Offered research topics:

Investigations and detection of Majorana bound states in quantum topological wires

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Introduction:

Majorana fermions, which are their own anti-particles have been originally postulated by Ettore Majorana in 1937 in the context of elementary particle physics. They obey non-abelian statistics and their existence is topologically protected. The last property is very promising from the point of view of quantum computation, because Majorana states could constitute qubits robust to decoherence processes. For this reason in recent years a quest has been initiated to define promising conditions for appearance of Majorana fermions in a solid state as well as their unambiguous detection.

The most promising experimental realization seems to be so called topological quantum wire, which exists as a result of proximity effect between standard s-wave superconductor and semiconductor quantum wire with large Rashba interaction, subjected into external magnetic field. In such a wire is effectively induced p-wave superconductivity and unpaired Majorana states emerge at the ends of the wire. The project is concerned to investigation of such states.

Reaserch Project Objectives and Methodologies:

The goal of the project is the theoretical investigation of the appearance of Majorana bound states in quantum topological wires and their detection. The wire can be modelled by Kitaev chain or microscopic tight binding Hamiltonian. It will be coupled to quantum dots or other topological wires in various configurations. It is planned within the project the investigation of the electron transport through such hybrid systems, also in the form of fractional Josephson junctions. Current characteristics will allow for detection of possible Majorana states and their influence on Coulomb interactions inside the dots. The calculations will be performed in the framework of Green’s function approach, which deserves a proper numerical implementation and selfconsistent treatment.