Randomness-Induced Quantum Spin Liquids in Furstrated Magnets: Application to 2D ^{3}He and Organic Salts

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Experimental quest for the hypothetical "quantum spin liquid (QSL)" state recently met several promising candidate materials on geometrically frustrated lattices such as triangular and kagome lattices. Its first realization might be the nuclear spins in the second-layer solid ^{3}He adsorbed on graphite, which can be viered as the $s = 1/2$ Heisenberg triangular-lattice system possessing a considerable amount of multiple spin exchange. A gapless QSL behavior accompanied by the temperture (T)-linear specific heat was observed there. More recently, similar gapless QSL behaviors are observed in several frustrated antiferromagnets including the triangular organic salts κ-$(ET)_2Cu_2(CN)_3$ and $EtMe_3Sb[Pd(dmit)_2]_2$, and the kagome herbersmithite $CuZn_3(OH)_6Cl_2$. We have argued that these compounds might contain significant amount of (effective) randomness or inhomogeneity, and this randomness or inhomogeneity might be essential in realizing the experimentally observed QSL behaviors. The origin of the effective randomness or inhomogeneity could be of variety: the disordered arrangement of ^{3}He atomes in 2D ^{3}He, the freezing of the charge (dielectric) degrees of freedom in triangular organic salts, and the Zn^{2+}/Cu^{2+} intersite disorder in herbertsmithite. We model these magnets by the random-bond s=1/2 Heisenberg model on geometrically frustrated 2D lattices, *e.g.,* the triangular lattice, numerically compute various physical quantities by the exact-diagonalization method, and demonstrate that, when the randomness exceeds a critical value, the model generically exhibits a randomness-induced gapless QSL-like state, a "random-singlet state". The results seem to provide a consistent explanation of the recent experimental observations on 2D ^{3}He and organic salts.

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