New incommensurate magnetic phases in the multiferroic compound MnCr$_2$O$_4$

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Nowadays, chromium-based normal spinel oxides ACr$_2$O$_4$ are one of the most studied materials in the condensed matter community due to the interplay between its magnetic, electric and structural properties [1,2]. In particular, for MnCr$_2$O$_4$, the ground state magnetic structure is still controversial because the magnetic structures reported by different groups and investigated by independent techniques are inconsistent [1-3].

The magnetic structure of this compound was reinvestigated by magnetization, specific heat and neutron diffraction experiments at different temperatures. The results revealed that a new magnetic phase, not previously reported, is developed below 18 K. The magnetic phases present in this sample were: ferrimagnetic order below $T_C = 45$ K; conical spin order with propagation vector $K_S1=(0.62(1), 0.62(1), 0)$ below $T_{S1} = 20$ K; and conical spin order with propagation vector $K_{S2}=(0.660(3), 0.600(1), 0.200(1))$ below $T_{S2} = 18$ K.

Using the super-space group formalism, the symmetry of the nuclear and magnetic structures is determined (see figure 1). Through simple theoretical calculations, we derive the directions along which the electric polarization lies for each magnetic phase.

Figure 1. Scheme of the magnetic structures for each of the 2 different phases