Measuring Antiferromagnetic Resonance in NiO Using THz Time-Domain Spectroscopy

(preliminary report)

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Antiferromagnetic materials are of great interest for use in data storage devices due to their insensitivity to external magnetic fields, their lack of stray magnetic fields, and their magnon spectra in the THz regime. Research is currently focussed on the manipulation and detection of their magnetic states, particularly at ultrafast timescales.

In this work, we developed a THz time-domain spectroscopy setup to study antiferromagnetic resonance in the antiferromagnet NiO. The setup uses two photoconductive antennas (PCAs) which are excited by a 1064 nm laser and in combination act as a THz emitter and detector. As shown in *Figure 1*, a delay line in the detector path allows measurements to be performed in the time domain. To test the setup, we performed a spectroscopic study on a 500 µm thick, (111) cut single crystal of NiO as a function of temperature from 295 K- 400 K, finding good agreement with a previous study [1]. By studying the higher frequency out of plane mode around 1 THz, we found that the resonance frequency decreased with increasing temperature. We found the relationship $\omega = \omega_0[M_0'(T)]^n$, where $\omega_0 = 1.09$ THz is the resonance frequency at T=0 K and $M_0'(T)$ is the reduced magnetisation calculated using a Brillouin function, represents the experimental data well. As shown in *Figure 2*, the best fit was found with a value of $n = 0.73$, which is close to the value of $n = 0.72$ found in *Moriyama 2019* [1]. The resonance linewidth, and therefore the magnetic damping, was found to increase with temperature.

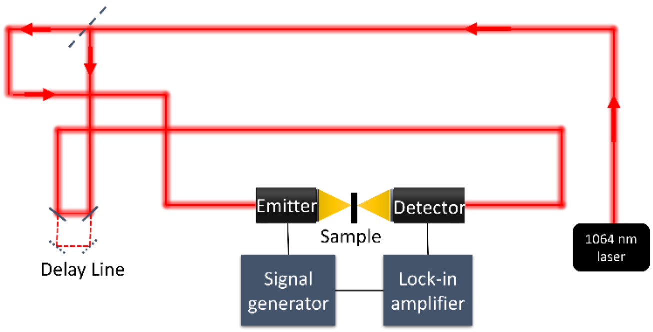

Figure 1: Schematic of the THz time-domain spectroscopy setup. The emitter and detector are two photoconductive antennas, excited by a 1064 nm laser.

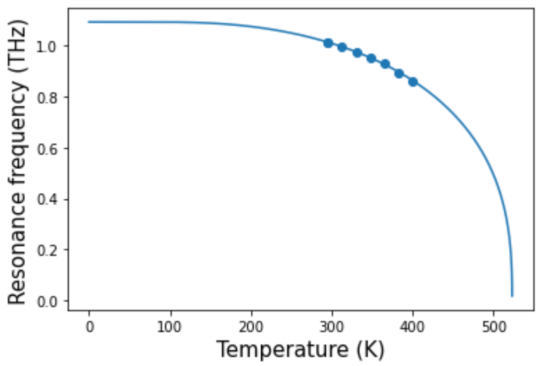

Figure 2: Plot of resonance frequency vs temperature for NiO. The fit is calculated using a Brillouin function.

[1] Moriyama, T., Hayashi, K., Yamada, K., Shima, M., Ohya, Y., & Ono, T. (2019). *Intrinsic and extrinsic antiferromagnetic damping in NiO.* Physical Review Materials, 3(5). https://doi.org/10.1103/physrevmaterials.3.051402