FTIR Magneto-Spectroscopy in the NHMFL DC facility: New Developments, Tests and Optimization of Experimental Protocols

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This year was devoted to proof of principle work on two experimental techniques based on using the IR experimental set-up in the 35 T resistive magnet in cell 8.

1. Photocurrent FT-IR spectroscopy at 35 T

Working with a user's experiment at SCM3 (Long Ju at MIT) we successfully measured a far-infrared response on graphene samples of a few micrometer size. The experimental environment in Cell 8 is more appealing for scientific goals due to high magnetic fields up to 35T and 1.6 K temperature environment, as well as higher intensity of the IR radiation and simple operation of the samples exchange. We requested time for zero-field tests (no power) for a new designed probe and obtained a reasonable spectrum during week-end days only, when the power plant is off and whole facility is silent. Unfortunately, the real application of this technique is quite challenging at cell 8 due to the significant electrical noise picking-up from the environment, even if no water and power are applied.

2. High-field sub-THz electron magnetic resonance spectroscopy.

For some studies, like triplet condensation in quantum magnets, the intrinsic THz energy gap is decreasing with applied magnetic fields and their field behavior cannot be extracted from FTIR measurements below some frequency. This limit is about 13 cm-1 for FTIR setup at cell 8 due to strong absorption lines. On other hand the electron spin resonance (ESR) technique allows access to the low-frequency part of the magnetic excitation spectrum, but requires different equipment, and, more importantly for the users, a separate experimental request for magnet time.

The idea of the performed experiment is to combine two these experimental techniques on the same probe with an sample and mounted next-to-side Si bolometer. For the high frequency range, the Bruker IFS 66v has been used as a broadband radiation source and magnetic field was fixed. For the low frequency range, VDI source of the monochromatic sub-THz radiation has been used and magnetic field was swept. The canted antiferromagnet $Ca_2Fe_2O_5$ was used as the benchmark sample, exhibiting two energy gaps at 14.3 cm-1 and 44 cm-1. The examples of measured ESR spectra are shown at Fig.1. As result, a frequency-field diagram of magnetic excitations (Fig.2) is completed with the several magnetic modes disclosed in the frequency range 75-115 GHz. The employment of multipliers allows increases to this frequency range.

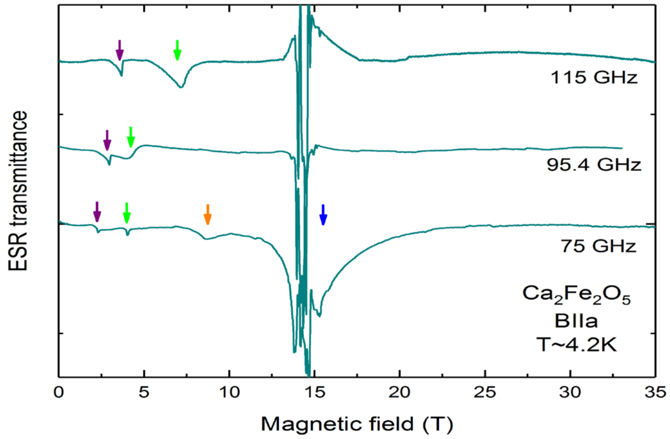

Fig.1: ESR spectra measured at cell 35 using IR probe. The big change of ESR transmittance at 14.5 T corresponds to the spin-flop magnetic phase transition

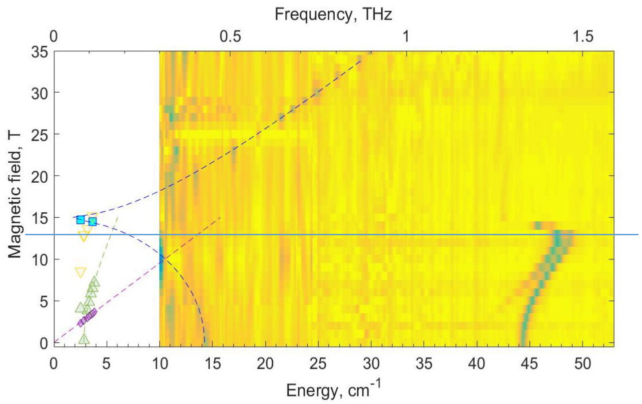

Fig.2: Low-energy magnetic excitations of $Ca_2Fe_2O_5$. The colorful picture corresponds to the normalized transmittance spectra measured by FTIR set-up, whereas dots represent ESR data.

Conclusions

Electron magnetic resonance spectra can be successfully measured using the IR probe at cell 8. This creates a "2 for 1" experiment for spectroscopic studies in the THz range and allows the user to obtain a complete picture of magnetic excitation spectrum during the same experiment at NHMFL.

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