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Fractionalizing Majorana Fermions: Non-Abelian Statistics on the Edges of Abelian Quantum Hall States

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We study the non-Abelian statistics characterizing systems in which the edges of fractional quantum Hall states are gapped by proximity coupling to superconductors and ferromagnets. We show that as more superconductor-ferromagnet interfaces are introduced, the ground state degeneracy grows with a quantum dimension of a square root of an even integer, corresponding to a new family of non-Abelian anyons. Topologically protected braiding of two anyons can be achieved by a sequence of adiabatic manipulations of the system. We show that the unitary transformations resulting from these braiding operations realize a richer set of representations of the braid group than those realized by non-Abelian anyons based on Majorana fermions. We discuss implications of these braiding operations to topological quantum computation, and consider possible realizations of these ideas in experimentally accessible solid state systems.