Supercurrent-mediated coupling between two Andreev spin qubits: experimental data

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Semiconducting spin qubits are currently one of the most promising architectures for quantum computing. However, they face challenges in realizing high-fidelity quantum non-demolition readout and multi-qubit interactions over extended distances. A recent alternative, the Andreev spin qubit (ASQ), has emerged with realizations in InAs/Al hybrid nanowire Josephson junctions [1,2]. In these qubits, the spin degree of freedom is intrinsically coupled to supercurrent via the spin-orbit coupling. The spin-dependent supercurrent of ASQs facilitates qubit readout using circuit quantum electrodynamics (cQED) techniques, as recently demonstrated and can facilitate inductive multi-qubit coupling via a shared inductance [3].

Here, we investigate the supercurrent-mediated coupling between two ASQs in separate SQUID loops that share a third gate-tunable Josephson junction. To experimentally investigate the coupling between the two ASQs, we use a nanowire transmon. The transmon Josephson energy is effectively set by the state of the two ASQs in the SQUID loops which leads to a spin-state-dependent transition frequency of the transmon. By dispersively coupling the transmon to a readout resonator we can spectroscopically probe the ASQ using conventional microwave techniques developed for cQED. We explore the dependence of the ASQ-ASQ coupling strength on the gate-tunable inductance of the coupling junction and on the flux through the SQUID loops. Finally, we compare the result to the expectations from our theoretical modelling.

References

[1] M. Hays et al., Science 373, no. 6553 (2021) 430-33
[2] M. Pita-vidal and A. Bargerbos et al., arXiv : 2208.10094 (2022)
[3] Padurariu et al. Physical Review B 81, no. 14 (2010) 144519

Figures

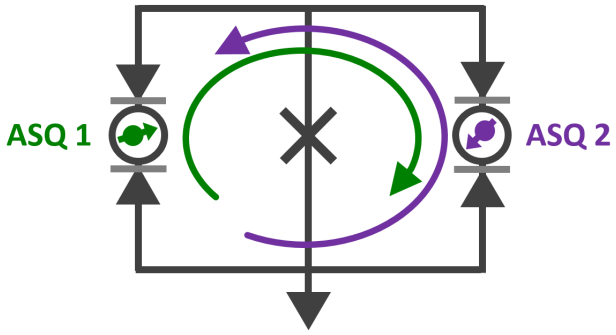

Figure 1: Circuit model of the device showing two Andreev spin qubits and a coupling Josephson junction in parallel.