A fast singlet-triplet qubit in planar Ge driven by a tunable g-factor difference

Josip Kukučka[1]
J.Saez-Mollejo[1], F.Martins[3], D.Jirovec[1], A.Ballabio[2], G.Tavani[2], D.Chrastina[2], G.Isella[2] and G.Katsaros[2]

[1]Institute of Science and Technology Austria, Klosterneuburg, Austria.
[2]Laboratory for Epitaxial Nanostructures on Silicon and Spintronics, Physics Department, Politecnico di Milano, Como, Italy
[3]Hitachi Cambridge Laboratory, Cambridge, UK

josip.kukucka@ist.ac.at

Exceptional properties such as long coherence times [1], fault tolerant single [2] and two-qubit fidelities [3], fast and high fidelity state read-out [4,5], together with CMOS integration capabilities [6] set spin-qubits amongst the top players in the race towards the quantum computer.

Currently, those exceptional characteristics are scattered among different spin-qubit platforms. This is where Ge kicks in. Firstly, a large spin-orbit coupling allows fast and fully electrical spin state manipulation. Secondly, holes couple only weakly to nuclear spins. Finally, the small effective mass and the low disorder in this material reduces the fabrication complexity. Recent experiments have demonstrated high-quality qubits operating in depletion mode [7], two-qubit gates [8] and a four-qubit quantum processor [9].

Here, we show our results on singlet-triplet qubit in planar Ge. Exploiting the large and tunable out-of-plane g-factors allows X-rotations of up to 600 MHz, and a quality factor exceeding 200 at a magnetic field of only 10 mT.

The reported results not only compete with state of the art spin qubits but pave also the way for on-chip co-integration with superconducting technology. Furthermore, the electrical tunability of g-factors might offer an in-situ solution for the standing problem of non-uniform spin-qubit transition frequencies, qubit addressability and crosstalk protection in dense spin-qubit arrays.

References

[1] J.T. Muhonen et al, Nature Nanotechnology, 9 (2014) 986-991
[2] Y.C.Yang et al, npj Quantum Information, 5 (2019)
[3] A.R.Mills et al, Science Advances, 14 (2022)
[4] G.A.Oakes et al, arxiv:2203.06608 (2022)
[5] E.J.Connors and J.J.Nelson et al, Phys.Rev.Applied, 13 (2022) 024019
[6] R.Maurand et al, Nature Communications, 7 (2016) 13575
[7] D.Jirovec et al, Nature Materials, 20 (2021) 1106-1112
[8] N.W.Hendrickx and D.P.Franke et al, Nature, 577 (2020) 487-491
[9] N.W.Hendrickx et al, Nature, 591 (2021) 580-585