Magnetic Field Induced Spin Reorientation Transition in $YFeO_3$ Probed with THz Spectroscopy

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ABSTRACT-**By using terahertz time-domain spectroscopy (TDS), we systematically investigate the spin reorientation transition (SRT), a switching of macroscopic magnetization rotated by 90 º, in $YFeO_3$ single crystal triggered by magnetic field. Our results suggest that the chosen of R would tailor the dynamical rotation properties of Fe ions, leading to the designable spin switching in the orthoferrite antiferromagnetic systems.**

I. INTRODUCTION

Recently, temperature and magnetic field induced spin reorientation transition (SRT) in $RFeO_3$ attracts lots of interests due to the potential applications in spintronics and energy efficient information technology. Different from other rare-earth orthorferrites, $YFeO_3$ is an excellent candidate for investigation of external magnetic field induced SRT of iron sublattice due to the nonmagnetic characteristic of Y ions, which avoids the complex exchange interaction between rare-earth ions and Fe ions under magnetic field. In the present study, we employed THz time-domain spectroscopy to study the temperature and magnetic field dependence of spin wave excitation, as well as the manipulation of spin reorientation transition with external field. THz TDS measurements in the transmission configuration were conducted on a c-cut $YFeO_3$ single crystal in the frequency range of 0.1 to 2 THz with temperature range from 3 K to 290 K. The magnetic field with magnitude up to 7 T is applied perpendicularly to the propagation direction of incident THz pulse.

II. RESULTS

Figure 1 presents the resonant frequency and amplitude of the quasi-ferromagnetic (FM) spin-wave mode as a function of temperature. The resonant frequency of FM mode shows mostly temperature independence with a mean value of 0.29 THz. Additionally, the amplitude of FM mode decreases slightly as the sample is cooled. We do not observe any other resonances at higher frequency range, which means that antiferromagnetic (AFM) mode in $YFeO_3$ has never been available for the c-cut sample in the whole temperature range. In other word, $YFeO_3$ stays in the Γ_4 phase from T_N to the temperature as low as a few Kelvin, and SRT in $YFeO_3$ does not occur by changing temperature.

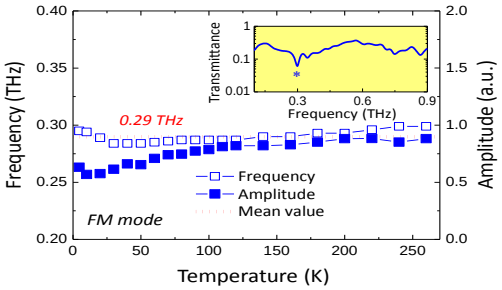

Fig.1. The resonance frequency and the spectral amplitude of quasi-ferromagnetic (FM) mode in the *c*-cut $YFeO_3$ single crystal are shown as functions of temperature.

Next, we focus on the study of magnetic field induced SRT in $YFeO_3$. The magnetic field of THz pulse and external magnetic field are set parallel to the *a*-axis of $YFeO_3$ crystal ($\mathbf{H}_{ext}$//$\mathbf{H}_{THz}$//*a*-axis). The main result about magnetic field induced SRT is shown in Figure 2. At lower applied magnetic field (H<2 T), the frequency of FM mode keeps relative constant. By increasing the magnitude of H above 2 T, the frequency of FM-mode starts to decrease quickly with magnetic field, and the mode is still observable with the field up to 7 T. The frequency softening of FM-mode is indicative of the appearance of SRT induced by magnetic field. On the other hand, the FM-mode persists up to 7 T implies the SRT does not complete under the field of 7 T. It is important to note that a higher resonant frequency at 0.55 THz is clearly observed at the magnetic field of 4 T, and this frequency mode decreases slightly with the magnetic field. According to our experimental results, we can conclude that the $YFeO_3$ is Γ_4 phase without magnetic field, and the crystal is transformed into Γ_{24} phase when apply the magnetic field.

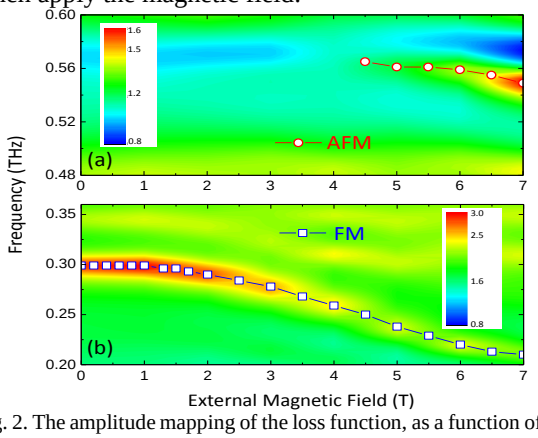

Fig. 2. The amplitude mapping of the loss function, as a function of the external magnetic field along *a*-axis, in the cases of two spectrum regions: AFM mode (a) and FM mode region (b) at temperature of 260 K.

III. SUMMARY

Owing to be absence of *4f*-electrons in Y ion, the spin reorientation of Fe sublattices can only be induced by the applied magnetic field, rather than temperature. Our data are in agreement with a simplified thermodynamic model with two-sublattice approximation.

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