Universität Basel

Research Project

Andreev qubits for scalable quantum computation

Third-party funded project

Project title Andreev qubits for scalable quantum computation
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Project Website https://nanoelectronics.unibas.ch/
Project start 01.03.2019
Probable end 02.03.2023
Status Completed

Our goal is to establish the foundations of a radically new solid state platform for scalable quantum computation, based on Andreev qubits. This platform is implemented by utilizing the discrete superconducting quasiparticle levels (Andreev levels) that appear in weak links between superconductors. Each Andreev level can be occupied by zero, one, or two electrons. The even occupation manifold gives rise to the first type of Andreev qubit, which has recently been demonstrated by some of the consortium members. We will characterize and mitigate the factors limiting the coherence of this qubit to promote these proof of concept experiments towards a practical technology. The odd occupation state gives rise to a second type of qubit,
the Andreev spin qubit, with an unprecedented functionality: a direct coupling between a single localized spin and the supercurrent across the weak link. Further harnessing the odd occupation state, we will investigate the so far unexplored scheme of fermionic quantum computation, with the potential of efficiently simulating electron systems in complex molecules and novel materials. The recent scientific breakthrough by the Copenhagen node of depositing of superconductors with
clean interfaces on semiconductor nanostructures opened a realistic path to implement the Andreev qubit technology. In these devices, we can tune the qubit frequency by electrostatic gating, which brings the required flexibility and scalability to this platform. We will demonstrate single- and two-qubit control of Andreev qubits, and benchmark the results against established scalable solid-state quantum technologies, in particular semiconductor spin qubits and superconducting
quantum circuits. To carry out this research program, we rely on the instrumental combination of experimentalists, theorists and material growers, together having the necessary expertise on all aspects of the proposed research.

Keywords quantum computing, quantum bit, quantum electronics, nanoelectronics, nanotechnology, superconductivity, Jospehson junction, Andreev Bound State
Financed by
Commission of the European Union

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