High-sensitivity optical magnetometry with squeezed light

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Optical and atomic quantum noise in magnetometry can be reduced by optical squeezing and spin squeezing, respectively. Dispersive readout, e.g. by Faraday rotation, can moreover produce spin squeezing, an effect that is expected to improve when squeezed light is used. We report progress toward a Bell-Bloom optical magnetometer with 100 fT/(Hz) sensitivity, simultaneously limited by optical and atomic quantum noise, and enhanced by optical squeezing. The strategy builds upon prior work on squeezed-light enhancement of spin noise spectroscopy in Rb vapor [1], and aims to improve upon prior squeezed-light magnetometry records of nT/(Hz) in 2010 [2] and 2 pT/(Hz) in 2012 [3]. The instrument will be a testbed for the study of optical and atomic quantum noise and their interaction in magnetometry

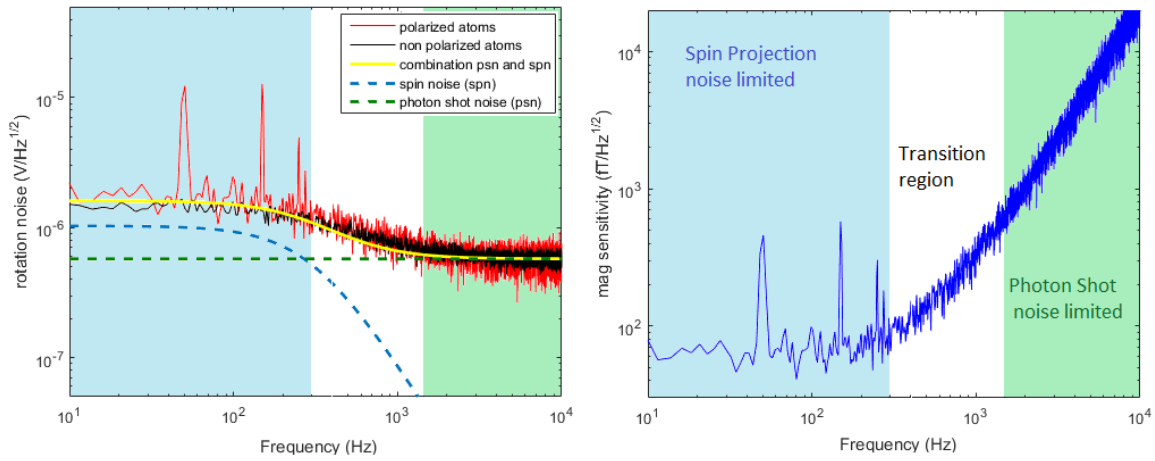

Figure 1. Power spectral density of the phase sensitive signal corresponding to photon shot noise limited performance of the magnetometer. The use of squeezed light probing is predicted to have beneficial effects in each frequency region: directly lowering the magnetic noise floor for high frequency signals, for which photon shot-noise dominates, giving stronger QND measurements for low-frequency signals, for which atomic projection noise dominates, and increasing the effective bandwidth of the sensor in the transition region .

[1] V. Lucivero et al., Sensitivity, quantum limits, and quantum enhancement of noise spectroscopies, Phys. Rev. A **95**, 041803(R) (2017).

[2] F. Wolfgramm et al., Squeezed-Light Optical Magnetometry, Phys. Rev. Lett. **105**, 053601, (2010).

[3] T. Horrom et al., Quantum-enhanced magnetometer with low-frequency squeezing, Phys. Rev. A **86**, 023803, (2012).