A $^3\text{He} - ^{129}\text{Xe}$ co-magnetometer with $^{87}\text{Rb}$ magnetometry

Mark Limes, Dong Sheng, Mike Romalis

$^3\text{He}$ and $^{129}\text{Xe}$ are read out by probing polarized $^{87}\text{Rb}$ by Faraday rotation. The spins are manipulated using a $^{87}\text{Rb}$ pump laser and magnetic field coils, with parallel or perpendicular pump/probe beams.

The $^{87}\text{Rb}$ magnetometer using π pulse detection has a sensitivity of 40 fT/sqrt(Hz).

References:

Pump and Probe

Parallel and Perpendicular Pump/probe Schemes

After hyperpolarizing $^3\text{He}$ and $^{129}\text{Xe}$ using spin-exchange with optically pumped $^{87}\text{Rb}$, a π/2 pulse is applied to the noble gases. Two detection periods then determine the phases with which the noble gases enter and leave the “in-the-dark” decoupling period.

Rb π pulses gives decoupling of the Rb-Xe Fermi-contact interaction along a single axis by a factor approaching $10^4$, a factor of $10^2$ better than sine-wave depolarization schemes [1] (inset).

By flipping the bias field, we can calibrate our system using Earth’s rotation. A pulse rotation frequency equal to the sum of the He and Xe precession frequencies gives a measurement that is insensitive to Rb π pulse height. Small imperfections, such as time delays between the pulse axes, can lead to artificial additions to the x-y pulse sequence rotation.

An “in-the-dark” decoupling pulse scheme averages the $^{87}\text{Rb}$ polarization along three axes, introduces no net helicity of the field pulses, and is rotated to null the effect of the sequence on the precession frequency ratio.

References: