Complex magnetic order in quasi-one-dimensional compound Ca_3CoIrO_6

J. Sugiyama[1], G. M. Morris[2], H. Nozaki[1], Y. Ikedo[1], P. L .Russo[2], J. H. Brewer[2,3], E. J. Ansaldo[2], C. Martin[4], S. Hébert[4], and A. Maignan[4]

[1] *Toyota Central Research and Development Labs. Inc., Nagakute, Aichi 480-1192, Japan*
[2] *TRIUMF, 4004 Wesbrook Mall, Vancouver, BC, V6T 2A3 Canada*
[3] *CIfAR and Department of Physics and Astronomy, University of British Columbia, Vancouver, BC, V6T 1Z1 Canada*
[4] *CRISMAT, CNRS/ISMRA 6508, 6 bd du Maréchal Juin, 14050 Caen Cedex, France*

In the compound with the general formula $Ca_3Co\mathit{B}O_6$ (B = Co, Rh, or Ir), the crystal structure is made up of $Co\mathit{B}O_6$ linear chains parallel to the c-axis, spaced apart by Ca^{2+} ions which fill the space between them. The chains themselves are made up of alternating face-sharing pairs of blocks: CoO_6 trigonal prisms and $\mathit{B}O_6$ octahedra. The chains form a hexagonal array in the ab plane so each chain is surrounded by six other structurally identical chains. For $Ca_3Co_2O_6$, the spins of Co^{3+} ions in the prism tend to order ferromagnetically (FM) along the chain, while the interchain interaction is weaker and favors antiferromagnetic (AF) order. Note that the Co^{3+} ions in the octahedron are non-magnetic, because they are in a low-spin state. The balance of these competing interactions gives rise to interesting magnetic properties, such as the partially disordered AF (PDA) state below 28 K, while short-range AF order persists up to $\sim$ 100 K [1,2].

According to a very recent μ^+SR experiment on Ca_3CoRhO_6 [3], although the charge distribution in the chain changes to Co^{2+} and Rh^{4+}, the compound exhibits essentially the same magnetic transitions; that is, short-range AF order appears below $\sim$ 180 K, the PDA state completes below $\sim$ 90 K, and finally the ferrimagnetic state emerges below $\sim$ 20 K. The increase in the transition temperatures compared with those of $Ca_3Co_2O_6$ suggests the effect of the wide spread 4d-orbitals of Rh^{4+} ions.

In order to determine whether the magnetic behavior is similar for Ca_3CoIrO_6, we have measured a μ^+SR spectrum using a polycrystalline sample. We found that short-range AF order appears below $\sim$ 300 K, while long-range order sets in below $\sim$ 110 K. Moreover, the ZF spectrum exhibits a very clear oscillation (at $\sim$ 50 MHz) below 100 K, but its volume fraction is only $\sim$ 20% even at 1.8 K. Since the oscillation for $Ca_3Co_2O_6$ and Ca_3CoRhO_6 is strongly damped, and eventually only the first minimum is seen in the ZF-spectrum, the magnetic nature of Ca_3CoIrO_6 is likely to be rather different from that of the others.

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