Determination of spin orientation during phase transition in orthoferrite by terahertz TDS spectroscopy

Keita Nakamura, Hiroshi Watanabe and Tohru Suemoto,
Laser and Synchrotron Research Center, Institute for Solid State Physics,
The University of Tokyo, Japan
Corresponding Author: suemoto@issp.u-tokyo.ac.jp

Ultrafast manipulation of spin states is one of the emerging topic in the field of spintronics. Ferromagnetic and antiferromagnetic materials are promising for application to spin valves and spin current injection as well as optically controlled spin memories. Among these materials, rare earth orthoferrites, showing weak ferromagnetism due to canted spins are particularly useful and interesting because of the spin reorientation phase transitions. In this report we propose and demonstrate determination of spin orientation during the phase transition by using terahertz time domain spectroscopy (THz-TDS).

We investigate (001)-cut single crystal of $Dy_{0.7}Er_{0.3}FeO_3$, which shows spin reorientation transition (between c and a-axis) around 10 K but the details are not known. This sample has two magnetic resonance modes, F (ferromagnetic) and AF (antiferromagnetic) as shown in the inset of Fig. 1(a). By observing the THz absorption polarized parallel to the a-axis using a sub-monocycle THz pulse, we can quantify the a-axis component of the magnetic dipole fluctuation due to spin precession. F and AF modes show complementary temperature dependences as shown in Fig.1 (a). Using these two curves, we estimated the rotation angle of the magnetization as a function of temperature, which shows a very good agreement with a model based on anharmonic anisotropy potentials (Fig. 1(b)). This shows clearly the transition is "rotation-type" rather than "abrupt-type".

It was also found that the THz method is insensitive to domain structures and superior to usual SQUID method particularly in studying the spin orientation under unsaturated magnetic field.

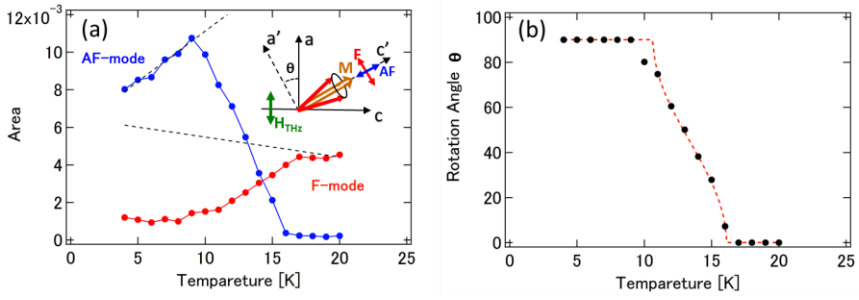

Figure 1- (a) Temperature dependence of the terahertz absorption. Inset shows the spin orientation and fluctuations. (b) Spin rotation angle (dots) and that from calculation (dashed line).