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Magnetically frustrated dynamics on the Cairo pentagonal lattice; Bi2Fe4O9

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The octahedrally and tetrahedrally coordinated Fe3+ (S=5/2) ions in Bi2Fe4O9 form a quasi two-dimensional Cairo pentagonal lattice (Pbam). Combined with predominantly antiferromagnetic interactions, this leads to a strong frustration with Tn=245 K while $_{CW} = -1670$ K in a fairly unexplored geometry. The magnetic structure for T<Tn can be indexed with k=(½, ½, ½) 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 Bi2Fe4O9 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. Additionally, we have measured inelastic neutron scattering on IN20 (ILL) with polarization analysis, which has enabled us to study the nature of the anisotropic fluctuations for the different magnetic excitations. All this has been modelled in SpinW with very good agreement.

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