Majorana fermions in a world of strong correlations

P. Majek,[1] K. P. Wójcik,[2,3] and I. Weymann[1]

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

[2] *Physikalisches Institut, Universität Bonn, Nussallee 12, D-53115 Bonn, Germany*

[3] *Institute of Molecular Physics, Polish Academy of Sciences, 60-179 Poznan, Poland*

Majorana fermions awakened the interest of many physicists of various specializations in the last few years. Originally considered in the field of elementary particles, now play a significant role in condensed matter physics and quantum information, all because of topological superconductors, where such quasiparticles can be observed. As a result, Majorana fermions will be topologically protected bound states, which may prove particularly applicative as a qubit - quantum bit necessary to perform operations on quantum computers. There is an exciting race going on right now, where the goal is to demonstrate the existence of such zero-energy states, in one-dimensional topological superconductors, among others. Majorana fermions may be found at the ends of such nanowires.

The goal of this presentation is to confront the Majorana zero-energy modes with well-known strongly correlated systems, where phenomena, such as the Kondo effect are present, which stimulates physicists all over the world. One of the most prominent examples of such systems in a mesoscopic scale, where the Kondo effect plays a vital role, is a quantum dot. Right now, with the aid of technology and experience, quantum dots are being deeply explored, not only in regards to electronic transport but also thermoelectric effects such as thermopower or thermal conductance, which are the effects of an applied temperature gradient. Currently, answering the question of how such exotic quasi-particles can affect these well-known systems plays a meaningful role in condensed matter physics research.

Our contribution to this dynamically developing area is the theoretical study of the double quantum dot system in the presence of Majorana fermion, associated with effective coupling V_M. Our research is based on the well-established numerical renormalization group method, which allows describing the quantum transport effects in strongly correlated mesoscopic systems with great accuracy. We are showing that the presence of such half-fermionic particles destroys the second stage of Kondo screening, giving rise to a fractional value of conductance in one spin channel, which is directly coupled with the nanowire. On the other hand, we signalize the effects such as characteristic thermopower sign change induced by the Majorana coupling, as well as unconventional behavior of the spin polarization in the presence of a topological superconductor.

References:

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