.2308.14214

[2] C. Deans, L. Marmugi, and F. Renzoni, Appl. Opt., AO **57**, 2346 (2018).

[3] V. Gerginov, S. Krzyzewski, and S. Knappe, J. Opt. Soc. Am. B **34**, 1429 (2017).

[4] C. Troullinou, R. Jiménez-Martínez, J. Kong, V. G. Lucivero, and M. Mitchell, Physical Review Letters **127**, 193601 (2021).