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Ferroelectricity and magnetic orderings in Delafossite family compounds

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Since discovery of the ferroelectric polarization induced by magnetic field in CuFeO2, delafossite family compounds have attracted much attention, because some theoretical formula, which had been presented, could not explain the ferroelectric polarization of CuFeO2. We have been investigating correlation among their magnetic orderings, lattice symmetry and ferroelectric polarization in AFeO2 (A=Cu, Ag, Na) systems. In CuFeO2, the ferroelectric polarization is induced by chemical substitutions for Fe sites in CuFe1-xBxO2 (B=Al, Ga, Rh, Mn) as well as magnetic field. The magnetic structure in the ferroelectric phase is proper screw type with magnetic point group 21' determined by the neutron diffraction experiments.[1] The ferroelectric polarization parallel to the propagation vector in CuFeO2 can be explained by both extended inverse-Dzyaloshinsky-Moriya(DM) effect and d-p hybridization mechanism. We have also demonstrated that the spin-orbit interaction in Fe ions, coupling spin and orbital orders, plays a crucial role to the ferroelectricity in both of which break the crystal symmetry, by observing incommensurate 2q orbital modulation in the ferroelectric phase of CuFe1-xGaO2 by soft X-ray resonant diffraction.[2] When nonmagnetic Cu ions on A-site are substituted by Ag or Na ions, the magnetic orderings are completely modified from CuFeO2. In AgFeO2, cycloid type magnetic structure with m1' point group is stabilized, which is concomitant with ferroelectric polarization, as the lowest temperature phase in zero-field.[3] Also in alpha-NaFeO2, the other type of cycloidal ordering (m1') appears mainly in magnetic field. In these systems, taking account of extended inverse DM effect, ferroelectric polarization direction is along general direction in the ac plane and does not follow the well-known inverse DM formula. In this presentation, I will discuss the relationship between the magnetic ordering and ferroelectricity in these delafossite family compounds.

[1] *T. Nakajima et al, Phys. Rev. B, 2009, 79, 214423,* ***[2]*** *Y. Tanaka et al, Phys. Rev. Lett, 2012, 109, 127205,* ***[3]*** *N. Terada et al, Phys. Rev. Lett, 2012, 109, 097203*

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