Electric-field sensing using single diamond spins

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The ability to sensitively detect individual charges under ambient conditions would benefit a wide range of applications across disciplines. However, most current techniques are limited to low-temperature methods such as single-electron transistors, single-electron electrostatic force microscopy and scanning tunnelling microscopy. Here we introduce a quantum-metrology technique demonstrating precision three-dimensional electric-field measurement using a single nitrogen-vacancy defect centre spin in diamond. An a.c. electric-field sensitivity reaching 202±6 V cm−1 Hz−1/2 has been achieved. This corresponds to the electric field produced by a single elementary charge located at a distance of ~150 nm from our spin sensor with averaging for one second. The analysis of the electronic structure of the defect centre reveals how an applied magnetic field influences the electric-field-sensing properties. We also demonstrate that diamond-defect-centre spins can be switched between electric- and magnetic-field sensing modes and identify suitable parameter ranges for both detector schemes. By combining magnetic- and electric-field sensitivity, nanoscale detection and ambient operation, our study should open up new frontiers in imaging and sensing applications ranging from materials science to bioimaging.

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