Quantum enhancement of sub pT/$\sqrt{\text{Hz}}$ optically pumped magnetometer with squeezed light

Charikleia Troullinou[1], Ricardo Jiménez-Martínez[1], Jia Kong[2], Vito Giovanni Lucivero[1] and Morgan W. Mitchell[1],[3]

[1] ICFO-Institut de Ciencies Fotoniques, The Barcelona Institute of Science and Technology, 08860 Castelldefels (Barcelona), Spain
[2] Department of Physics, Hangzhou Dianzi University, 310018, Hangzhou, China
[3] ICREA – Institució Catalana de Recerca i Estudis Avançats, 08015 Barcelona, Spain

Optically pumped magnetometers (OPM) probing the light-atom interaction of spin polarized hot vapor ensemble are quantum sensors with very wide range of applications ranging from space science to medical diagnosis. In the fundamental level, optical and atomic quantum noise in magnetometry can be reduced by optical squeezing and spin squeezing, respectively. We report **quantum enhancement of a high density Bell Bloom optical magnetometer with 100 fT/$\sqrt{\text{Hz}}$ sensitivity**, simultaneously limited by optical and atomic quantum noise. Using off-resonant **polarization squeezed light generated in a subthreshold optical parametric oscillator** [1] we probe a polarized ensemble of 10^{13} atoms/cm^3 and achieve an increase of the signal to noise ratio. [2] In contrast to previous squeezed-light enhanced magnetometers [3], [4], [5] the relatively simple architecture of Bell Bloom enables independent optimization of the spin preparation and probing while supporting continuous QND measurements. At the same time, it allows clear theoretical understanding of the different quantum noise contributions. The use of squeezed probe light is experimentally shown to improve the **high-frequency sensitivity** as well as the **signal bandwidth of the OPM** while also evading back action noise. The results provide experimental input to the much-discussed question of whether squeezing techniques can in practice improve the performance of atomic sensors .

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