Successive Phase Transitions and Multiferroic character in Electronic Ferroelectric, $RFe_2O_4$ ($R = \text{Lu}, \text{Yb}$).

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Charge and spin frustrated system, $RFe_2O_4$ is one of the candidates of multiferroic materials because it is considered as an “electronic ferroelectric” having electric polarization arising from polar charge order of divalent and trivalent iron ions \([1]\). However recently, some questions arose about the existence of the ferroelectricity and the polar charge ordering in this material \([2]\).

Responding to these discussions, we made precise pyroelectric current measurement in YbFe$_2$O$_4$ single crystal and succeeded in proving the presence of electric polarization. Moreover, we found that the temperature variation of $(1/3 1/3 \text{ integer})$ diffraction signal (Fig.b) was consistent with that of the polarization (Fig.a). These results strongly support the existence of “electronic ferroelectricity” in $RFe_2O_4$. The polar charge ordering is also supported from the space group consideration in the subgroup of R-3m.

This electronic polarization arising from electronic ordering brings many interesting properties, such as magnetoelectric effect and non-linear conductivity. The magnetoelectric effect was cleared out by the analysis with impedance spectroscopy in LuFe$_2$O$_4$. The temperature variations of resistivity, capacitance, relaxation frequency and magnetization all trace out clear hysteresis loop \([3]\). These results suggest the multiferroic nature in $RFe_2O_4$. Non-linear conductivity was also revealed through in-situ measurement of sample resistivity and temperature in YbFe$_2$O$_4$. Below the charge ordering temperature of 350 K the conductivity increased non-linearly with current \([4]\). Furthermore this material shows successive transitions around room temperature. We will report detailed investigations for these anomalies.


Figure: Temperature variations of the polarization (a) and integrated intensity of $(1/3 1/3 \text{ integer})$ diffraction signal (b).