Coherent coupling of two distant Andreev level qubits

Artem Kononov[1]
Luk Yi Cheung[1], Roy Haller[1], Carlo Ciaccia[1], Jann Hinnerk Ungerer[1,2], Jesper Nygård[3], Christian Schönenberger[1,2]

[1] *Department of Physics, University of Basel, Basel, Switzerland*
[2] *Swiss Nanoscience Institute, University of Basel, Basel, Switzerland*
[3] *Center for Quantum Devices, Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark*

artem.kononov@unibas.ch

Andreev qubits are an emerging platform for quantum computation. These qubits utilize the discrete superconducting quasiparticle levels (Andreev levels) that appear in weak links between superconductors. The Andreev qubits combine the scalability of the superconducting circuits and a compact footprint. Until now, the experiments on Andreev qubits [1] and Andreev spin qubits [2] have focused on the manipulation and readout of single qubits. However, realizing universal quantum computation based on Andreev qubits requires connectivity between pairs of Andreev qubits that enables implementation of two-qubit gates.
Here, we experimentally study Andreev qubits in InAs nanowires with epitaxial Al. We demonstrate for the first time a non-local interaction over millimeter distance of two Andreev pair qubits, mediated by a novel microwave cavity architecture. This architecture is based on a molecular state resonator, that minimizes microwave leakage from the antisymmetric coupling mode to the readout circuit, but allows fast readout via the symmetric mode. We have observed parity switching in both qubits and, more importantly, Andreev state entanglement in the even parity case, paving the way for distant two-qubit gates based on Andreev qubits. We additionally demonstrate that the symmetry of the coupling mode is reflected in the symmetry of the entangled two-qubit state.

References

[1] C. Janvier et al., Science 349 (2015) 1199
[2] M. Hays et al., Science 373 (2021) 430