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High-sensitivity diamond magnetometer with nanoscale resolution

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The detection of weak magnetic fields with high spatial resolution is an important problem in diverse areas ranging from fundamental physics and material science to data storage and biomedical science. Here we describe a novel approach to magnetometry that takes advantage of recently developed techniques for coherent control of solid-state electronic spin quantum bits. To be specific, we investigate the use of spins associated with Nitrogen-Vacancy (NV) centers in diamond. Two key features distinguish our approach: the possibility to confine the sensing spins into a solid sample of nanometer dimensions that can be brought into direct proximity of a localized magnetic field source; and the potential of achieving high spin densities while maintaining good coherence properties, enabling the detection of sub-femtotesla magnetic fields. The resulting magnetic sensor, which can operate at room-temperature, ambient conditions, is projected to provide an unprecedented combination of ultra-high sensitivity and spatial resolution. As an example, we show that this could enable sensing of nanotesla magnetic fields with resolution well below 50 nanometers –allowing for the detection of a single nuclear spin's precession within one second. Finally, we describe first experiments toward the realization of these ideas.