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Non-Abelian statistics and topological quantum information processing in 1D wire networks JASON ALICEA, YUVAL OREG, GIL REFAEL, FELIX VON OPPEN, MATTHEW P.A. FISHER — Topological quantum computation provides an elegant way around decoherence, as one encodes quantum information in a non-local fashion that the environment finds difficult to corrupt. Here we establish that one of the key operations—braiding of non-Abelian anyons—can be implemented in one-dimensional semiconductor wire networks. Previous work [Lutchyn et al., arXiv:1002.4033 and Oreg et al., arXiv:1003.1145] provided a recipe for driving semiconducting wires into a topological phase supporting long-sought particles known as Majorana fermions that can store topologically protected quantum information. Majorana fermions in this setting can be transported, created, and fused by applying locally tunable gates to the wire. More importantly, we show that networks of such wires allow braiding of Majorana fermions and that they exhibit non-Abelian statistics like vortices in a p+ip superconductor. We propose experimental setups that enable the Majorana fusion rules to be probed, along with networks that allow for efficient exchange of arbitrary numbers of Majorana fermions. This work paves a new path forward in topological quantum computation that benefits from physical transparency and experimental realism.

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