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From high T_c superconductivity to quantum spin liquids[1]

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The underdoped cuprates exhibit many unusual properties going under the name pseudogap. These observations lend support to the notion that high Tc superconductivity is intimately tied to doping of a Mott insulator. Building on earlier work on the quantum spin liquid, the resonating valence bond (RVB) idea of Anderson provides an adequate physical understanding of the pseudogap. The problem can be formulated as a gauge theory even though many details are beyond the powers of current calculational tools. Part of the difficulty is that the pseudogap phenomenology occurs only at finite temperature where precise statements about excitations and possible emergent gauge fields cannot be made. Meanwhile the problem of the quantum spin liquid is a simpler version of the high Tc problem where significant progress has been made recently. It is understood that the existence of a matter field can lead to deconfinement of the U(1) gauge theory, and novel new particles such as fermionic spinons which carry spin 1/2 and no charge, and gapless gauge bosons can emerge in a new critical state at low temperatures. Two experimental systems, the organic compound and the Kagome lattice, have emerged as promising examples of a spin liquid. I shall argue that these may be described by a spinon Fermi surface and Dirac spinons coupled to a U(1) gauge field, respectively. Further experimental tests will be discussed.

[1]P.A. Lee, Reports on Progress in Physics, to be published.