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Rotation sensing with ^{14}N/^{15}N and ^{13}C nuclear spins in diamond

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Diamonds doped with nitrogen-vacancy (NV) centers are a promising solid-state platform for rotation sensing [1,2] capable of operating in a broad range of environmental conditions. In our previous work [3], we demonstrated a solid-state rotation sensor based on ^{14}N nuclear spins intrinsic to NV centers in diamond. This type of sensor detects rotation by measuring the shift in the precession rate of nuclear spins, analogous to vapor-based NMR devices. However, nuclear-spin-based rotation sensors are inherently sensitive to variations in the magnetic field, which produce changes in the precession rate similar to those produced by rotation, limiting the long-term stability of the device. This issue can be overcome by simultaneously measuring the precession of two spin species with different gyromagnetic ratios, which can be combined to obtain the rotation rate while canceling the contribution from magnetic field fluctuations.

In this work we implement this idea using a diamond containing two isotopes of nitrogen (^{14}N and ^{15}N) and simultaneously measure the precession rates of NV nuclear spins of both isotopes. We found that we were able to suppress the magnetic sensitivity of the rotation sensor by several orders of magnitude. We also investigate the use of ^{13}C nuclear spins in diamond as a candidate system for rotation sensing. We demonstrate a technique that takes advantage of microwave-swept "Landau-Zener"crossover resonances to transfer spin polarization between NV electron spins and 13C nuclear spins via their transverse hyperfine interaction [4,5], allowing for both optical hyperpolarization and readout.

The nuclear spin interferometric technique developed in this work may find application in solid-state frequency references and in extending tests of fundamental interactions at micro- and nanoscale to those involving nuclear spins. With further improvements, it may also find use in practical devices such as miniature diamond gyroscopes for navigational applications.

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