DC magnetometry below the Ramsey limit with rapidly rotating diamonds

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Magnetometers based on the nitrogen-vacancy (NV) center in diamond provide µT - nT sensitivity for single centers at ambient temperature and mm-to-sub-µm length scales, making them attractive resources for studying a range of magnetic phenomena in challenging, real-world sensing environments. Since many magnetic phenomena of importance in navigation and biomagnetism manifest as slowly varying or static magnetic fields, intense effort has been devoted in particular to improving dc sensitivity [1]. Many if not all of these approaches to improving the measurement *signal* are frustrated by a commensurate increase in *noise*. Ramsey-type magnetometry remains the optimum measurement sequence, limiting the attainable sensitivity to that set by the ensemble dephasing time T_2^*, typically less than 1 µs.

In this talk, I will report on our demonstration [2] of quantum sensing of dc magnetic fields exceeding the sensitivity of conventional T_2^*-limited dc magnetometry by more than an order of magnitude. We used nitrogen-vacancy centers in a diamond rotating at periods comparable to the spin coherence time to convert dc magnetic fields to ac [3], and characterized the dependence of magnetic sensitivity on measurement time and rotation speed. Our method up-converts only the dc field of interest, eliminates in-diamond noise and and preserves the quantum coherence of the sensor. These results definitively improve the sensitivity of a quantum magnetometer to dc fields, demonstrating that sensitivity below the T_2^* limit is possible and can be applied to any diamond magnetometer where $T_2 \gg T_2^*$ to yield an order of magnitude or more sensitivity improvement.

[1] J. Barry, *et al. Rev. Mod. Phys.* **92**, 015004 (2020).

[2] A. A. Wood, A. Stacey and A. M. Martin, arXiv:2203.14230 (2022).

[3] A. A. Wood, A. G. Aeppli, E. Lilette, Y. Y. Fein, A. Stacey, L. C. L. Hollenberg, R. E. Scholten and A. M. Martin *Phys. Rev. B* **98**, 174114 (2018).