Interplay of magnetism and Majorana quasiparticles in artificial molecules

Piotr Majek[1] and Ireneusz Weymann[1]

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

Although experimental realization of Majorana fermions remains a challenging and unsolved problem in condensed matter physics, it is a topic of high importance due to its invaluable potential within quantum computing. One of the most promising systems to host these exotic quasiparticles, which are characterized by the equivalence of creation and annihilation operators describing them, are the topological one-dimensional superconducting nanowires, where Majorana bound states can be found at its ends. The presence of Majorana zero modes on such a nanowire can manifest itself through the zero-bias conductance peak. To measure electronic transport properties of such a system, quantum dots can serve as non-invasive spectroscopic probes, whose properties are well studied and understood. At low temperatures, strong electron correlations in such a zero-dimensional system lead to the Kondo effect. As magnetism is a non-negligible ingredient to induce Majorana modes in the topological nanowire, we are looking at the Majorana-Kondo competition in the spin-dependent transport through the double quantum dot system, where the ferromagnetic leads serve as the source of electrons. In our studies, we combine Kondo-correlated double quantum dot system with one-dimensional superconducting nanowires, focusing on the electronic and thermoelectric transport properties of such hybrid nanostructures in the presence of external magnetic field. The low temperature spectral functions as well as conductance are studied with the aid of numerical renormalization group technique, which is a well established tool of great accuracy in terms of analysing various complex quantum impurity systems. We show that introducing the spin dependency greatly modifies the two-stage Kondo effect for spin-up and spin-down channels, suppressing the transport through the quantum dot. When the topological superconductor is coupled to the second quantum dot, the low-temperature transport is lifted up to e^2/h.

This work is supported by the National Science Center (NCN) through the grant No. 2021/41/N/ST3/01885