ESRF	**Experiment title:** X-RAY DETECTED MAGNETIC RESONANCES : A COMPARISON OF GADOLINIUM AND YTTRIUM IRON GARNETS	**Experiment number:** HE-3670
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1. DESTRUCTIVE INTERFERENCES BETWEEN MODES OF OPPOSITE HELICITIES IN GdIG

Even though yttrium iron garnet (YIG) and gadolinium iron garnet (GdIG) have identical crystal structures and nearly the same Curie Temperatures (T_C=551-556K), the replacement of the diamagnetic ($^1S_0$) Y^{3+} cations with paramagnetic ($^8S_{7/2}$) Gd^{3+} cations in the dodecahedral (24c) sites, deeply alters the magnetic properties of GdIG: this is because the Gd spins are selectively coupled by exchange interactions to the Fe spins located in the tetrahedral corrdination sites (24d). Recall that the Gd spins get fully ordered only below some ordering temperature ($T_B \approx$ 69 -100K) which is much lower than the compensation temperature (T_{CP} = 290K). It has long been known that major changes did affect the FMR spectra at the compensation point such as the inversion of the Larmor precession helicity. Incidentally, we discovered [1,2] that destructive interferences between modes of opposite helicities could affect the XDMR spectra recorded well above T_{CP}.

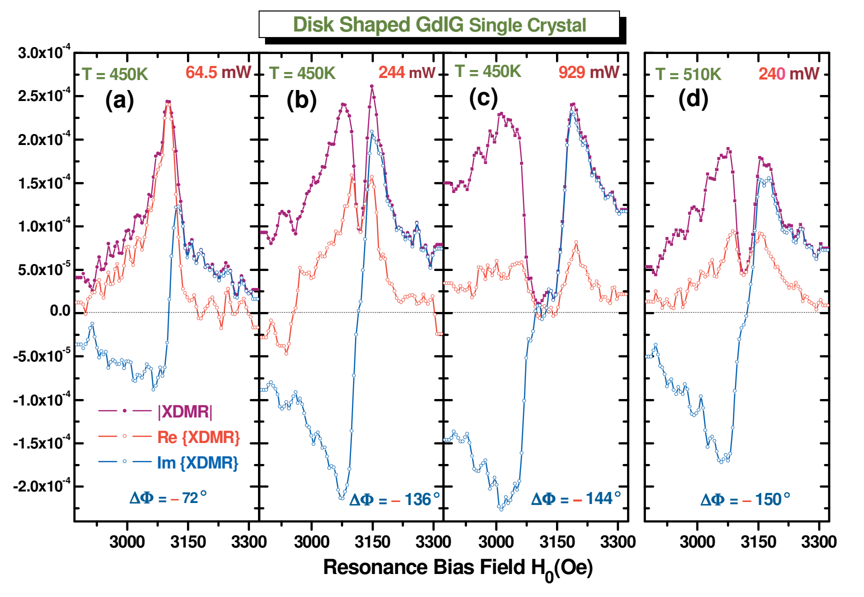


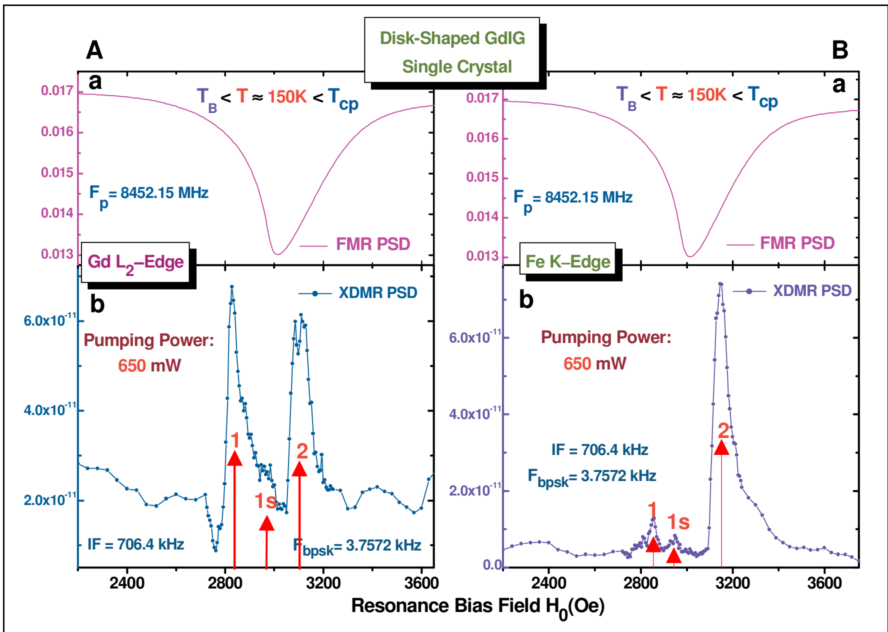
Fig. 1 Vector analyses of a whole series of XDMR spectra GdIG recorded at the Fe K-edge for T > T_{CP} . Note that a new type of saturation effect takes place at pumping powers in excess of 150 mW.

This is typically illustrated with Fig. 1 in which we reproduce vector analyses of XDMR spectra of GdIG recorded at the Fe K-edge for T> T_{CP}. Everything looks like the XDMR spectra would undergo a peculiar saturation effect at pumping powers in excess of 150 mW. Most characteristic is a strong decrease of the Real (absorptive) part of the complex XDMR spectrum, whereas the modulus and PSD spectra get heavily dominated by the Imagninary (dispersive) part of the complex XDMR spectrum. As confirmed elsewhere by simulations, this is exactly what happens in case of a destructive interference between two non-uniform modes of unequal intensity, opposite precession helicities and wavevectors $\pm$**k**. This looks consistent with the Suhl's 2nd order instability process which refers to a nonlinear four magnon scattering process

In which two unform magnons ($\mathbf{k} = 0$) were annihilated, two nonuniform magnons ($\pm\mathbf{k}$) being simultaneously created {3,4}. Whereas Suhl's theory was developed in the framework of *exchange* spin waves, it should be kept in mind that XDMR spectra recorded at the Fe K-edge are concerned with the precession dynamics of *orbital* magnetization components that experience dipole–dipole but *not* exchange interactions.

2. UNFORESEEN LINE SPLITTINGS IN THE XDMR SPECTRA RECORDED BELOW T_{CP}

It is not yet fully understood why no similar destructive interference effect could be detected below T_{CP}. There is however a new effect that was observed at low temperature for: $T_B \leq T \approx 150K < T_{CP}$ and which manifests itself as a splitting of the XDMR spectra recorded either at the Gd L_2 or Fe K edges [5].



Figs. 2 Comparison of the FMR (a) and XDMR (b) PSD spectra recorded either at the Gd L_2 –edge (A) and at the Fe K-edge. All spectra were recorded in the transverse detection geometry (TRD) using a superheterodyne readout electronics.

This is nicely illustrated with Fig. 2A(b) in which the XDMR PSD spectrum recorded at the Gd L_2-edge splits into two well resolved, narrow lines of nearly equal intensities (labeled 1 and 2). In contrast, the FMR PSD spectrum which was measured simultaneously is much broader. Let us emphasize that the XDMR spectrum recorded at the Fe K-edge under strictly identical conditions is also split but it is now strongly dominated by a sharp line peaking at high field and labeled 2 in Fig 2B(b). Furthermore, a careful vector analysis revealed that there was a phase difference of nearly 180° between the weak and strong signals respectively labeled 1 and 2 in Fig. 2B(b). In contrast, there is no appreciable phase difference between the split lines of the XDMR spectrum recorded at the Gd L_2-edge [5].

A tentative interpretation of these results is proposed in reference [5]. It is our idea that , slightly above T_B, the precession of the Gd spins located in the dodecahedral (24c) sites cannot be described as a uniform mode. This is due to site-selective exchange interactions which develop between the Gd spins and the spins located at the tetrahedrally coordinated iron sites (24d). As proved by ^{57}Fe NMR, the corresponding exchange integral (J_{dc}) is nevertheless considerably weaker than the exchange integral (J_{ad}) between the octahedral a-sites and tetrahedral d-sites of iron which are strongly antiferromagnetically coupled. The net result may well be a splitting in two resolved resonant modes with unequal anisotropy fields. One may envisage that the narrow line labeled 1 which is slightly more intense could be assigned to Gd spins exchange coupled with iron spins at d-sites. One should also keep in mind that XDMR spectra recorded at the K-edge systematically benefit of some *site selectivity* in favor of the thetrahedral d-sites: it is our interpretation that this is again the weak site-selective exchange interaction (J_{dc}) with the Gd spins which is at the origin of a splitting of the uniform resonant mode involving the strongly coupled spins precessing at the octahedral a-sites and tetrahedral d-sites of iron. Spin-orbit interactions would result in a similar splitting of the uniform mode of precession of the orbital magnetization components. In short, the very weak line labeled 1 could be assigned to a weak contribution of a mode involving the precession of uncoupled orbital magnetization components located at the octahedral a-site of iron, the strong line labeled 2 being unambiguously assigned to magnetization components located at the d-sites and which would be strongly coupled to the Gd c-sites.

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