Co NMR in Ca3Co2O8: an intriguing frustrated Ising chain system

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$Ca_3Co_2O_6$ is a geometrically frustrated, Ising-spin-chain system, with alternate stacking of a high-spin ($S = 2$) Co^{3+} trigonal (T) site and a non-magnetic Co^{2+} octahedral (O) site along the c axis, arranged in a triangular lattice. Exchange coupling is ferromagnetic (FM) and stronger between neighboring T ions along the chains, whereas it is antiferromagnetic (AF) and much weaker between chains.

For $5\text{K} < T < T_c \approx 25$ K. a long wavelength incommensurate spin density wave correctly describes the magnetic structure, whose average local justifies the name of modulated partially disordered antiferromagnet (MPDA). Magnetic field along $\hat{c}$ leads to successive transitions to a ferrimagnetic (FI), and a FM phase. The mean field picture of these three phases is however questioned by the appearance of magnetization steps, hysteretic behaviour and metastability at lower tempertures.

In a single crystal the quadrupole split spectra of O ^{59}Co from FM chains, at high field, are distinguished from the minority FI chains and majority FI chains, at lower fields.[1] The thermally activated nuclear spin-lattice relaxation of T ^{59}Co in the three distinct local configurations provide slightly different energy gaps that fit the Glauber model for the spin susceptibility of an Ising spin system. The intra- and inter-chain exchange constants J_1, $J_2 + J_3$ are the variational parameters, whose best-fit values yield the correct critical temperature T_c and the magnetic wavevector at $T = 0$. This simple mean field model and its pitfalls will be discussed in relation with the stability of the zero-field ground state, which has been recently identified by neutron scattering [2] as the commensurate antiferromagnetic structure, surprisingly taking over the incommensurate spin-density wave at low temperature (below 5K).

[1] G. Allodi *et al.*,Phys. Rev. B **83**, 104408 (2011).

[2] S. Agrestini *et al.*, Phys. Rev. Lett. **106**, 197204 (2011).