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Magnetically frustrated dynamics on the Cairo pentagonal lattice

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The octahedrally and tetrahedrally coordinated Fe^{3+} ($S=5/2$) ions in $\text{Bi}_2\text{Fe}_4\text{O}_9$ form a quasi two-dimensional Cairo pentagonal lattice (*Pbam*). Combined with predominantly antiferromagnetic interactions, this leads to a strong frustration with $T_n=245$ K while $\theta_{CW}=1670$ K in a fairly unexplored geometry. The magnetic structure for $T < T_n$ can be indexed with $k=(\frac{1}{2}, \frac{1}{2}, \frac{1}{2})$ with a noncollinear magnetic structure of Fe1 and Fe2 moments, 2 different sites, and an interpenetrating pattern of fourfold spin rotations, a very novel magnetic state.

Previous measurements studying the low-lying excitations, 0–30 meV, in the ordered phase were measured on small single crystals (< 0.6 g). Beauvois et al. (PRL2020) argues that no anisotropy is required while Duc Le et al. (PRL2021) indicates an easy-plane single-ion anisotropy. Accordingly, Beauvois find the acoustic AF mode is not gapped while it is for Duc Le.

We have synthesized a 2.35 g, high quality single crystal of $\text{Bi}_2\text{Fe}_4\text{O}_9$ and are re-examining the magnetic excitations. Already at energy transfers below 10 meV we see distinct discrepancies between our data and previous data in the ordered phase using CAMEA and EIGER (PSI). Our data show a clear double spin gap, that allows us to differentiate axial and planar anisotropy scenarios. This will enable us to establish the microscopic model and perform quantitative analysis of the frustrated state above T_n .

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