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Protected qubits and quantum computation using Josephson junctions

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Several schemes of topological protection have been proposed, in which qubits are realized as degenerate ground states of quantum many-body systems so that all likely perturbations are exponentially suppressed. In the realm of Josephson junction physics, this approach was pioneered by Doucot, Vidal, Ioffe, and Feigelman in 2002. I will report a variation of their scheme that offers greater robustness and flexibility. Its key element is a "quantum transformer", a superconducting current mirror operated in the quantum regime. This is a four-terminal device whose energy depends only on $\phi_1 - \phi_2 + \phi_3 - \phi_4$, with exponentially small "error terms" like $\cos(\phi_1 - \phi_4)$. The qubit is implemented by connecting terminal 1 with 3 and 2 with 4. I will describe a realization of the basic element, qubit measurements and unitary gates, and also discuss some parameter tradeoffs.