Dirac spinons and magnetization plateau in the s=1/2 Kagome antiferromagnet

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The spin-1/2 kagome Heisenberg antiferromagnets (KHAFs) provide a fascinating platform for exploring novel quantum many-body states. A growing body of numerical calculations supports the existence of a quantum spin-liquid ground state, with possibilities of either a Z_2 gapped QSL or a gapless U(1) Dirac QSL. However, real materials are subject to inevitable perturbations and quenched disorder that can stabilize magnetically ordered states or lead to inhomogeneous ground states.

From a materials standpoint, the recently synthesized $YCu(OH)_6X_3$ (X=halogen) compounds stand out due to their nearly perfect kagome lattice structure. Singularly, $YCu_3(OH)_{6+x}Br_{3-x}$ (x~0.5) precludes conventional magnetic ordering down to 50 mK and displays thermodynamic and spectroscopic signatures of Dirac spinons.

First, we address a 1/9 magnetization plateau predicted for the isotropic KHAF.

Second, employing ^{63}Cu nuclear quadrupole resonance (NQR) and muon spin relaxation/rotation (μSR) techniques, we explore the ground state nature and low-energy spin dynamics of $YCu_3(OH)_{6+x}Br_{3-x}$. The inverse Laplace transform analysis of ^{63}Cu NQR reveals an inhomogeneous ground state dominated by a majority of a gapless spin liquid intermingled with a few percentages of spin singlets of varying energy gaps. Furthermore, the ^{63}Cu NQR relaxation rate evinces distinct signatures of Dirac spinons, featuring a power-law dependence of $1/T \sim T^{\eta}$ with η=1.35 at temperatures below T~0.13J (≈8 K).

Finally, we observe one-pair and two-pair spinon–antispinon excitations and a superlinear behavior of the spinon Raman susceptibility at low temperatures, indicative of the presence of a Dirac nodal structure. Conversely, for the magnetically ordered counterpart X = Cl, we observe the coexistence of spinon and magnon states, suggesting that magnons form through spinon binding.