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Highly entangled quantum states of matter

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Highly entangled quantum matter is a new class of matter that correspond patterns of intricate quantum entanglement. The phases of matter have traditionally been classified by their symmetry properties described by group theory. For decades we believe that symmetry breaking states describe all possible phases of matter. However, the discovery of topological order suggested that Landau theory does not describe all quantum phases. In topological order, the phases are not described by the patterns of symmetry, but by the patterns of long-range quantum entanglement. Recently, we have identified a new class of states, called symmetry-protected topological order, which correspond to patterns of short-range quantum entanglement with symmetry. We find that this class of quantum phases and corresponding patterns of entanglement can be described by an abstract mathematical theory - group cohomology theory. In this talk, I will review the background and the basic theory of symmetry-protected topological phases.