Physical Architecture for a Universal Topological Quantum Computer Based on a Network of Majorana Nanowires

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The idea of topological quantum computation (TQC) is to encode and manipulate quantum information in an intrinsically fault-tolerant manner by utilizing the physics of topologically ordered phases of matter. Currently, the most promising platforms for a topological qubit are either in terms of Majorana fermion zero modes (MZMs) in spin-orbit coupled superconducting nanowires or in terms of the Kitaev Z2 surface code. However, the topologically robust operations that are possible in these systems can be efficiently simulated on a classical computer and are thus not sufficient for realizing a universal gate set for topological quantum computation. Here, we show that an array of coupled semiconductor-superconductor nanowires with MZM edge states can be used to realize a more sophisticated type of non-Abelian defect, a genon in an Ising ?X Ising topological state. This leads to a possible implementation of the missing topologically protected ?pi/8 phase gate and thus paves a path for universal topological quantum computation based on semiconductor-superconductor nanowire technology. We provide detailed numerical estimates of the relevant energy scales, which we show to lie within accessible ranges.

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