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$FeMn_3Ge_2Sn_7O_{16}$: a Spin-liquid Candidate with a Perfectly Isotropic 2-D Kagomé Lattice

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The compound $Fe_4Si_2Sn_7O_{16}$ has a hitherto unique crystal structure, consisting of ionic oxide layers based on edge-sharing FeO_6 and $Sn^{4+}O_6$ octahedra alternating with layers of intermetallic character based on $FeSn_6^{2+}$ octahedra, separated by covalent SiO_4 tetrahedra. The ionic layers contain kagomé lattices of magnetic Fe^{2+} cations (octahedral crystal field, high-spin [HS] d^6, $S = 2$) with perfect trigonal symmetry; while the intermetallic layers are non-magnetic because the Fe^{2+} is in the low-spin ($S = 0$) state. The formula is more correctly written as $Fe_4Si_2Sn_7O_{16}$ to differentiate the one LS-Fe^{2+} per formula unit in the intermetallic layer from the three HS-Fe^{2+} per formula unit in the kagomé oxide layer.

$Fe_4Si_2Sn_7O_{16}$ also has a unique magnetic ground state below a Néel ordering temperature T_N = 3.5 K, in which the spins on 2/3 of the Fe^{2+} sites in the kagomé oxide layers order antiferromagnetically, while 1/3 remain disordered and fluctuating down to at least 0.1 K. The nature and origin of this unique "striped" partial spin-liquid state is unclear. The fact that it breaks trigonal symmetry, which the more conventional q = 0 or $\sqrt{3}\times\sqrt{3}$ kagomé states would not, raises the possibility that the anisotropic distribution of the 6 unpaired spins on HS-Fe^{2+} ($t_{2g}^4e_g^2$) plays a role. To test this possibility, we have now synthesised an isotropic analogue with a kagomé lattice of HS Mn^{2+} ($t_{2g}^3e_g^2$), by co-substituting Ge^{4+} for Si^{4+} in the bridging/stannite layers to match the lattice dimensions between layers.

We found that $FeMn_3Ge_2Sn_7O_{16}$ has the same "striped" magnetic ground state as $Fe_4Si_2Sn_7O_{16}$, in the same temperature range, ruling out this explanation. However, the zero-field striped structure is collinear for $FeMn_3Ge_2Sn_7O_{16}$ vs. non-collinear for $Fe_4Si_2Sn_7O_{16}$, which may indeed be a consequence of the change in anisotropy on the magnetic kagomé site, and suggests that FeMn3Ge2Sn7O16 is an even more ideal spin-liquid candidate than $Fe_4Si_2Sn_7O_{16}$. We also found that an external applied magnetic field lifts the degeneracy on the disordered site, giving rise to another ordered magnetic structure never before observed nor predicted on a kagomé lattice.

Speakers Gender

Male

Travel Funding

No

Level of Expertise

Experienced Researcher

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No

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