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Names and affiliations of applicants (*indicates experimentalists):

M. Loewenhaupt*, A. Schneidewind*, Th. Reif*
Institut für Angewandte Physik, TU Dresden

A. Hiess*, S. Kramp* ILL Grenoble

W. Neubeck*, C. Vettier* ESRF

Report:

$NdCu_2$ crystallizing in the orthorhombic $CeCu_2$-structure is known for its complicated magnetic phase diagrams, including commensurate, incommensurate and also intermediate antiferromagnetic and ferromagnetic magnetic structures in dependence of in temperature and magnetic field. From neutron diffraction magnetic peaks indicating three antiferromagnetic phases are known: AF1 ($T \leq 4.0$ K) with the fundamental wave vector τ = (0.6 0 0); AF2 (4.0 K $\leq T \leq$ 4.2 K) with $\tau' = \tau + \epsilon$ where τ is the same wave vector as in AF1 and ϵ = (0.003 0.003 0); AF3 (4.2 K $\leq T \leq T_N$ = 6.5 K) with $\tau^* =$ **(0.62** 0.044 0) [1].
Using the different properties of synchrotron x-ray scattering compared to neutron diffraction we expected to get some additional informations about the magnetic structure transitions and the nature of their behaviour.

Experimental

We used a large $NdCu_2$- single crystal made by Czochralski method, which was already used to get the neutron diffraction data because of some problems with our prepared sample. It was polished mechanically directly before the experiment. The scattering surface was orientated perpendicular to the a-axis.
The main experimental difficulty presented temperature measurement and stabilitization. At the beginning we could not reach any magnetically ordered state (T_N = 6.5K) though the temperature reading indicated T = 1.8 K. However, by adding a considerable amount of He exchange gas we were able to reach the low temperature phase AFl. But there was still a discrepancy between the sample temperature and the controller read out. Furthermore, it was difficult to stabilize the temperature and to run the experiment in well defined temperature steps (AT = 0.03 K was planned). Thus, especially the measurements in the AF2 phase (existing in a temperature range of only 0.2 K) could not be done in a reproducible way.

Checking the occurence of resonance enhancement at the L_{III}-Nd- edge some resonant magnetic signal was found. But a high fluorescence level decreased the peak-underground ratio. We can not exclude the origin in the existence of a remaining unmagnetic layer on the surface.

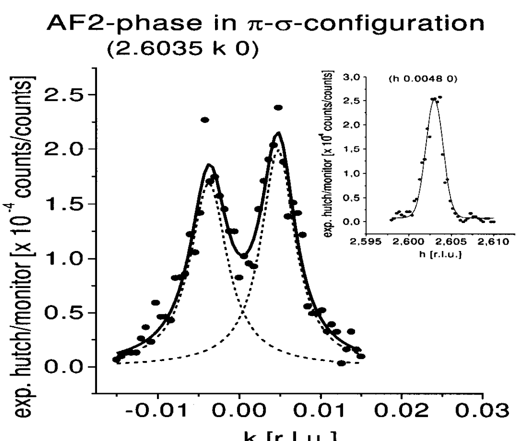
Results

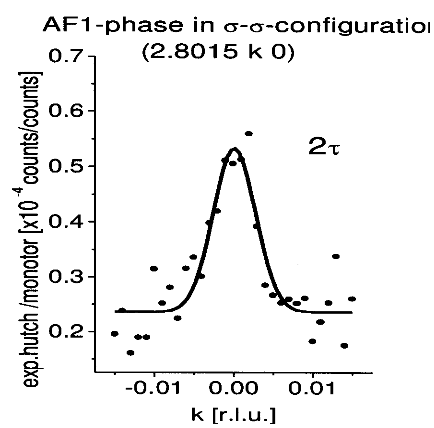
Because of high photon intensities and excellent q-resolution of the instrument we got very good results in spite of the named problems. Scattering in the nonresonant regime and using polarization analysis (LiF (220), pol arization 0.997) reflections of all magnetic phases AFl, AF2 and AF3 were observed at the expected positions, for AFl by peaks up to the fifth, AF2 to the third harmonics. It is remarkable that the neutron scattering data of the AF2 phase with its huge magnetic unit cell of approximately 300a x 300b x c (1300 Å x 2100 Å x 7.4 Å) are reproduced by x-ray scattering. Both methods detect quite different regions of the sample: neutrons average over the whole bulk while x-rays see only the region from the surface into the bulk limited by the penetration depth.

At the positions of τ' satellite in AF2 we could separate the splitting of the τ'- reflection (see left fig.), what was not possible with neutrons. The values of ϵ do not exact agree with the calculated from higher harmonics neutron data (ϵ_a = 0.0031 = 0.000707 $\AA^{-1}$, ϵ_b = 0.0042 = 0.00006 $\AA^{-1}$ >> $\epsilon_{b,neutr}$ = 0.003).

In addition we observed in a-a-configuration in the AFl-phase reflections at positions in the reciprocal space that are related to a wave vector of 2τ. They could originate from a modulation of the lattice spacing due to magneto-elastic coupling. The intensity ratio of these reflections to the (200) Bragg peak is only 10^{-8} (see right fig.).

To test working in resonant regime we had at least a first short overview using an optimal prepared $DyCu_2$-sample and found resonant magnetic reflections one decade higher then nonresonant measured.





Conclusions

We had shown, that synchrotron x-ray investigation is useable to improve neutron results on magnetic structures of $NdCu_2$. Better sample preparation and improved cryogenic handling should allow to get excellent results, also on other RCu_2-compounds.
Analyzing of the 2τ- problem could be helpful to learn something about coupling of magnetism and lattice in our compounds.

References

[1] Loewenhaupt, M. et al., Z. Phys. **B 101** (1996) 499.