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Absolute vector magnetometry with atomic vapor by referencing to microwave polarization CHRISTOPHER KIEHL, TOBIAS THIELE, DANIEL WAGNER, TING-WEI HSU, MARK O. BROWN, CINDY A. REGAL, University of Colorado, Boulder/JILA/NIST, SVENJA KNAPPE, University of Colorado, Boulder/FieldLine Inc. — Many of the applications of sensitive magnetometers, ranging from precision measurements, dark-matter searches, and timekeeping to biological imaging, navigation, and exploration, can benefit from full vector detection. Several options have been explored to extend atomic magnetometers based on hot vapor cells, which are the most sensitive uncooled sensors, to the vector domain. While lengthy and mechanically complicated calibration algorithms exist, directional accuracy with these sensors remains elusive due to the lack of a stable and precise reference to calibrate drifts in relative axes orientation that are often defined by bias coil or beam propagation directions. In this talk, I will describe an approach to sensitive and accurate vector magnetometry in a hot vapor cell that exploits the 3D structure of a microwave field as a stable reference. Using an algorithmic construct, we first map the full polarization ellipse of a microwave field from the Rabi oscillations observed between hyperfine magnetic sublevels driven with different microwave polarization components. Importantly, our construct reveals typically unknown systematics such as coil misalignments, background fields, Stark shifts, and pressure shifts to within our measurement sensitivities. With the polarization ellipse acting as a calibrated reference, we are able to use solely Rabi measurements to absolutely determine both the direction and magnitude of an unknown magnetic field.

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