Terahertz Time-Domain Spectroscopy in High Magnetic Fields

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Introduction and Experimental

Observation of integer and fractional quantum Hall effects in two-dimensional electron gas systems is one of the more striking phenomena in semiconducting systems in high magnetic fields [1]. Our work focuses on utilizing terahertz frequency spectroscopic techniques as extension of the commonly performed transport measurements to study inter- and intra-Landau Level coherences in two-dimensional systems such as gallium arsenide-based 2DEG's as well as to newer material systems line monolayer dichalcogenides (MoS_2) and graphene [2]. Our work at NHMFL is to develop terahertz time-domain spectroscopy in high magnetic fields in the Split Florida-Helix (SFH) magnet in Cell 5 and to study these population and coherence dynamics in 2D systems. To date, we have successfully demonstrated a non-degenerate pump probe spectroscopy in Faraday reflection geometry [3], which was published during this reporting period with results from our prior reporting period. In this reporting period, we have designed and tested a reflection-geometry based version of TTDS for use in Cell 5[2].

Results and Discussion

Our preliminary work performed all-optical pump-probe spectroscopy on (100) gallium arsenide at 25T in the Split Florida-Helix magnet in Cell 5. Fig. 1 shows the ultrafast oscillations taken at 25T and 15K. These oscillations are well described by a coherent acoustic phonon model and a four level system approximation. These results were published in Optics Letters in this reporting period[3].

Our initial experiments to extend this technique to the terahertz frequency domain were unsuccessful. The main complication is the absence of a transmission axis for Faraday geometry measurements it the current SFH, which necessitated the more complex reflection apparatus. We believe that the current *reflection* design of our spectrometer is the cause of this failure and are working with the McGill group to test an alternate configuration. Our new configuration will adapt a transmission geometry apparatus that we have already tested in the 10T (Cell 1) system[2], which we believe will be more successful in the SFH.

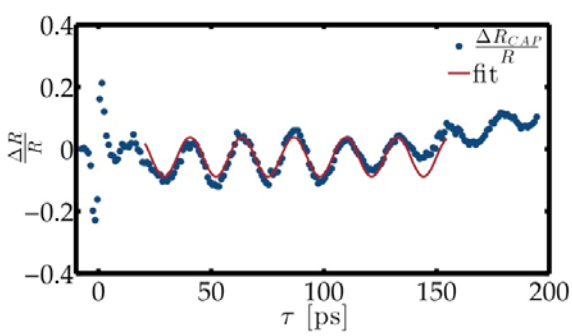

Fig.1 The coherent acoustic phonon signal (dot) and a fitting (line) to a sinusoidal model. From [1].

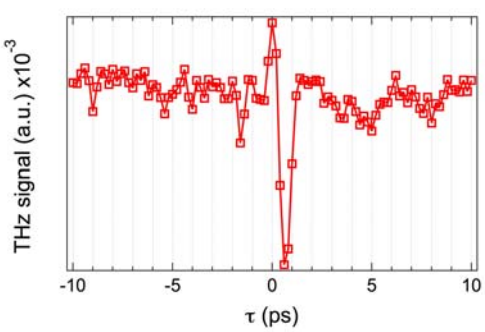

Fig.2 The time-resolved THz signal generated and detected on the tabletop of Cell 5 optics table.

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