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Topological order, quasi-particle statistics and braiding from ground state entanglement YI ZHANG, TARUN GROVER, University of California, Berkeley, ARI TURNER, University of Amsterdam, MASAKI OSHIKAWA, Institute for Solid State Physics, University of Tokyo, ASHVIN VISHWANATH, University of California, Berkeley — Topologically ordered phases are gapped states, defined by the properties of excitations when taken around each other. By calculating Topological Entanglement Entropy (TEE) of a disc shaped partition using a Monte Carlo technique, we establish the existence of topological order in $SU(2)$ symmetric gapped spin liquids and lattice Laughlin states obtained by the Gutzwiller projection technique. On the other hand, the TEE of partitioning the torus into two cylinders is generally different and depends on the chosen ground state. We demonstrate a method to extract the statistics and braiding of excitations, given just the set of ground state wave-functions on a torus. Central to our scheme is the identification of groundstates with minimum entanglement entropy, which reflect the quasi-particle excitations. We demonstrate our method by extracting the modular$\mathcal{S}$ matrix of an $SU(2)$ symmetric chiral spin liquid, and prove that its quasi-particles obey semionic statistics. This method offers a route to a nearly complete determination of the topological order in several cases.

Yi Zhang
University of California, Berkeley

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