Spin-resolved transport properties of a quantum dot-Majorana nanowire system

A.Huguet,[1,2] K.Wrzesniewski,[1] and I.Weymann[1]

[1] *Institute of Spintronics and Quantum Information, Adam Mickiewicz University, Poznan, Poland*

[2] *Institut de Physique de Rennes, Rennes University, Rennes, France*

The resurgence of Majorana fermions in theoretical physics as a potential foundation for topological quantum computing [1], led in the last decade to a rapid rise of developments in the condensed matter systems [2], such as topological superconducting nanowires, which host Majorana quasiparticles at the ends [3].

The presence of Majorana modes can be probed by attaching quantum dots to the wires, which can then exhibit some non-trivial and unique transport properties. In this work we thus theoretically study a leakage of Majorana zero mode from the edge state of topological superconducting nanowire into a single quantum dot weakly coupled to two ferromagnetic leads. Such system is expected to indicate the presence of Majorana quasiparticles through spin-resolved transport characteristics.

Using the real-time diagrammatic technique [4] in the first order of the perturbation theory, we determine the charge current and associated differential conductance in the linear and non-linear response regimes.

Two protocols of how the bias voltage is applied to the system are considered. The first one is a fork geometry, where the current flows between the grounded nanowire and two ferromagnetic leads with equal electrochemical potentials. In the second geometry, topological superconductor remains grounded, while the bias voltage is applied symmetrically between the left and right electrodes.

Moreover, we consider two magnetic alignments of the ferromagnetic electrodes, parallel and antiparallel one, allowing us to determine the tunnel magnetoresistance of the system. By calculating the transport properties for various parameters we identify unique spin-resolved features associated with the presence of Majorana zero-energy modes.

References:

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