MAR06-2005-004913

Abstract for an Invited Paper
for the MAR06 Meeting of
the American Physical Society

Quantum critical phases in two dimensions: U(1) spin liquids

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Usually, we expect that stable phases of matter can be described in terms of quasiparticle excitations that interact only weakly at low energies. However, it is now clear that certain quantum spin liquids dramatically violate this expectation, but can nonetheless exist as stable zero-temperature phases in two-dimensional systems. These are the critical or algebraic spin liquids, which have no broken- symmetry ordering, but support gapless spin-carrying excitations. These states are promising candidates for the longstanding goal of the unambiguous experimental detection of a quantum spin liquid state; they have been suggested to play a role in certain strongly correlated materials, and they possess a variety of striking, and measurable, properties. I will discuss recent work on the simplest algebraic spin liquids. These are a type of two-dimensional U(1) spin liquid, and can be described at low energies by gapless Dirac fermions (spinons) coupled to a compact U(1) gauge field (photon). I will outline an argument that establishes the stability of these states in a large-N limit, and thus resolved a longstanding controversy. Next, I will discuss some of the remarkable properties of these states, and conclude with a discussion of open issues.