Physics Colloquium

Generalized Lieb-Schultz-Mattis constraints on phases of quantum magnets

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Quantum magnetic systems with a large number of spins often enable the emergence of a great variety of interesting phases at zero temperature. Yet, there are fundamental constraints on the infrared behavior of quantum magnets from the ultraviolet data encoded in the microscopic lattice of spins. As the first and the most well-known example, the Lieb-Schultz-Mattis (LSM) constraint forbids trivial phases from arising in certain quantum magnets with SU(2) spin rotation and the lattice translation symmetries. As an important experimental consequence, it enables the confirmation of exotic phases like quantum spin liquids, whose intrinsic properties are often hard to probe directly, through the examination of the absence of spontaneous symmetry breaking which is more accessible with standard spectroscopy measurements. In this talk, we will present a new topological perspective of the LSM constraint. We will show how the LSM constraint is related to the constraints on the surface modes of symmetry-protected topological states. Using this relation, we will discuss a large class of generalizations of the LSM constraint incorporating different space groups (including both translations and point group symmetries) and different spin symmetries. The range of applicability of such generalized LSM constraints is vastly extended compared to the original version. We will also discuss how the generalized LSM constraints enforce the “exotic-ness” of continuous phase transitions in quantum magnets.

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