Universität Basel

Research Project

Topological quantum states in double nanowire devices ERA-NET

Third-party funded project

Project title Topological quantum states in double nanowire devices ERA-NET
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Topological quantum computing (TQC) is an emerging field with strong benefits for prospective applications, since it provides an elegant way around decoherence. The theory of TQC progressed very rapidly during the last decade from various qubit realizations to scalable computational protocols. However, the experimental realizations of these concepts lag behind. Important experimental milestones have been achieved recently, by demonstrating the first signatures of Majorana states which are the simplest non-Abelian anyons. However, to realize fully topologically protected universal quantum computation, more exotic anyons, such as parafermions are required. Thus, the unambiguous demonstration of parafermion states will have a great impact on the development of universal quantum computation.

The experimental realization of parafermions is challenging, since they are based on the combination of various ingredients, such as crossed Andreev reflection, electron-electron or spin-orbit interaction, and high quality quantum conductors. Thus, the investigation of all these ingredients is essential and timely to achieve further experimental progress. The team of SuperTop is composed of six leading groups with strong and complementary experimental background in these areas with the aim to realize parafermions in double nanowire-based hybrid devices (DNW) for the first time.

The main objectives of SuperTop are:

a) development of different DNW geometries, which consist of two parallel 1D spin-orbit nanowires coupled by a thin superconductor stripe and

b) investigation of the emerging exotic bound states at the superconductor/semiconductor interface of the DNW.

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SuperTop first grows state-of-the-art InAs and InSb based nanostructures, in particular InAs nanowires (NWs) with in-situ grown epitaxial superconducting layer, NWs with built-in InP barriers and InSb nanoflakes. Based on these high quality materials, different device geometries of DNW are fabricated and the emerging novel states are investigated. The topological character, quantum phase transition, coherence time, coupling strength to QED as key features of the engineered new states are planned to be addressed by various cutting-edge low temperature measurement techniques (e.g. non-local spectroscopy, noise, current-phase relationship measurement or integration into coplanar resonators). The experimental team of SuperTop is supported by in-house theoretical experts of TQC, who will contribute to the interpretation of the results and development of technologically feasible topologically protected quantum architectures. SuperTop first grows state-of-the-art InAs and InSb based nanostructures, in particular InAs nanowires (NWs) with in-situ grown epitaxial superconducting layer, NWs with built-in InP barriers and InSb nanoflakes. Based on these high quality materials, different device geometries of DNW are fabricated and the emerging novel states are investigated. The topological character, quantum phase transition, coherence time, coupling strength to QED as key features of the engineered new states are planned to be addressed by various cutting-edge low temperature measurement techniques (e.g. non-local spectroscopy, noise, current-phase relationship measurement or integration into coplanar resonators).The experimental team of SuperTop is supported by in-house theoretical experts of TQC, who will contribute to the interpretation of the results and development of technologically feasible topologically protected quantum architectures.

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