

Magnetic oscillations due to spinons in a quantum spin liquid hosted by a Kagome lattice

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Magnetization measurements strongly suggest that the Kagome lattice Mott insulator $\text{YCu}_3(\text{OH})_6\text{Br}_2[\text{Br}_{1-y}(\text{OH})_y]$ (YCOB) is a quantum spin liquid. In such a system, antiferromagnetic order is suppressed by geometrical frustration and quantum fluctuations. Under these conditions, spin-charge separation of electrons can produce charge-neutral spinons, fermions that possess spin but no charge. Using ultrasensitive torque magnetometry, de Haas-van Alphen oscillations are observed, giving strong evidence for both the spinons and an effective gauge field which allows the coupling of the applied magnetic field to these charge-neutral particles. A theoretical model of spinon band structure that includes Dirac nodes near the $1/9$ magnetization plateau produces quantitative predictions consistent with the observed oscillations.

The Figure shows several aspects of the experiments. The observation of a $1/9$ plateau in the magnetization of YCOB at around 20 T (a), is a strong indication that the material is a quantum spin liquid; the data were recorded in the 75 T Duplex magnet. At fields above the $1/9$ plateau, de Haas-van Alphen oscillations are seen in the second derivative of the magnetic torque with respect to field [(b), dotted lines]; their presence in several samples of YCOB and in data from both the 60 T Midpulse magnet, and the 41.5 T quasistatic magnet (b), show they are an intrinsic property of YCOB. The oscillations show a complicated dependence on the orientation of the YCOB crystals (c) caused by the gauge field; angles shown are between the crystal c axis and the field. The temperature dependence of the oscillations (d) is consistent with the spinons being fermions; it agrees with the Lifshitz-Kosevich formula, originally derived for electrons in metals. The inset to (d) shows the bespoke torque magnetometer (designed in a collaboration between the MagLab and industry) employed for measurements in both pulsed and quasistatic fields.

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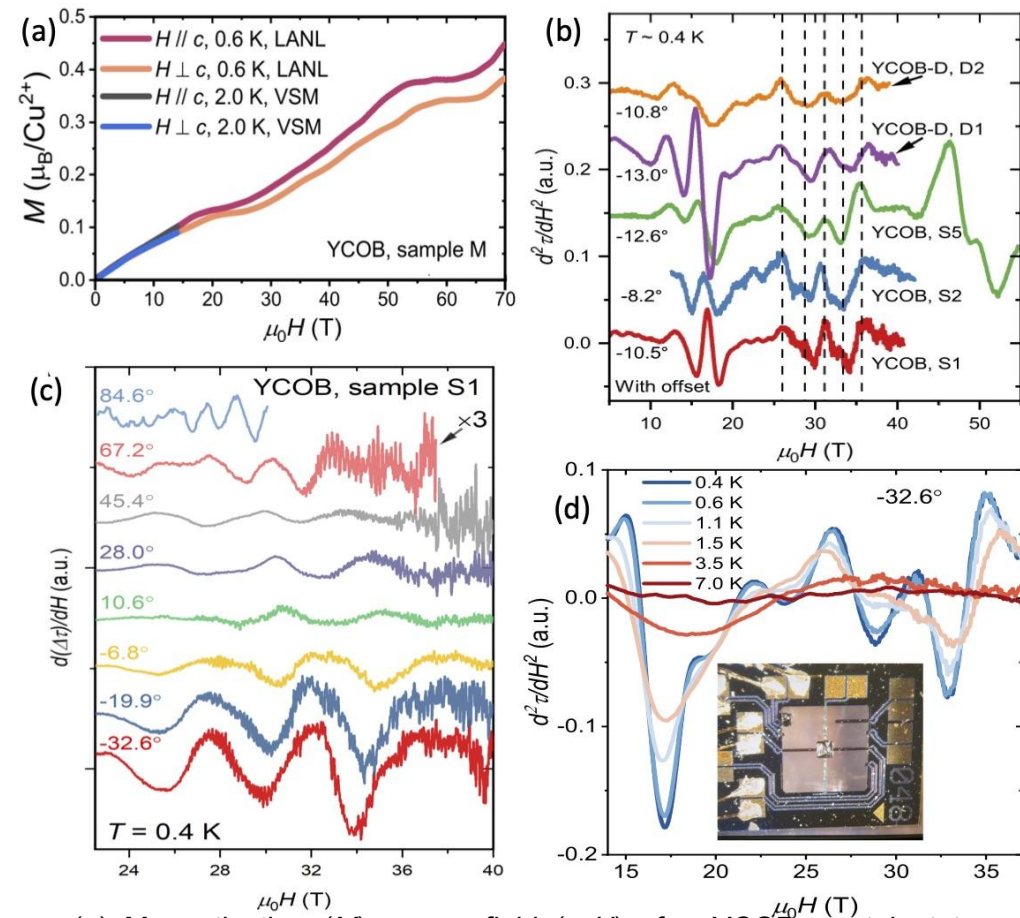


Figure. (a) Magnetization (M) versus field ($\mu_0 H$) of a YCOB crystal at two different orientations. (b) $d^2\tau/dH^2$, where τ = torque, for several YCOB samples. (c) Torque oscillations for different angles between H and the crystal c axis. (d) Oscillations in $d^2\tau/dH^2$ versus field for several different temperatures. Inset: torque magnetometer chip.