Emulating Majorana qubits and their braiding in Ising chains of Josephson qubits

S. Backens[a], A. Shnirman[a], **Yu. Makhlin**[b], Y. Gefen[c], J.E. Mooij[d], and G. Schön[e,f]

[a]Institut für Theorie der Kondensierten Materie, Karlsruhe Institute of Technology, Karlsruhe, Germany
[b]Condensed-matter physics Laboratory, National Research University Higher School of Economics, Moscow; Landau Institute for Theoretical Physics, Chernogolovka, Russia
[c]Department of Condensed Matter Physics, Weizmann Institute of Science, Rehovot, Israel
[d]Kavli Institute of Nanoscience, Delft University of Technology, Delft, The Netherlands
[e]Institut für Theoretische Festkörperphysik, Karlsruhe Institute of Technology, Karlsruhe, Germany
[f]Institute of Nanotechnology, Karlsruhe Institute of Technology, Eggenstein-Leopoldshafen, Germany

We consider properties of an Ising-type chain of Josephson-junction quantum bits by exploring its mapping onto a chain of Majorana fermions, where topological qubits can be implemented. Local control of the superconducting qubits allows for manipulation of the quantum states of the Majorana zero modes. We consider braiding of the Majorana modes, as well as more general rotations, as quantum logical gates in a Delta-junction geometry and, further, propose implementation of braiding in a strictly one-dimensional chain. In both cases mapping onto a system of free fermions is achieved with an extra qubit, which controls Ising couplings at the junction. We propose an experimental implementation of this scheme in a chain of superconducting flux qubits and analyze stability of the quantum gates in this setup (arxiv:1703.08224).