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Magnetoelastic and Magnetodielectric Properties of Ferrimagnetic Spinel Vanadates

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Orbital ordering, in which specific *d* orbitals are occupied by electrons at each transition metal, occurs in several transition-metal oxides. Because of the spatial anisotropy of *d* orbitals, such orbital ordering strongly affects the elastic properties as well as dielectric properties of materials. In addition, when orbital ordering is strongly coupled with magnetic ordering (and this often happens through the so-called Kugel-Khomskii interaction),orbital ordering can be controlled by magnetic field via orbital-spin coupling. This results in large magnetoelastic as well as magnetodielectric effect.

Here, we show the intriguing magnetoelastic and magnetodielectric properties of spinel vanadates, MnV_2O_4 and FeV_2O_4.[1][2] In these compounds, V^{3+}, in which there are two *d* electrons in triply degenerate $t_{2}g$ orbital ($3d^2$) and thus there is an orbital degree of freedom, occupies the B site (octahedral site) of the spinel structure, and the ordering of this V orbital occurs at low temperatures. In addition, because of the antiferromagnetic interaction between the A site (tetrahedral site) occupied by Mn^{2+} ($3d^5$) or Fe^{2+} ($3d^6$) and the B site occupied by V^{3+}, ferrimagnetic ordering occurs, where the A-site spin and B-site spin align to the opposite direction. We found that these two orderings, orbital ordering and ferrimagnetic ordering, occur at the same temperature in these compounds. This "multiferroic" situation leads to various interesting magnetoelastic and magnetodielectric properties in these compounds, for example, magnetic-field-induced structural phase transition, "colossal" magnetostriction arising from the magnetic-field-induced alignment of tetragonal (orthorhombic) domains, large magnetocapacitance, and a memory effect of capacitance with magnetic field.

REFERENCES
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CA04

Magnetic Transitions of Multiferroics Revealed by Soft X-ray Scattering

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Coexistence of magnetism and ferroelectricity with gigantic cross coupling in frustrated magnets has recently attracted much attention. Discovery of such magnetoelectric coupling effects has been the primary drive of the multiferroics research. In frustrated magnets, the magnetic phases involved in the magetoelectric couplings are complicated and commonly incommensurate with lattice. In addition, the magnetic transition temperature is higher than the ferroelectric one, suggesting that the ferroelectricity is induced by magnetic order, unlike old examples of multiferroics.

In this talk, we will present measurements of resonant soft-x-ray magnetic scattering on frustrated magnets to study the magnetic transitions associated with multiferroicity. Resonant soft-x-ray magnetic scattering is a newly developed technique which is sensitive to the magnetic moment of transition-metal d electrons, allowing us to probe magnetic order with high sensitivity. Our results on $TbMn_2O_5$ and $CoCr_2O_4$ reveal the detailed coupling of ferroelectricity and antiferromagnetic ordering and set fundamental symmetry constraints on the mechanism of multiferroicity.