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# Absence of magnetic thermal conductivity in the quantum spin liquid candidate $YbMgGaO_4$

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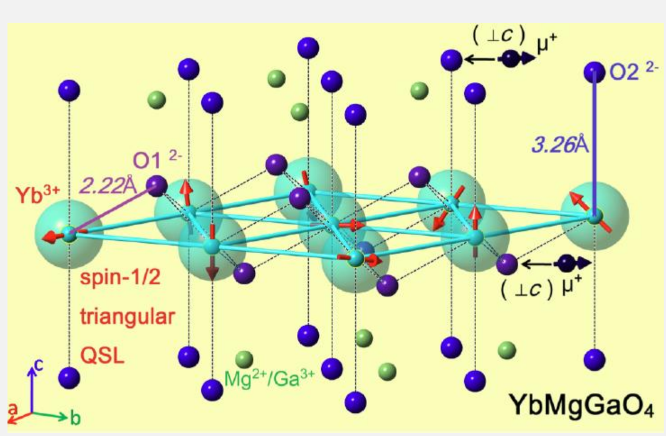
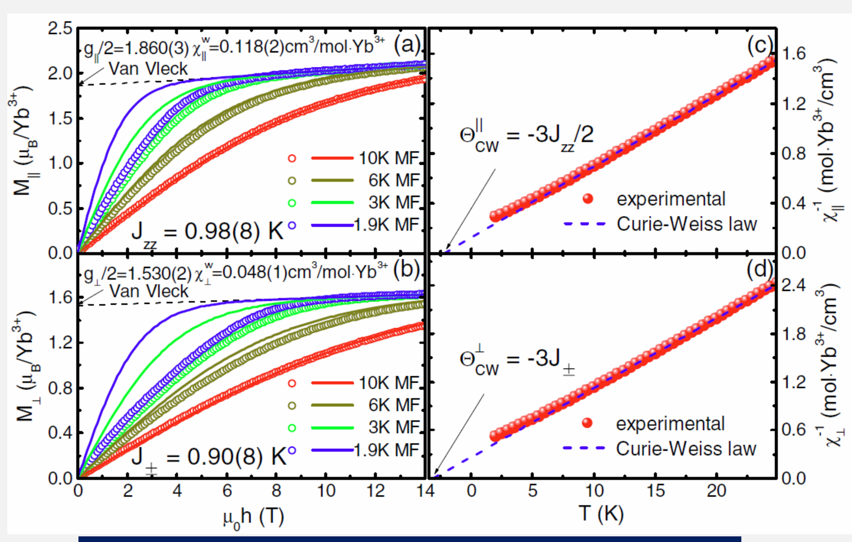
We present the ultralow-temperature specific heat and thermal conductivity measurements on single crystals of $YbMgGaO_4$, which was recently argued to be a promising candidate for a quantum spin liquid (QSL). In a zero magnetic field, a large magnetic contribution of specific heat is observed, and exhibits a power law temperature dependence ($C_m \sim T^{0.74}$). On the contrary, we do not observe any significant contribution of thermal conductivity from magnetic excitations. In magnetic fields $H \geq 6$ T, the exponential $T$ dependence of $C_m$ and the enhanced thermal conductivity indicate a magnon gap of the fully polarized state. The absence of magnetic thermal conductivity at the zero field in this QSL candidate puts a strong constraint on the theories of its ground state.

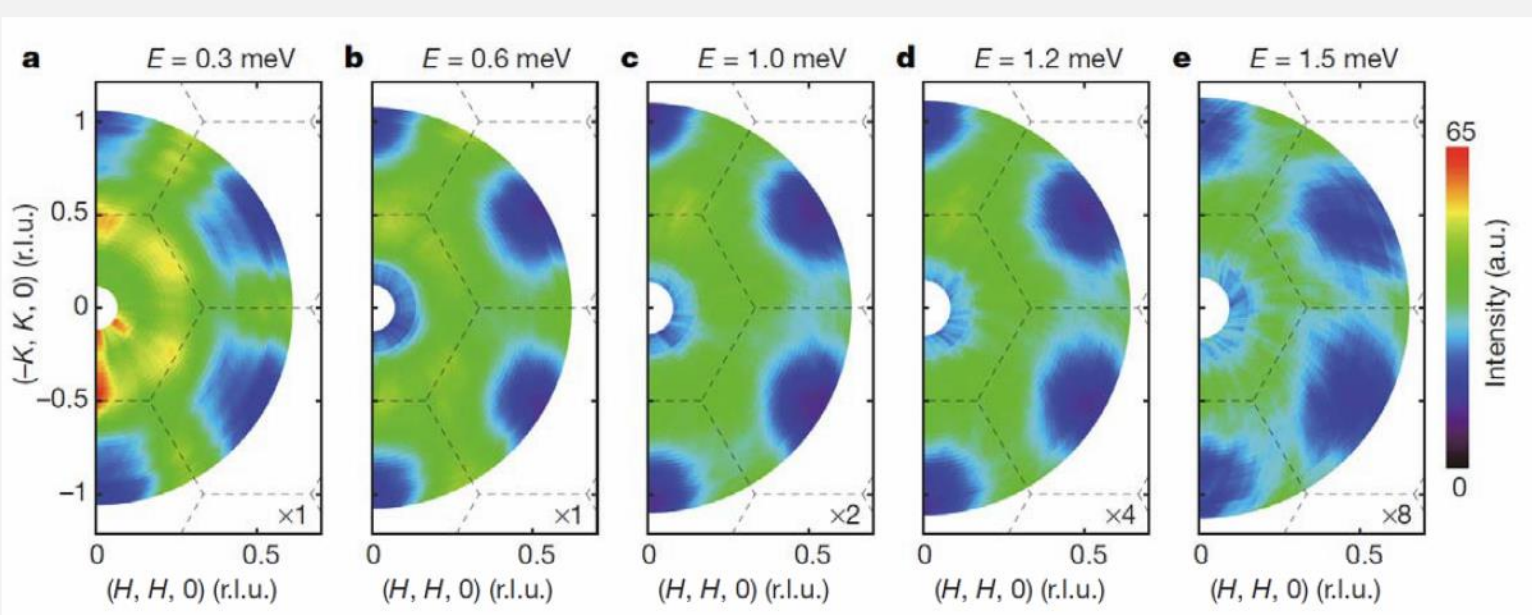
## $YbMgGaO_4$: a QSL candidate

2D triangular lattice of spin-1/2 $Yb^{3+}$



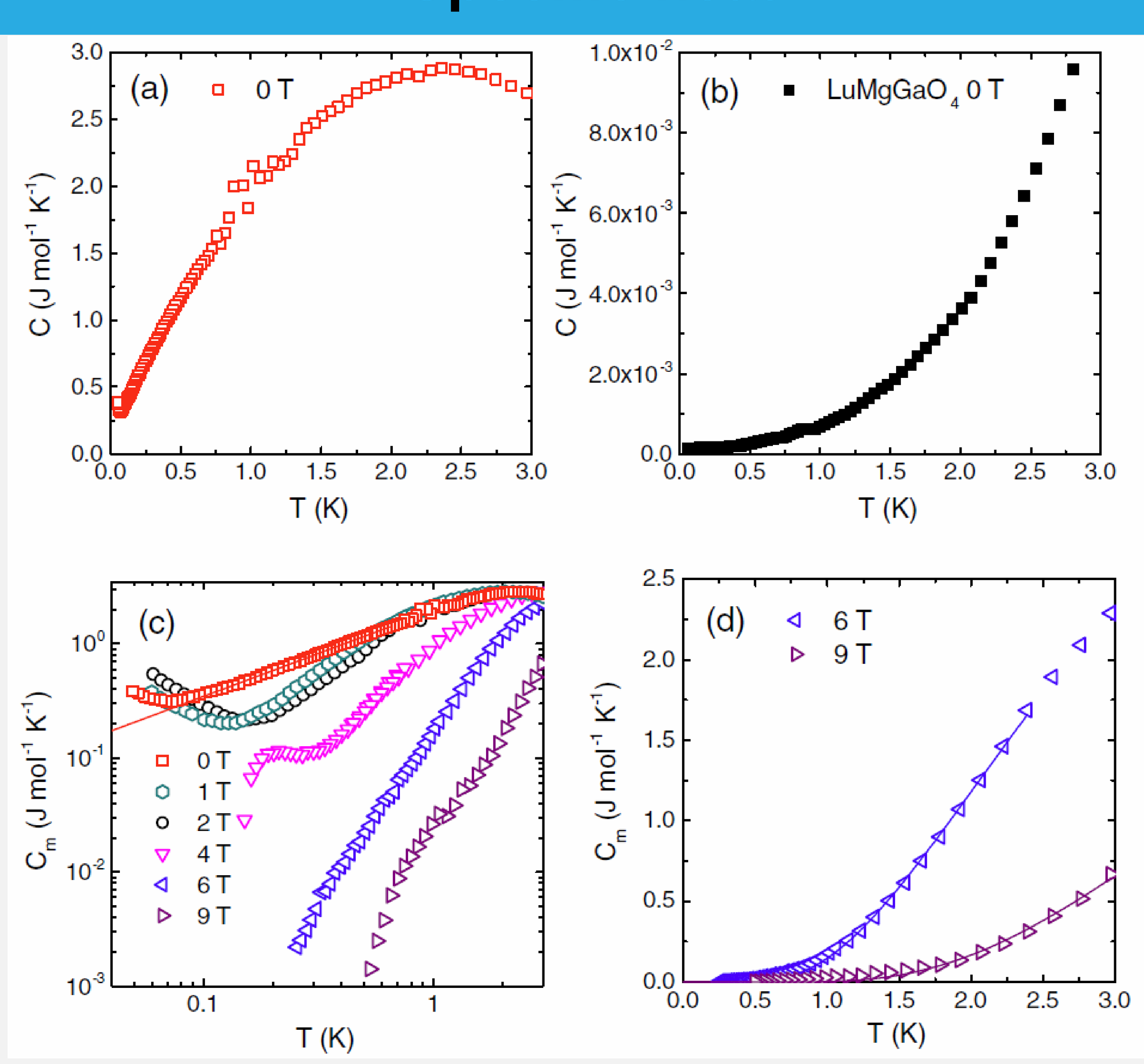



Magnetization and magnetic susceptibility




A broad continuum of spin excitations, which is a hallmark of the QSL state, was observed in neutron scattering measurements

## Specific heat




Zero-field specific heat: well fitted by $C_m = cT^{\beta}$ with β = 0.74, close to 2/3.

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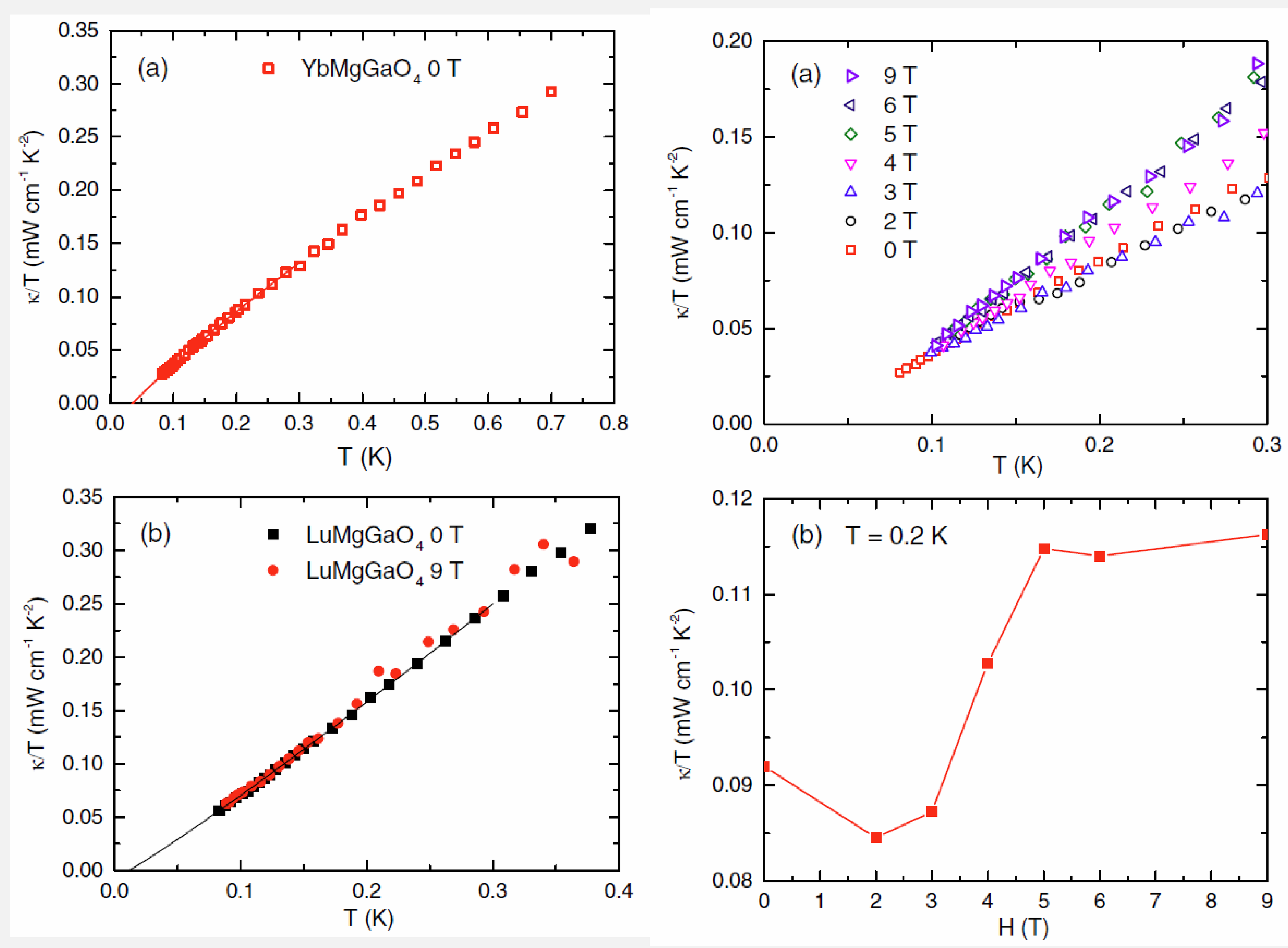
A gapless U(1) QSL with a spinon Fermi surface according to Ref. [5]

Magnetic field rapidly suppresses the $C_m$. The temperature dependence of the $C_m$ gradually turns into an exponential one, which is attributed to the magnons with a gap in a fully polarized state.

## Thermal transport properties




At zero field, $\kappa_0/T$ is negative, and the power of the temperature dependence is abnormally lower than 2. The $\kappa/T$ first decreases slightly for $H < 2$ T, then there is a sharp increase between 2 and 5 T, and it finally saturates for $H > 5$ T. While the magnetic state of $YbMgGaO_4$ in the intermediate fields ($0 < H < 5$ T) is rather complex, it simply tends to become a fully polarized state for $H > 5$ T at such low temperatures. In the fully-polarized state with a magnon gap of several Kelvins, there are almost no magnetic excitations to scatter phonons below 0.3 K; therefore, the κ of $YbMgGaO_4$ at $H > 5$ T is purely contributed by phonons. At lower fields, it is the additional scattering of phonons by magnetic excitations that suppresses the κ and gives the abnormal temperature dependence of κ and the unphysical negative $\kappa_0/T$ for $YbMgGaO_4$.

## Discussions

➢**The absence of magnetic thermal conductivity at zero field means that either (a) the presumed gapless spinons do not exist in $YbMgGaO_4$ and the large $C_m$ has some other magnetic origin;**
**or (b) the gapless spinons do exist but for some reason they do not conduct heat significantly in $YbMgGaO_4$. One possible mechanism of the spinon localization may be the disorder of $Mg^{2+}$-$Ga^{3+}$ sites (random occupation) in the double layers of Mg/$GaO_5$ triangular bipyramids.**

## References

(Only major ones listed):
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