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Universal topological quantum computation from a superconductor/Abelian quantum Hall heterostructure

ROGER MONG, California Institute of Technology

Non-Abelian anyons promise to reveal spectacular features of quantum mechanics that could ultimately provide the foundation for a decoherence-free quantum computer. A key breakthrough in the pursuit of these exotic particles originated from Read and Green's observation that the Moore-Read quantum Hall state and a (relatively simple) two-dimensional $p + ip$ superconductor both support so-called Ising non-Abelian anyons. Here we establish a similar correspondence between the Z_3 Read-Rezayi quantum Hall state and a novel two-dimensional superconductor in which charge-$2e$ Cooper pairs are built from fractionalized quasiparticles. In particular, both phases harbor Fibonacci anyons that—unlike Ising anyons—allow for universal topological quantum computation solely through braiding. Using a variant of Teo and Kane's construction of non-Abelian phases from weakly coupled chains, we provide a blueprint for such a superconductor using Abelian quantum Hall states interlaced with an array of superconducting islands. These results imply that one can, in principle, combine well-understood and widely available phases of matter to realize non-Abelian anyons with universal braid statistics.