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Systematic Construction of Braids for Topological Quantum Computation CAITLIN CARNAHAN, Dept. of Computer Science and NHMFL, Florida State Univ., DANIEL ZEUCH, N.E. BONESTEEL, Dept. of Physics and NHMFL, Florida State Univ. — In topological quantum computation, quantum gates are carried out by braiding worldlines of non-Abelian anyons in 2+1 dimensional space-time. The simplest such anyons for which braiding is universal for quantum computation are Fibonacci anyons. Reichardt [1] has shown how to construct nontrivial braids for three Fibonacci anyons which yield 2×2 unitary operations whose off-diagonal matrix elements (in the appropriate basis) can be made arbitrarily small through a simple and efficient iterative procedure. A great advantage of this construction is that it does not require either brute force search or the Solovay-Kitaev method. There is, however, a downside—the phases of the diagonal matrix elements cannot be directly controlled. Despite this, we show that the resulting braids can be used to construct leakage-free entangling two-qubit gates for qubits encoded using four Fibonacci anyons each. We give two explicit constructions—one based on the "functional braid" approach of Hu and Wan [2], and another based on the "effective qubit" approach of Hormozi et al. [3].
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