Bulk Magnetization Measurement of Nuclear Spins Polarization

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Introduction

Magnetization (*M*) results from both spin and nuclear contribution where the latter part is neglected because of the small nuclear magnetic moment compared to the spin one. We tried to measure the nuclear magnetic moment by polarized neutron reflectivity (PNR) at low temperature and high magnetic field. The PNR results are compared with DC *M-H* measurement to check if *M* is fully saturated at this condition.

Experimental

PNR measures the intensity of neutron beam reflected specularly from the surface of the sample and is compared to that of the incident beam. Reflectivity is related to the depth profile of neutron scattering length density (SLD) of the sample. The neutron SLD consists of two components: nuclear and magnetic. The angular dependence of PNR can tell whether the spin dependence is coming from magnetism or nuclear polarization.

We measured magnetization of MgO single crystal by using vibrating sample magnetometer in the PPMS cryostat. Sample was treated in a non-magnetic environment to avoid external magnetic impurities.

Results and Discussion

We find that spin dependence of PNR signal shows up regardless of the orientation of *Q* with respect to magnetization (left figure). Considering that ^{25}Mg can have nuclear polarization (^{24}Mg and O does not have significant spin dependent nuclear polarization), it is 9-16 % polarized.

Figure in right shows *M-H* data that exhibit an exclusively diamagnetic response at 300 K and diamagnetic and para/ferromagnetic responses at 2 K. The magnetization value is much too small to be detected with PNR. We do not know the origin of *M*; however, Fe impurities at the level of 10-25 ppm can produce the observed effect.

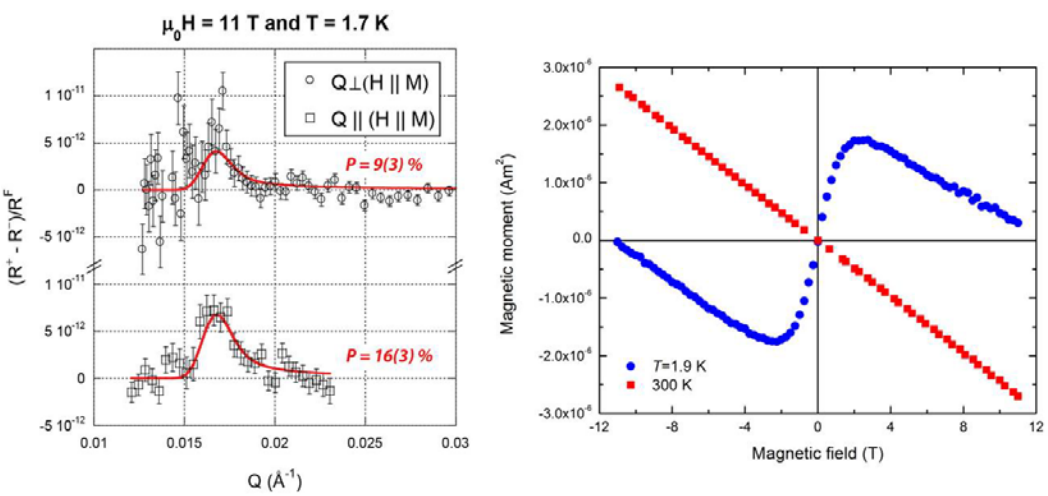

Figure 1. (Left) Spin dependence of reflectivity. (Right) *M-H* curve of MgO.

Conclusions

We observed spin dependence of the PNR from a bulk single crystal of MgO for an applied field of 11 T at 1.7 K. The spin dependence is not observed at low fields or high temperatures. At low temperatures, it does not exhibit the angular dependence required for scattering of neutrons by magnetism. Thus, the spin dependence comes from ^{25}Mg which nuclei can have nuclear polarization. The magnitude of the effect suggests a much larger value than would be expected from "brute force" polarization of nuclei at 11 T and 1.7 K.

Acknowledgements

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References

[1] M. Fitzsimmons and Jae Wook Kim, in preparation.