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Intrinsic new properties of a quantum spin liquid

Quantum fluctuations are expected to lead to highly entangled spin-liquid states in certain two-dimensional spin-1/2 compounds. We have synthesized and measured thermodynamic properties and muon spin relaxation rates in the copper-based two-dimensional triangular-lattice spin liquids $Lu_3Cu_2Sb_3O_{14}$ and $Lu_3CuZnSb_3O_{14}$. The former is the least disordered of this kind discovered to date. Magnetic entropy generation at high temperatures has been ruled out after carefully correcting for the lattice specific heat. Surprisingly, roughly half of the magnetic entropy is missing down to temperatures of $O(10^{-3})$ the exchange energy, independent of magnetic field up to $g\mu_B H > k_B\Theta_W$, where Θ_W is the Weiss temperature. The magnetic specific heat divided by temperature $C_M(T)/T$ and muon spin relaxation rate $\lambda(T)$ are both temperature-independent at low temperatures, followed by logarithmic decreases with increasing temperature. This behavior can be simply characterized by scale-invariant time-dependent fluctuations with a single parameter. Since no cooperative effects due to impurities are observed, the measured properties are intrinsic. They are evidence that in $Lu_3Cu_2Sb_3O_{14}$ massive quantum fluctuations lead to either a gigantic specific heat peak from singlet excitations at very low temperatures or, perhaps less likely, an extensively degenerate possibly topological singlet ground state.

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