Terahertz Magnetospectroscopy of Gadolinium Gallium Garnet in Fields up to 25 T

J. Bao[1,2], N. Marquez Peraca[1], F. Tay[2,3], T. E. Kritzell[3], X. Li[2], G. T. Noe II[2], I. Katayama[4], J. Takeda[4], H. Nojiri[5], H. Yamahara[6], H. Tabata[6], A. Baydin[2,7], and J. Kono[1,2,7,8,*]
[1]Department of Physics and Astronomy, Rice University, Houston, TX, USA
[2]Department of Electrical and Computer Engineering, Rice University, Houston, TX, USA
[3]Applied Physics Graduate Program, Smalley-Curl Institute, Rice University, Houston, TX, USA
[4]Department of Physics, Graduate School of Engineering Science, Yokohama National University, Yokohama, Japan
[5]Institute for Materials Research, Tohoku University, Sendai, Japan
[6]Department of Electrical Engineering and Information Systems, Graduate School of Engineering, University of Tokyo
[7]Smalley-Curl Institute, Rice University, Houston, TX, USA
[8]Department of Materials Science and NanoEngineering, Rice University, Houston, TX, USA
[*]Email: kono@rice.edu

1. Introduction

Terahertz (THz) spectroscopy of solids in high magnetic fields can often provide new insight into the microscopic physics behind complex many-body behaviors [1]. Advanced THz techniques and high magnetic field generation techniques are available, but combination of the two has only been realized recently [2,3].

Here, we report results of THz magnetospectroscopy experiments on gadolinium gallium garnet (GGG), or $Gd_3Ga_5O_{12}$, in magnetic fields up to 25 T. GGG is a frustrated magnet [4], in which purely antiferromagnetic exchange interactions exist among Gd^{3+} ions located on two triangular sublattices. The frustration prevents ordering, and the system is best described as a spin liquid at low temperatures [5]. However, an applied magnetic field (~1 T) produces an antiferromagnetic phase below 0.38 K [4]. Microwave electron paramagnetic resonance (EPR) measurements on GGG have been performed, revealing a single line with $g \approx 2$ [6]. However, properties of GGG in high magnetic fields remain unexplored.

2. Experimental Methods

We used the Rice Advanced Magnet with Broadband Optics (RAMBO) [7] to perform magnetospectroscopy measurements (Fig. 1a). A mini-coil produced a millisecond-duration pulsed magnetic field, while THz electromagnetic pulses of picosecond length propagated through the sample. A single-shot detection technique [2] allowed us to obtain multiple THz waveforms within each magnetic field pulse (Fig. 1b). We conducted measurements in the Faraday geometry with THz polarization along the $[1\bar{1}0]$ orientation.

3. Results

Figure 2 shows the transmission THz power spectra at (a) 230 K and (b) 10 K. Each curve corresponds to a different magnetic field. At 230 K, a single peak due to the EPR of Gd^{3+} ions is observed; from its slope versus magnetic field, we obtained $g = 2.05$. At 10 K, in addition to the EPR line, we observed a new lower-frequency line at magnetic fields above 17 T. This feature (labeled "X" in the figure) also blue-shifted with increasing magnetic field. We will present more detailed temperature and magnetic field dependent experimental data and discuss the possible origin of the lower-frequency peak.

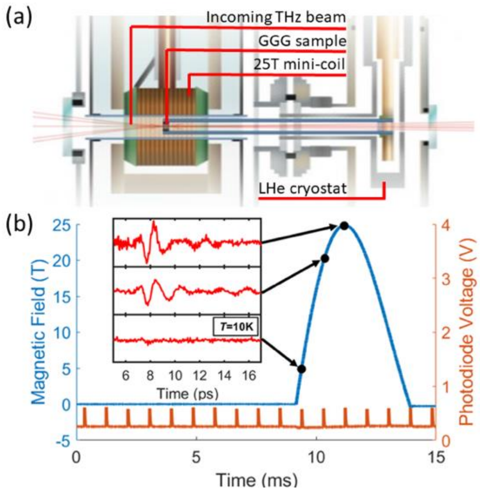

Fig. 1. (a) RAMBO system. The sample is mounted on a sapphire rod, connected to the cold finger of a liquid helium cryostat. The 25-T mini-coil magnet is emersed in liquid nitrogen. (b) Magnetic field pulse (blue), and time-domain THz waveforms (red) recorded at three magnetic fields within the magnetic field pulse.

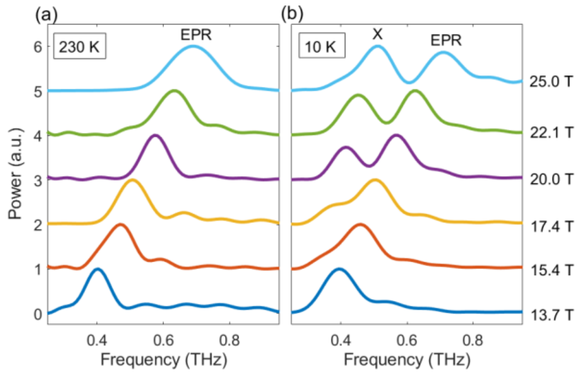

Fig. 2. Power spectra of THz radiation transmitted through the GGG crystal at (a) 230 K and (b) 10 K at various magnetic fields. Curves are vertically offset for clarity.

References

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