Comparison among Ramsey, spin-echo and CPMG pulse protocols for magnetometry applications

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We will discuss the frequency response function of a time-domain atom interferometer as it relates to magnetometry. We show that a pulse sequence of the type $\pi/2 - (N\pi) - \pi/2$ (where $N$ is the number of $\pi$ pulses applied) is sensitive to DC magnetic fields for $N = 0$ (Ramsey interference) whereas a pulse sequence with $N = 1$ (spin echo) is immune to DC fields with increased frequency response at higher frequencies [1]. The interferometer response function $g_N(\omega, T)$ (as shown in Fig. 1a) has a peak response frequency and characteristic bandwidth, which are determined by the number of $\pi$ pulses, the overall time in the interferometer ($T$), and the pulse spacing. In this talk, we’ll compare and contrast standard pulse sequences (Ramsey, spin echo, and CPMG). We demonstrate how Ramsey, spin echo and CPMG interferences can be performed on a cold atom cloud. We present data from our cold atom experiments performed in an unshielded environment that conclusively show a significant enhancement in coherence time using spin echo protocol versus Ramsey protocol (Fig. 1b). We connect our cold atom work to on-going work using similar protocols but with nitrogen vacancies in diamond crystal lattices as an alternate atomic medium.

FIG. 1: (a) The response function, $g_N(\omega, T)$, is plotted as a function of magnetic-field frequency for Ramsey and spin-echo pulse sequences. (b) Magnetic coherence time is plotted for Ramsey and spin echo pulse sequences. Note the dramatic increase in coherence time for the spin-echo sequence, which is immune to low frequency noise.

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