**Quantum sensing with a single erbium ion in silicon**

*Chunming YinA,B, Guangchong HuA, Qi ZhangA,B, Gabriele G. de BooA, Miloš RančićC,E, Brett C. JohnsonD, Jeffrey C. McCallumD, Jiangfeng DuB, Matthew J. SellarsC, & Sven RoggeA*

ACentre of Excellence for Quantum Computation and Communication Technology, School of Physics, University of New South Wales, Sydney, New South Wales 2052, Australia;

BHefei National Laboratory for Physical Sciences at the Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China;

CCentre of Excellence for Quantum Computation and Communication Technology, Research School of Physics, Australian National University, Canberra, Australian Capital Territory 0200, Australia;

DCentre of Excellence for Quantum Computation and Communication Technology, School of Physics, University of Melbourne, Melbourne, Victoria 3010, Australia;

EQuantronics Group, SPEC, CEA Saclay, 91191 Gif-sur-Yvette Cedex, France

Quantum sensing exploits quantum coherence of nanoscale systems with quantized energy levels to measure physical quantity [1]. For example, single nitrogen-vacancy centres in diamond have been employed to measure magnetic field, electric field, temperature, pressure, and rotation with high accuracy even at ambient conditions [1].

We have previously measured spectra of single erbium (Er) ions at 4.2 K with line widths smaller than 100 neV [2], which makes them good candidates for sensing. Here, we report on the use of a single Er ion as an atomic sensor for a neighbour single spin, electric field and strain in a silicon ultrascaled transistor. One Er ion exhibited strong magnetic dipole interaction with another erbium ion, and their optical transitions showed anti-crossings due to not only level crossing but also virtual photon exchange [3]. Furthermore, Stark shifts on the Er3+ spectra induced by both the overall electric field and the local charge environment are observed, and changes in strain smaller than 3 × 10–6 are detected, which is around 2 orders of magnitude more sensitive than the standard techniques used in the semiconductor industry [4].

These results open new possibilities for detecting the local strain and electric field in the channel of ultrascaled transistors and for building quantum coherent systems with single Er ions.

**References**

1. C. L. Degen et al., Rev. Mod. Phys. 89, 035002 (2017).
2. C. Yin et al., Nature 497, 91 (2013).
3. G. Hu et al., under preparation.
4. Q. Zhang et al., Nano Lett. 19, 5025 (2019).