A New Probe for Optically Pumped NMR in NHMFL Optics Facility

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Introduction

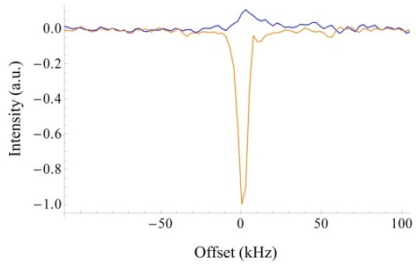
A new special purpose NMR probe has been constructed for optically pumped NMR (OPNMR) experiments using the NHMFL's Ultrafast Optics Facility in conjunction with a variety of DC magnet systems. This cryogenic probe provides both through-space and fiber optic access to the samples. The probe incorporates appropriate thermometry using a Cernox sensor, temperature control using an integrated heater, radiofrequency tuning and matching of the NMR circuit, and two-axis sample rotation capability. The probe is compatible with a He-3 cryostat for temperatures down to 300 mK and virtually all of the available magnets, including: SCM3, a 17.5 Tesla superconducting magnet, the new 25 T Split Florida-Helix magnet, and the 45 T Hybrid.

Experimental

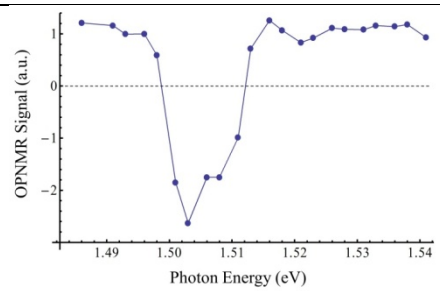
Following completion of construction and testing in August 2012, the probe was employed in preliminary OPNMR experiments in SCM3 at temperatures down to 4.2 K. The energy dependence of the OPNMR signal intensity was acquired in a single crystal of semi-insulating GaAs.

Results and Discussion

Ga-69 NMR spectra were collected with and without unpolarized CW optical excitation near the band gap of the material (1.52 eV), as shown in the figure. The optically-pumped spectrum (in orange) shows the expected enhanced emission NMR line. The photon-energy dependence of the OPNMR signal at 3.57 T exhibits a strong peak at photon energies just below the bandgap.



Thermally polarized (blue) and optically pumped (orange) ^{69}Ga NMR spectra of a semi-insulating GaAs single crystal at 3.57 T and 4.2 K (nominal temperature). Spectra were acquired following pre-saturation followed by a fixed recovery delay of 120s. The OPNMR spectrum was acquired under constant optical excitation with $\lambda = 824$ nm.



Photon-energy dependence of the ^{69}Ga OPNMR signal intensity from a semi-insulating GaAs single crystal in a 3.57 T magnetic field and an ambient temperature of 7.4 K.

Conclusions

Construction of the NHMFL OPNMR probe is complete, providing a new experimental capability at the NHMFL. This probe can be employed in any experiment requiring NMR spectra to be acquired with simultaneous optical irradiation at low temperature. However, these first results indicate significant sample heating under conditions of high power optical irradiation at low ambient helium pressure. Several possible solutions to this problem are under consideration, including (a) improved heat sinking of the optically exposed surface of the crystal and (b) immersion in superfluid He-4.

Acknowledgements

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References

[1] Kuhns, P. L. *et al. Physical Review B*, **55**, 7824-7830 (1997).
[2] Hayes, S. E.; Stanton, C. J. *Physical Review B,* **82**,085209 (2010).