A hybrid pumping spin-exchange-relaxation-free (SERF) atomic gyroscope using parametric modulation

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For next generation inertial navigation systems of vehicles, atomic spin gyroscopes are promising rotation sensors due to their high sensitivity and relatively compact active volume. The group of Michael Romalis first demonstrated in 2005 a spin-exchange-relaxation-free (SERF) atomic gyroscope that relys on polarised alkali-metal vapor and nobel gases co-located in a glass cell [1]. The realised sensitivity of 5.0×10^{-7} rad/s/$\sqrt{\text{Hz}}$ is already comparable with devices in the < 50 cm scale.

We present a dual-axis SERF atomic gyroscope using hybrid pumping and parametric modulation. Hybrid pumping can essentially reduce the polarization gradient, and leads to a better sensitivity [2]. To circumvent low frequency drifts, we employ the parametric modulation technique which modulates the direction of the atomic spin polarisation by an oscillating magnetic field in conjunction with lock-in detection. Compared to the light modulation techniques, such as a Faraday modulator or a photoelastic modulator, parametric modulation reduces costs and benefits miniaturization [3].

We will describe the experimental setup and model the coupled spin system under parametrical modulation. Additionally, we compare the performance when the modulation field is added in different axes. At the end, we will present simulation results of single beam SERF gyroscopes and identify feasible conditions for realizing high sensitivity.

References

[1] T. W. Kornack, R. K. Ghosh, and M. V. Romalis, Physical Review Letters **95**, 2 (2005).

[2] J. Lee, A. Almasi, and M. Romalis, Physical Review Letters **120**, 161801 (2018).

[3] V. Shah and M. V. Romalis, Physical Review A - Atomic, Molecular, and Optical Physics **80**, 1 (2009).