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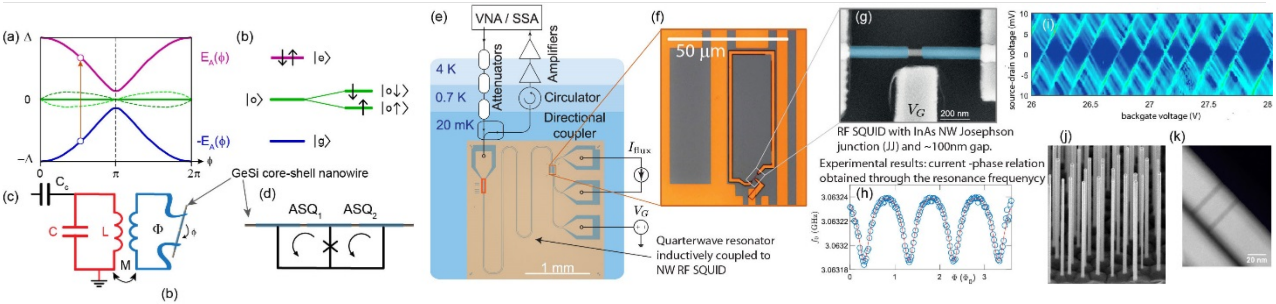
25. Nov. 2018

PhD fellowship on Andreev qubits for scalable quantum computation

A fellowship for an **experimental PhD thesis** work is now available in the **Nano- and Quantum Electronics** group at the Department of Physics of the University of Basel: www.nanoelectronics.ch

We are partner in a FET-open project, funded by the European Commission. The partners come from Budapest, CEA-Saclay, Copenhagen, Delft, Madrid, and Pisa.

It is 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 defines the first type of Andreev qubit, while the odd occupation state gives rise to a second type of qubit, the **Andreev spin qubit (ASQ)**, with an unprecedented functionality: a direct coupling between a single localized spin and the supercurrent across the weak link. We will investigate the so far unexplored ASQ as a spin qubit that is intimately coupled to superconducting circuits. The Andreev qubits shall be implemented in semiconducting nanowire (NWs) based Josephson junctions. 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. Further information on the definition of an Andreev spin qubit, as well as the current state-of-the-art in the Schönenberger lab can be found in the subsequent figure.



Quarterwave resonator inductively coupled to NW RF SQUID

RF SQUID with InAs NW Josephson junction (JJ) and ~100nm gap.

Experimental results: current -phase relation obtained through the resonance frequenycy

(a) Energy-phase relation of a short Josephson-junction (JJ) with (b) the even (e, blue and purple) and the odd (o, green) energy states that can be used as qubit states. The green state is a spin doublet, for which the Josephson current is zero in a conventional JJ (solid green line in (a)). However, the combination of spin-orbit coupling and lifting of time-reversal symmetry results in the dashed green lines with dispersion and therefore with currents. (b) shows an energy diagram for a fixed phase, (c) an RF readout scheme and (d) a scheme to couple two qubits via there currents. (e-g) show a nanowire-based JJ in an RF-SQUID loop coupled to a transmission-line resonator. (h) represents a measurement of the frequency of the resonator as a function of flux. Grown InAs-NWs with built in InP barriers to define quantum dots (QDs) are shown in (j,k), while (h) is a measurement of he Coulomb blockade of such a NW.

We look for a highly motivated student (preferably a physicist) who is keen to explore fundamental aspects of **quantum devices**. You will design and fabricate your own devices using state-of-the-art micro- and nanofabrication technologies. The nanowires will be grown by a collaborator, but you will be involved in the future designs and characterizations not limited to electrical measurements. Electric measurements, on which you will focus on, will be done down to millikelvin temperatures and include DC to up to 6 GHz radio-frequency techniques based on modern cryogenic circuitry (for example rf-resonators) and cold amplifiers.

All PhD fellows are expected to work in a team and collaborate with other PhD and postdoctoral fellows, as well as bachelor and master students joining the lab part of their time. Start of the project: Jan-May 2019. Duration 3-4 years. **Requirement**: you need to have a **profound understanding of quantum and solid state physics** as it is taught in a physics curriculum.

To apply, please email to Christian.Schoenenberger@unibas.ch a short curriculum vitae including names and contact info of referees and scanned copies of grades. Please add a short statement (few lines only) on your motivation and your education / background in quantum physics and solid-state physics.

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