Competing magnetic phases and spin-reorientation transitions in ortho- and hexa- ferrites

Hena Das[1,2]

[1]*Laboratory for Materials and Structures, Tokyo Institute of Technology, 4259 Nagatsuta, Midori-ku, Yokohama, Kanagawa 226-8503, Japan*

[2] *Kanagawa Institute of Industrial Science and Technology (KISTEC), 705-1 Shimoimaizumi, Ebina 243-0435, Japan*

When multiple magnetic sublattices are formed in a single-phase structure, mutual magnetic interactions between these sublattices lead to unique magnetic and related phenomena, such as spin-reorientation (SR) transitions, ferrimagnetism, magnetoelectricity and topological orders. The formation of these magnetic sublattices can be attributed to many factors, such as certain chemical compositions or the formation of unique charge-ordered (CO) states. In this presentation, I will discuss magnetic properties of two ferrite systems, $PbFeO_3$ [1] and $LuFeO_3$ [2-3], where the multiple magnetic sublattices originate from unique CO states and hence bear significant consequences. In $PbFeO_3$ ortho-ferrite, we have observed SR transition at high temperature (~ 418 K). We showed that a non-trivial Pb^{2+}/Pb^{4+} CO state creates two magnetic Fe1 and Fe2 sublattices with mutually competing magnetic anisotropies and hence trigger the SR transition. In $LuFeO_3$ based hexa-ferrites, certain non-polar phonon distortion ($\boldsymbol{Q_{K_3}}$) not only induces ferroelectric (FE) and ferromagnetic (FM) orders, but also a strong coupling between them and topological orders [2]. Recently, we have proposed an idea to realize non-collinear Fe^{2+}/Fe^{3+} CO ferrimagnetic orders near room temperature having a considerably high magnetization $\mathbf{M} \sim 1.1 - 1.3\ \mu_B$/Fe their strong coupling with FE ($\mathbf{P} \sim 6 - 15\ \mu C/cm^2$) order driven by the antisymmetric Dzyaloshinskii-Moriya (DM) exchange interaction between the localized spins in the electron doped $LuFeO_3$ [3]. I shall deliberate upon that and discuss in detail the microscopic mechanisms to achieve electric field induced spin-reorientation transitions and magnetic switching phenomena.

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[3] H. Das, Phys. Rev. Research **5**, 013007 (2023).