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Braiding statistics approach to symmetry-protected topological phases

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Symmetry-protected topological (SPT) phases can be thought of as generalizations of topological insulators. Just as topological insulators have robust gapless boundary modes protected by time reversal and charge conservation symmetry, SPT phases have boundary modes protected by more general symmetries. In this talk, I will describe a method for analyzing 2D SPT phases using braiding statistics. I will present this approach in the context of a simple example: a 2D Ising paramagnet with gapless edge modes protected by Ising symmetry. First, I will show that if the paramagnet is coupled to a Z_2 gauge field, the resulting π-flux excitations have different braiding statistics from that of a usual Ising paramagnet. This result provides a simple proof that the spin model belongs to a distinct quantum phase from a conventional paramagnet. Second, I will show that the π-flux braiding statistics directly imply the existence of protected edge modes. I will argue that this analysis can be generalized to any 2D SPT phase with unitary symmetries.

[1] M. Levin and Z.-C. Gu, Phys. Rev. B 86, 115109 (2012)