ESRF	**Experiment title:** Nanosecond Resolved X-ray Magnetic Circular Dicrhoism	**Experiment number:** HE-500
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Report:

Nanosecond-resolved XMCD experiments are currently carried out at ID24, using either a pump-probe or a real time approach, allowing dynamic magnetic measurements to be performed in an element selective way. A detailed study was done on the magnetisation dynamics of a $GdCo_{2.5}$ amorphous thin film, allowing us to obtain a set of important parameters as well as simple models to describe the magnetisation switching of such a system. For this dynamical analysis, a pulse of magnetic field in the nanosecond range was applied in the plane of the sample (the easy axis of magnetisation), while a biasing static field in the opposite sense ensures that the sample magnetisation will back to its initial condition after the pulse. The magnetisation is then probed by XMCD, with the x-ray beam in grazing incidence onto the film.

In this study, three parameters were varied: sample temperature, amplitude of bias field and amplitude of pulsed field. As the reversal of magnetisation is normally a thermally activated process, the temperature dependence has a crucial role in determining important sample parameters. The Néel-Brown model [1] states that a magnetic material exposed to a driving magnetic field will reverse its magnetisation as:

$$\tau = \tau_0 e^{\left(\frac{E_B}{kT}\right)}$$

where the τ_0 is the spin-lattice relaxation time (usually in the 10^{-9}s range) and the E_B is the barrier energy related to the internal and external field applied to the sample. This model is valid only when the external applied field is not far from the coercive static field, that is about 10^{-4} T in the present case.

Figure 1 shows the dynamic response for various sample temperatures, for applied external fields higher than the coercive field H_c. We can see that the temperature has an opposite effect as the one we could expect for thermally activated process. Two mechanisms explains this behaviour: first the applied field being very higher than H_c, we have mostly a viscous regime for the magnetisation reversal, where Néel-Brown model is no longer valid. Second, the magnetic compensation temperature is about 450K, and as we approach it, the anisotropy increases, as well as the coercive field H_c. It explains the time constant increase from 52ns (80K) to 102ns (253K), as the temperature approaches T_{comp}.

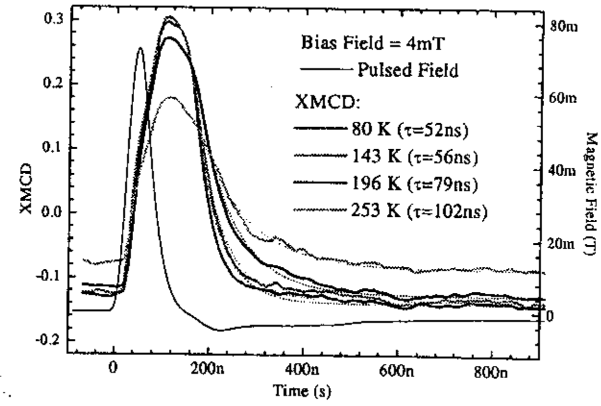

Figure 1: Time response of a GdCo2.5 amorphous film at the Gd L3 edge for various sample temperatures.

From measurements of magnetisation as a function of the pulsed field, we have deduced the dynamical coercive field of 10^{-2} T for a 30ns magnetic pulse width, that is about 100 times bigger than the static one. An increase in the dynamical coercive field is always observed for all magnetic materials, but a factor of 100 is quite unexpected. Other magnetically soft materials must be analysed for comparison.

The measurements with constant magnetic pulse and temperature for various bias field, has confirmed a viscous dominated regime. The time constant for reversing magnetisation varies inversely to the applied field, as one can see from figure 2a. The firsts steps of the magnetisation reversal after the pulse, are dominated by domain nucleation. After a certain quantity of nuclei formed, it becomes more energetically favourable to propagate the domain walls until the formation of a single domain in the whole sample. It has a characteristic exponential decay inversely related to the driving force, the applied field.

The figure 2b was obtained from these exponential decays, where we can observe a very good agreement with a simple linear fit. Extrapolation for the long times leads to the 'static' coercive field of 10^{-4} T. Also the constant that appears in the fitting equation can be directly related to the τ_0, that is 3.8 10^{-10} for this sample.

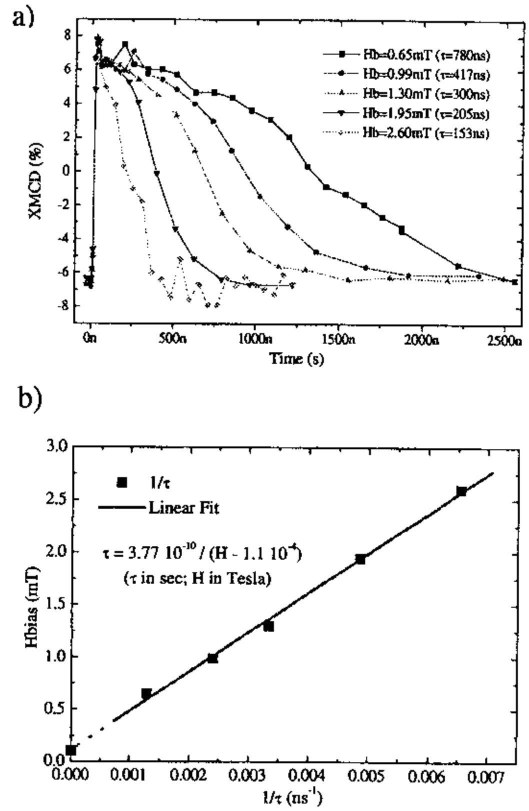

Figure 2: a) magnetisation reversal for various bias fields with temperature and pulsed field constants; b) linear fit obtained from exponential decays of a).

[1] L.Néel, *Ann. Geophys.*, **5**, 99, 1949.