High-field EPR Studies of an Antiferromagnetic Fe\textsubscript{18} Wheel

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Introduction

The goal of these experiments was to look for the effect of the mixing of magnetic states in the antiferromagnetic Fe\textsubscript{18} wheel at high magnetic fields. Magnetic dipole transitions between spin multiplets having different total spin (S) quantum numbers is normally forbidden by the EPR selection rule. However, in the presence of certain symmetry breaking interactions, they can become allowed. This was demonstrated earlier for the Mn-(3×3) antiferromagnetic grid [1]. For the Fe\textsubscript{18} wheel, at high magnetic fields, the level crossings and anti-crossings are more prominent.

Experimental

Experiments were performed using a cavity perturbation technique with waveguide probes developed at UF which are compatible with the 32 mm bore resistive magnets. A vector network analyzer associated with several different sources and multipliers was used as a spectrometer.

Results and Discussion

![Figure 1: (left) Angle-dependent data obtained at 91 GHz and 1.3 K from 0° to 200° in 10° steps. The data exhibit extrema (blue) separated by 90°. In between these extrema high-field quantum oscillations (red) are observed. (right) Temperature dependence of the high field oscillations at 91 GHz.](image)

At low fields (<15 T), the cavity transmission exhibits sharp minima (inverted peaks) typical of standard EPR signals due to magnetic dipole transitions between discrete energy levels. However, at higher fields, these peaks evolve into more-or-less evenly spaced oscillations. We propose that this behavior is associated with quantum oscillations of the low-energy density of states (density of energy levels) which results in a modulation of the microwave losses in the cavity. The density of states oscillations result from a hierarchy of ground-state energy level crossings due to the large number of excited spin states with successively higher spin quantum numbers (S = 0 up to 45). Thus, the low-energy density of states periodically piles up, resulting in quantum oscillations in the susceptibility akin to de Haas-van Alphen oscillations in metals.

Acknowledgements

This work was supported by the National Science Foundation (grant nos. DMR0239481 and DMR0414809).

References