XMaS the UK-CRG	**Experiment title:** Magnetic structure refinement of the 3q phases of neodymium metal by x-ray resonant exchange scattering.	**Experiment number**: 28-01-85
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Report:

Neodymium exhibits a number of magnetic structures below its initial Néel temperature of 19.9K. Following our earlier work on the 2**q** phase, we have extended our survey of the magnetic structures of neodymium and of the resonant response of the magnetic scattering cross section in this metal to the 3**q** phase. The aims of this experiment were as follows:

(i) To perform magnetic structure refinements of the 3**q** phases which are known to occur in the temperature range 6.0-8.3K. This involves the collation of a large number of integrated intensities using X-ray Resonant Exchange Scattering close to the L_{II} and L_{III} absorption edges (E= 6.722 keV and 6.208 keV respectively).

(ii) To measure the energy and polarisation dependence of the resonant scattering cross section in the 3**q** phase.

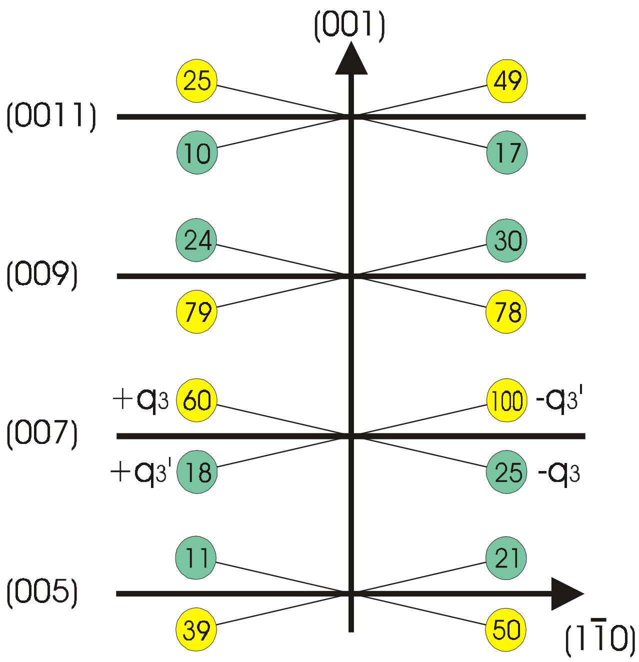
(iii) To investigate the c-axis splitting of the modulation vector ($\mathbf{q}_3$) associated with the moments on the cubic sites (Forgan et al. J. Magn. Magn. Mater. **104-107** 913 (1992)) in the high temperature phase.

(iv) If time and cryostat permitted, to perform similar measurements in the low temperature 4**q** phase.

Many of the objectives set out above have been achieved although not all were possible in the time available, due to failure of the cryostat heater and problems with the phi circle mounting.

Data has been collected that will enable us to perform magnetic structure refinements of the moments associated with the wavevector modulations $\mathbf{q}_{1;2}$ and $\mathbf{q}_3$ at 6K. It is expected that the structure associated with $\mathbf{q}_{1;2}$ will bear a marked resemblance to that of the 2**q** phase at 10K, although the wavelength of the modulation itself is slightly longer. Comparisons between magnetic x-ray and neutron scattering results have previously indicated that the scattering from the moments on the cubic sites appears to be weaker in the case of x-ray scattering (Watson et al. Phys. Rev. **B 57** R8095 (1998)). A possible reason for this is that a dipole resonance at an L edge does not directly sample the 4f moments but the polarisation of the 5d electron conduction band. A weaker f-d exchange on the cubic sites would therefore produce values of ordered moment that were apparently weaker. The structure refinements that we have carried out at 6K will provide two additional measurements of the comparative strengths of the scattering in this respect. The first of these consists of a comparison between cubic and hexagonal site moments with the $\mathbf{q}_3$ modulation; the second is the comparison of the relative magnitudes of the hexagonal moments with the $\mathbf{q}_2$ modulation and the cubic site moments with the $\mathbf{q}_3$ modulation.

At the high temperature end of the 3**q** phase the wavevector $\mathbf{q}_3$ acquires a component along the c-axis and moves out of the basal plane. In neutron scattering measurements, this produces an apparent splitting of the magnetic satellite due to domain averaging. In the case of x-rays, where it has always been the case that we have been able to scatter from a single magnetic domain, we would expect to see only a pair of magnetic satellites (*either* $\pm\mathbf{q}_3$ or $\pm\mathbf{q}_3'$) for this modulation.



Nevertheless, we have observed four satellites around each reciprocal lattice point. This provides evidence that the ordering at this temperature (7.5K) is in fact a 4**q** phase in its own right. Although it is still possible that domain averaging is occurring, we also note that the distribution of measured satellite intensities seems to be more due to a q-dependence than to different occupations of supposedly separate domains containing $\mathbf{q}_3$ and $\mathbf{q}_3'$. It is hoped that the result of the structure refinement itself will provide a conclusive answer to this question.

We have also produced measurements of the energy dependence of the resonant reponse in this phase at the L_{III} edge using polarisation analysis. As may be expected, the response of the moments associated with the wavevectors $\pm\mathbf{q}_3$ (i.e. mainly those at the cubic sites) shows fairly similar behaviour to that associated with the wavevectors $\pm\mathbf{q}_{1;2}$. A plot of the response in π-π mode at the (005)-$\mathbf{q}_3$ shows quadrupolar and dipolar resposes at 6.206 keV and 6.214 keV respectively.