An Accurate Rabi Vector Magnetometer Implemented with Hot Alkali Vapor

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Many vector magnetometry applications, including magnetic anomaly detection, navigation, bio-imaging, and space exploration require directional accuracy. A variety of magnetometers achieve vector operation by referencing to mechanical references, where machining tolerances and drifts limit vector accuracy. Known solutions to these systematics are scalar calibrations that involve physical rotations of the magnetometer system and absolute references such as the crystal axes in NV centers. In this work, we demonstrate an approach to accurate vector magnetometry that uses a microwave polarization ellipse (MPE) as an accurate 3D reference.

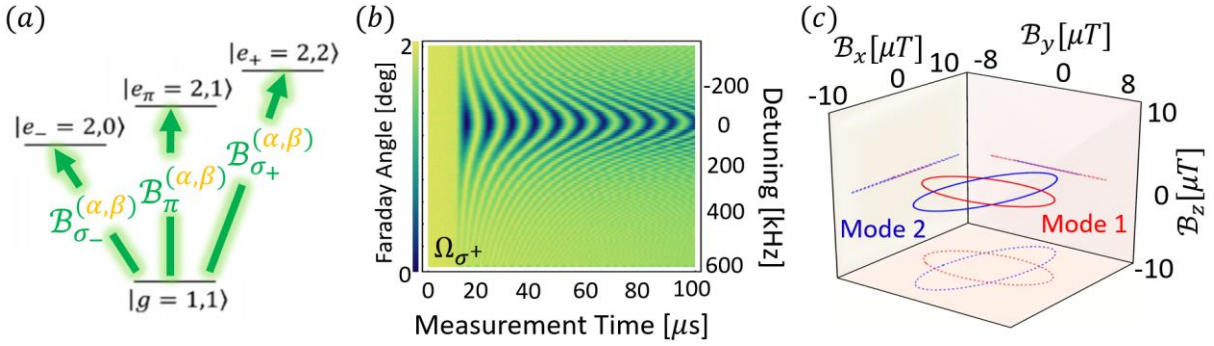

Figure 1: (a) A MPE drives hyperfine transitions in an effective 4-level atom. The corresponding Rabi frequencies depend on the direction (α, β) of the ambient DC magnetic field. (b) Chevron Rabi pattern of the σ^+ transition. (c) Calibrated MPEs of two cavity modes.

These measurements take place in a heated microfabricated vapor cell embedded within a microwave cavity; a platform with much greater sensitivity than a previous proof-of-concept experiment with cold atoms [1]. By continuously sensing the Faraday rotation of a far-detuned probe beam, we record sequential Rabi frequencies every millisecond enabling vector sensitivities down to the 30 μRad/$\sqrt{Hz}$. Importantly, we extract systematics such as coil system and MPE drifts, pressure shifts, and Stark shifts from an accumulation of Rabi oscillations driven at various microwave detunings.

References

[1] T. Thiele, Y. Lin, M. O. Brown, and C. A. Regal, Phys. Rev. Lett. **121** 153202 (2018).