ESRF

Experiment title:

Nuclear Resonant Small Angle Scattering

Experiment number:

HC-376

Beamline:

ID18

Date of Experiment:

from: 9-2-96 to: 15-2-96

from: 9-6-96 to: 18-6-96

Date of Report:

15-8-96

Shifts:

HYB 4.5+4.5

16B 6

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Received at ESRF :

19 AUG 1996

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Report:

I) Small Angle Scattering

In a first experiment, Small Angle Scattering (SAS) at rather large angles (0.1 - 1°) was determined by using aligned circular diaphragms. A SAS model substance, $^{57}Fe(OH)_3$ particles of about 3 nm diameter in a polymer network, was studied, which showed the expected X-ray SAS. However no nuclear resonant SAS, i.e. SAS with the characteristic time delay, could be observed.

Most of the beamtime was therefore devoted to a preliminary study of critical fluctuations in $^{57}FeBO_3$ at the Néel point (75.2° C). This system is of high interest because critical nuclear resonant scattering can be studied at easily accessible temperatures /1/ and because it is proposed as a single line Mössbauer source at synchrotrons stations /2/.

SAS was searched for at rather small angles (4- 200") by using a Si(ll1) reflection to determine the angular deviation from the direct beam. The sensitivity of the setup was tested by measuring the pure nuclear SAS from non-magnetized ^{57}Fe foils, as discovered during the commissioning time at ID18 /3/. However, from a perfect single crystal platelet of 57 $FeBO_3$ of 50 μm thickness at the Néel transition no comparable nuclear SAS could be observed.

II) Nuclear Bragg Reflection

For that reason, the critical fluctuations were searched for by a different experimental method. Rocking curves of Bragg geometry reflections of the perfect single crystal $^{57}FeBO_3$ were measured in the vicinity of the Néel temperature. Comparison of the electronic (prompt) and the nuclear (delayed) scattering at different reflections should yield information about the magnetic order at the transition point. Especially the pure nuclear reflections, which exist only due to antiferromagnetic order and vanish above the Néel temperature, should distinctly reflect details of the breakdown of magnetic order.

The rocking curves of the X-ray allowed reflection $^{57}FeBO_3(222)$ had a halfwidth of about 2“ for the electronic scattering, independent on temperature around Néel. This proves, that the crystal lattice was not influenced at the Néel point by possible magnetostrictive effects.

By contrast, the rocking curve halfwidths of the pure nuclear reflection $^{57}FeBO_3(111)$ showed a very pronounced temperature dependence, rising from a value of about 10” at 1K below Néel to more than 30” at the Néel point. This rise took place within less than 0.1 K. When the tryst al was placed in a weak permanent magnetic field, the rise was smeared out over 0.3K, in accordance with a broadening of the transition regime.

These first findings need to be substantiated by further measurements, at different reflections and reflection geometries. Especially the question, whether the pronounced rise of the rocking curve width is due to critical fluctuations or to the break-down of the nuclear scattering (transition from dynamical to kinematical scattering) needs further experimental studies and theoretical analysis.

/1/ A. I. Chumakov, M. V. Zelepukhin, G. V. Smirnov, U.van Bürck, R. Rüffer, R. Hollatz, H. D. Rüter and E. Gerdau, Phys. Rev. B41,9545 (1990)
/2/ G.V.Smirnov, U.van Bürck, A.I.Chumakov, A.Q.R.Baron and R. Rüffer, to be submitted to Phys. Rev. B
/3/ Yu.V.Shvyd’ko, A.I.Chumakov, E. Gerdau, R. Rüffer, A. Q. R. Baron, A. Bernhard and J.Metge, submitted to Phys.Rev.B