Abstract

This dissertation concerns the theoretical studies of the influence of many-body interaction on static and dynamic properties of Majorana zero modes, realized in fermionic spinless systems, which can be described by the Kitaev model.

The algorithm for Majorana zero modes identification has been presented in the thesis. The algorithm works for any Hamiltonian, also when many-body interactions are present in the system. First, the algorithm has been tested by comparing the results to the literature. In the next step, the influence of strength and range of the interaction on Majorana zero modes lifetimes and their spatial structures has been investigated. Increasing many-body interaction strength leads to decreasing Majorana zero modes stability. Moreover, if the range of the interaction increases, the destructive role of the interaction on Majorana zero modes lifetimes also increases.

The implementation of the new phase-gate for qubit based on Majorana zero modes was also presented. Unlike the standard phase gate implementation, which is based on the dynamic phase, the presented gate depends on the geometric phase. The protocol of the gate consists of the double braiding of two non-overlapping Majorana zero modes. It has been shown that the phase of this gate does depend on all Hamiltonian parameters, especially on the thesis major — many-body interactions.

In addition to presenting results and their analysis, the dissertation contains expanded theoretical introduction, related to all discussed problems. All useful derivations and proofs can be found in the Appendix attached to the thesis.

Key words Majorana zero modes many-body interactions Kitaev model quantum braiding topological quantum computer