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Topological Quantum Computing with Read-Rezayi States

LAYLA HORMOZI, Joint Quantum Institute, NIST and University of Maryland, NICK BONESTEEL, Department of Physics and NHMFL, Florida State University, STEVEN H. SIMON, Bell Laboratories, Alcatel-Lucent — In topological quantum computation quantum operations are carried out by moving quasiparticle excitations of certain quantum systems around each other in two space dimensions or equivalently by braiding their world-lines in three-dimensional space-time. Fractional quantum Hall states are among the prime candidates for realizing such quasiparticles. In particular, it has been shown that quasiparticles associated with the so-called Read-Rezayi (RR) states at $k > 2, k \neq 4$ can be used for universal quantum computation. In previous work we have shown how to construct two-qubit gates by braiding the so-called Fibonacci anyons — a class of non-Abelian anyons that are closely related to the quasiparticles of the $k = 3$ RR state. These two-qubit gates then together with single-qubit gates form a universal set of quantum gates. In this talk we point to certain properties of the quasiparticles of the $k = 3$ RR state which are unique to this state and which allow us to construct two-qubit gates in a simple and efficient way. We then present a method that can be used to efficiently construct two-qubit gates for any quasiparticle in the RR sequence at $k > 2, k \neq 4$. This work is supported by US DOE.

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