



Spin Liquid “Lakes” with Topologically-Interesting Edge States in TbInO3



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Funding Grants: G.S. Boebinger (NSF DMR-1157490,1644779)

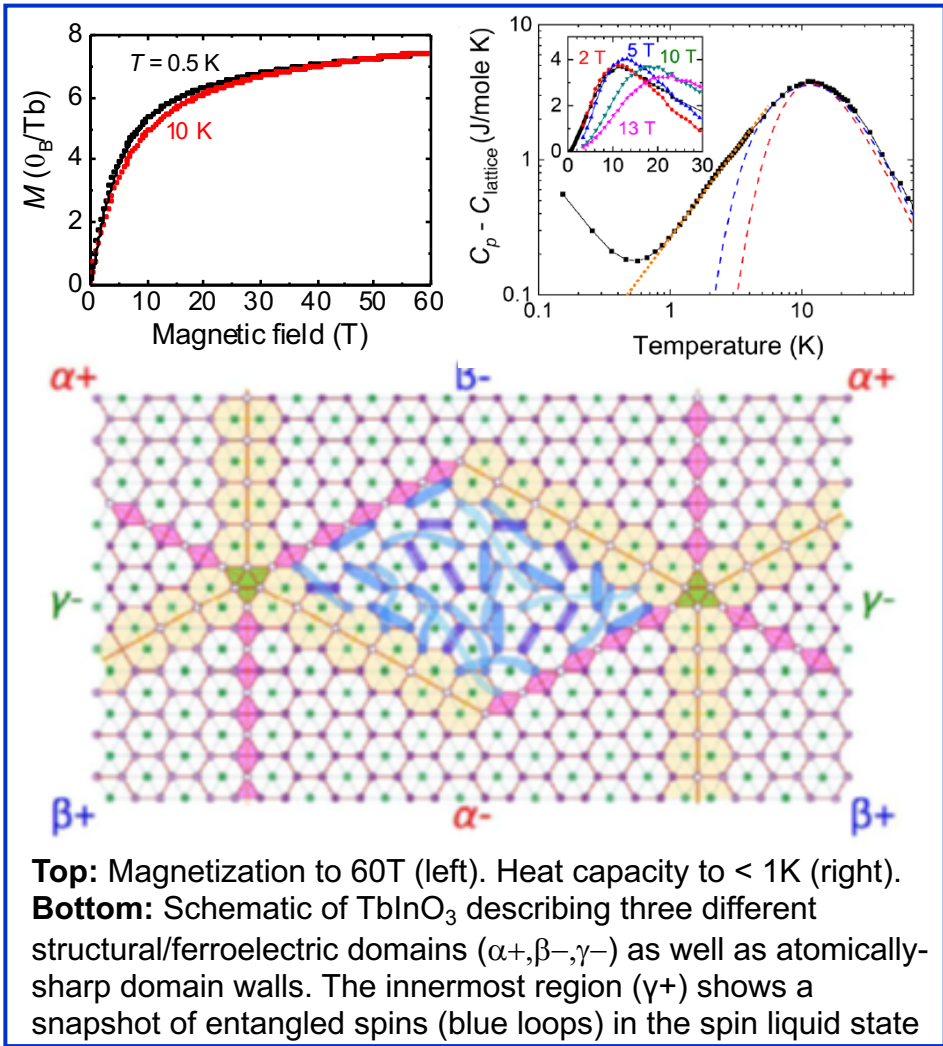
Recent pulsed magnet experiments support TbInO₃ as a spin liquid candidate in which structural and ferroelectric boundaries create topological edge states around the spin liquid regions.

TbInO₃ has a strongly frustrated 2D triangular structure of magnetic Tb ions. It is also a ferroelectric in which the In atoms can trimerize and the Tb atoms can be displaced above or below the 2D plane, creating six different kinds of ferroelectric domains (α_{\pm} , β_{\pm} , γ_{\pm}). The atomically-sharp domain walls have different magnetic exchange interactions than the interior of the domains, which results in magnetic edge states.

MagLab users have explored this material down with specific heat down to 0.15 K and with magnetization in magnetic fields up to 65 teslas to rule out magnetic ordering in this material, while magnetic exchange interactions may be as much as 20 K, which suggests a spin liquid state in TbInO₃. In addition, both measurements imply an emergent honeycomb magnetic lattice, as only one of two Tb sites has a magnetic ground state. Thus, TbInO₃ is a honeycomb magnetic lattice with a spin liquid state. Theory indicates that the clean and atomically thin edges between spin liquid regions can host Majorana fermions.

Piezo-force microscopy and scanning tunneling electron microscopy on these single crystals finds the structural and ferroelectric domains that are shown in the figure.

Reference: J.W. Kim, Y. Wang, F.T. Huang, Y. Wang, X. Fang, X. Luo, Y. Li, M. Wu, S. Mori, D. Kwok, E.D. Mun, V.S. Zapf, S.W. Cheong, *Spin liquid state and topological structural defects in hexagonal TbInO₃*, Phys. Rev. X, **9**, 031005 (2019) doi.org/10.1103/PhysRevX.9.031005



Top: Magnetization to 60T (left). Heat capacity to < 1K (right). **Bottom:** Schematic of TbInO₃ describing three different structural/ferroelectric domains (α^+ , β^- , γ^-) as well as atomically-sharp domain walls. The innermost region (γ^+) shows a snapshot of entangled spins (blue loops) in the spin liquid state

Facilities: 65 T magnets and PPMS (with dilution refrigerator) at the NHMFL-Pulsed Field Facility.