Spin-noise spectra acquired with stroboscopically modulated probe-light

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Atomic-optical magnetometers have reached a level of sensitivity limited by quantum effects. One quantum noise source that can potentially affect the sensitivity of such magnetometers is known as back-action noise. This arises from the coupling of light quantum polarization-fluctuations with the measured atomic-spin system. Stroboscopic modulation of probe intensity at twice the Larmor frequency can circumvent the back-action noise [1]. Besides the noise reduction, eliminating back-action noise paves the way for engineering spin-squeezed states, which can further enhance the sensor's sensitivity [2].

We investigate spin-noise spectra acquired using stroboscopically modulated probe light in cells with sub-mm^2 cross sections. Our focus is on buffer-gas-free atomic ensembles, where the hyperfine structure in the excited state is resolvable, and the second-rank tensor interaction of light with atoms cannot be ignored. We find that the AC Stark shift, along with residual optical pumping caused by the off-resonant probe light, substantially alter the spin-noise spectrum, deviating markedly from a simple Lorentzian profile. This deviation is particularly pronounced when measuring spin-noise spectra in the thermal state and should be considered when evaluating the threshold for spin-squeezing.

References

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