Ordering and Excitations in the Field-Induced Magnetic Phase of $\text{Cs}_3\text{Cr}_2\text{Br}_9$

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$\text{Cs}_3\text{Cr}_2\text{Br}_9$ is an interesting example of interacting spin-dimer system. As in other isotropic antiferromagnets such as Haldane or alternating chains and ladders, the ground state in zero field is a total spin singlet separated from the excited triplet by an energy gap. In a magnetic field $H$, a phase transition occurs at a critical field $H_{c1}$, where the gap to the lowest component of the Zeeman-split triplet closes. Above $H_{c1}$, field-induced magnetic order (FIMO) for spin components perpendicular to $H$ is induced by inter-dimer or inter-chain couplings. The FIMO transition may be considered as a Bose-Einstein Condensation.

$\text{Cs}_3\text{Cr}_2\text{Br}_9$ differs from other dimer systems currently studied (e.g. PHCC, $\text{TlCuCl}_3$) in two main ways: each $\text{Cr}^{3+}$ ion of the dimer has spin $3/2$ rather than $1/2$ for Cu-based systems and the arrangement of the dimers is hexagonal. This gives rise to anisotropy and frustration in a 3D lattice, respectively. The possibility of studying the magnetic ordering and the spin dynamics in a FIMO with sufficient detail to bring out features of frustration and anisotropy motivated the present neutron scattering study in $\text{Cs}_3\text{Cr}_2\text{Br}_9$. Two field orientations have been exploited, perpendicular and parallel to the easy axis $c$ (direction of the dimers). First, I present the diffraction study: the FIMO displays large hysteresis incommensurability, showing the importance of frustration. The impact of anisotropy is seen in the magnetic structure, whose nature strongly depends on the field direction. Second, I focus on spin dynamics: it quantifies the presence of anisotropy and shows its crucial role on the energy gap at $H_{c1}$, which is measurably open or not, depending on whether $H$ is perpendicular or parallel to $c$. Third, an explanation is proposed for the large value of the gap at higher field: it involves the mixing of higher order states (extended-FIMO), reflected by the absence of magnetization plateaus. Comparison with the sister $\text{Cs}_3\text{Cr}_2\text{Cl}_9$ compound provides a test of this hypothesis. *B. Grenier et al., Phys. Rev. Lett. 92, 177202 (2004)