INSTRUMENTATION FOR THE SINGLE-TURN MAGNET PROJECT PART 2: FARADAY ROTATION MEASUREMENTS OF TGG AS A MEANS OF FIELD CALIBRATION

R.D. McDonald (NHMFL-LANL), P.A. Goddard (NHMFL-LANL), C.H.Mielke (NHMFL-LANL) and J. Singleton (NHMFL-LANL).

We report Faraday rotation measurements of Terbium Gallium Garnet (TGG) in pulsed magnetic field. TGG is an ideal material in which to measure Faraday rotation as a means of field calibration due to its large Verdet constant. These measurements were performed in order to ascertain the Verdet constant and field dependence of magnetization, thus calibrating the field dependence of the Faraday rotation from a given TGG crystal against the voltage induced in a coil of known radius.

The measurements were made at a temperature of 292 K in an 8 ms rise-time, 50 T short pulse magnet. A 2mm long single crystal of TGG was used for this experiment, with parallel faces perpendicular to the [111] direction. Multi-moded plastic fibers, terminated with aligned linear polarizers, were glued to the either face of the TGG so that the rotation of the angle of polarization could be measured via the transmitted intensity. The sample was arranged in the magnet with the field parallel to the optical axis, the crystal's [111] direction. A red diode laser provided illumination and a photodiode was used for detection. At 292 K TGG is a paramagnet. The large magnetic moment of Terbium (J = 3) is responsible for its large magnetic susceptibility and hence large Verdet constant. An important consideration, when using such a material to calibrate high magnetic field is whether the magnetization will saturate. Faraday rotation is proportional to magnetization, such that the rotation of polarization will tend to zero in a saturated paramagnet. Figure 1a is the rotation of the angle of polarization up to a field of 50 T, measured as oscillations in the intensity. The oscillations are not periodic in magnetic field, suggesting a significant field dependence of the magnetization. The fit to obtain the Verdet constant (V = 7.54 Deg/T mm) accounts for the change in magnetization by use of the Brillouin function (see Figure 1b). The obtained value is in good agreement with previous work [1] and suggests that TTG is a suitable material for calibrating the field of the 300 T single turn magnet facility (see the simulation in Figure 1b).

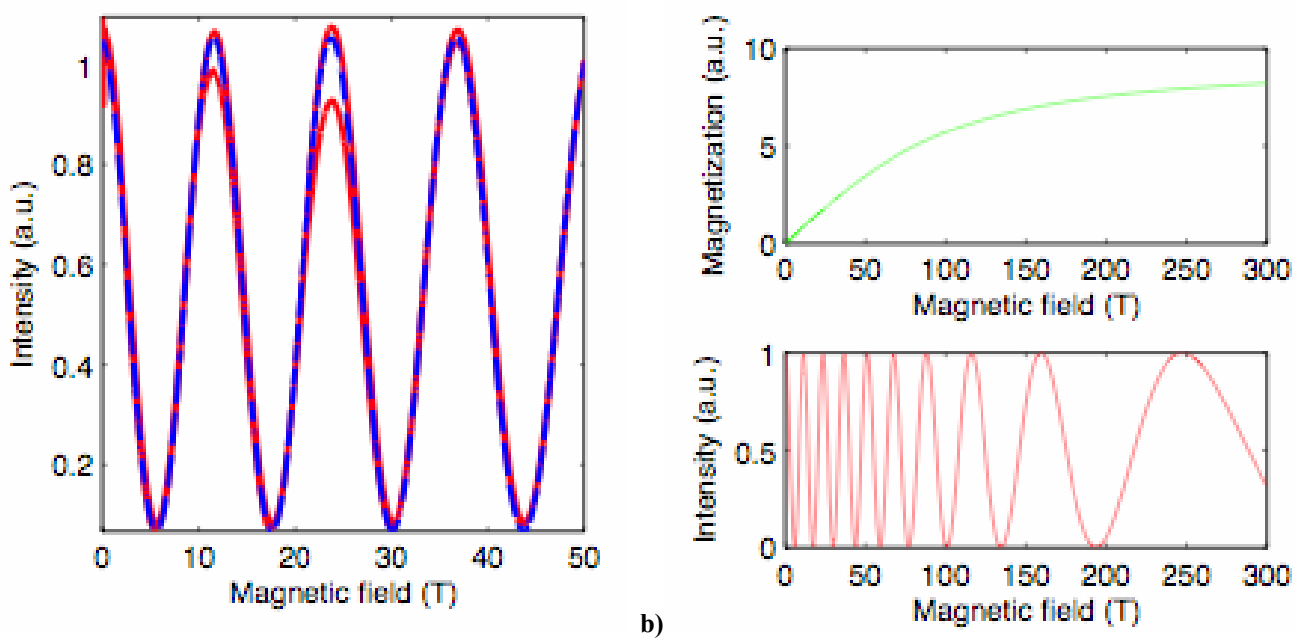

Figure 1a: The transmitted intensity as a function of magnetic field, measured (solid red line) and fitted (dashed blue line). **b:** The Brillouin function for a J = 3 system at a temperature of 292 K (top) and the predicted Faraday rotation spectrum of TGG up to a field of 300 T at 292 K (bottom)

References

[1] Barnes N.P., *et al*.,J. Opt. Soc. Am B, **9**, 1912-1915 (1992).