Incommensurate Magnetic Phases of the Multiferroic Compound $MnCr_2O_4$ Described with the Superspace Formalism

Miguel Pardo-Sainz[1,2]

[1]*Instituto de Nanociencia y Materiales de Aragón (INMA), Spain;* [2]*Osaka Metropolitan University, Japan*

Nowadays, chromium-based normal spinel oxides ACr_2O_4 are one of the most studied materials in the condensed matter community due to the interplay between its magnetic, electric and structural properties as well as to its potential application to different key industry sectors. In these compounds, several physical effects have been observed, which include magnetostriction, colossal magnetoresistance, multiferroic, spin frustration and more [1-4].

In particular, for $MnCr_2O_4$, the ground state magnetic structure is still controversial because the magnetic structures reported by different groups and investigated by independent techniques are inconsistent [1-7].

The magnetic structure of this compound was reinvestigated by magnetization, specific heat and neutron diffraction experiments at different temperatures. The results suggested that a new magnetic phase, not previously reported, is developed under 18 K when the sample is synthesized under a reductive atmosphere. The magnetic phases present in this sample were: long-range ferrimagnetic order below T_C = 45 K; incommensurate conical spin order with propagation vector $\vec{k}_{S1}$ = (0.62(1), 0.62(1), 0) below T_{S1} = 20 K; and incommensurate conical spin order with propagation vector $\vec{k}_{S2}$ = (0.660(3), 0.600(1), 0.200(1)) below T_{S2} = 18 K. These magnetic structures were observed to be highly dependent on the synthesis procedure, especially regarding the atmosphere in which the samples are synthetized. We try to offer an explanation in terms of the different magnetic exchange interactions competing in the system.

Finally, using the superspace group formalism [8-10], the symmetry of the nuclear and magnetic structures is described. The presence of transverse conical magnetic structures in the lower-temperature phases implies the existence of multiferroicity. Using simple theoretical calculations, we derive the directions along which the electric polarization lies for each magnetic phase.

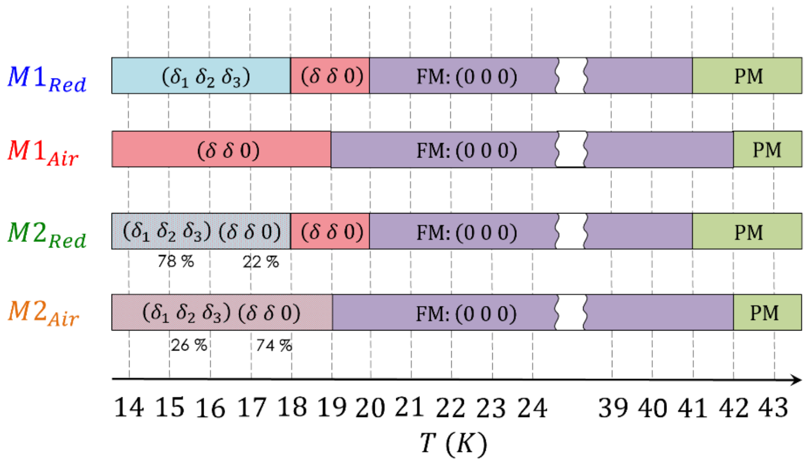

Fig. 1. Phases present in each of the $MnCr_2O_4$ samples together with their phase transition temperatures. Green: paramagnetic order, purple: ferrimagnetic order, pink: conical order with $\vec{k}_{S1}$ = (0.62(1), 0.62(1), 0), blue: conical order with $\vec{k}_{S2}$ = (0.660(3), 0.600(1), 0.200(1)).

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