



Experiment title:
Critical Fluctuations in $^{57}\text{FeBO}_3$ at the Néel Point

Experiment number:

HE-185

Beamline:

ID 18

Date of Experiment:

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Date of Report:

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Shifts:

2/3 fill: 15

Local contact(s):

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Report:

The experiment was aimed at studying the breakdown of antiferromagnetic spin order in $^{57}\text{FeBO}_3$ single crystals at the Néel temperature by measuring rocking curves of pure nuclear Bragg reflections. Such Bragg reflections originate exclusively from antiferromagnetic order, and their widths and intensities are expected to be a sensitive measure for the spatial and temporal extension of antiferromagnetic order.

The pure nuclear reflection (333) of an almost perfect single crystal platelet of $^{57}\text{FeBO}_3$ was selected for the experiment. The crystal was mounted in a small oven as previously used for related studies [1-3]. Since this oven had only a limited temperature stability of about 0.03 K, the magnetic phase transition at the Néel point (75.2 °C) was smoothed by the application of a weak external magnetic field. The measurements were performed in the 2/3 fill mode without time gating. In this case the nuclear reflection can be revealed only because of the extremely high suppression of the non-resonant reflection in the order of 10^{-10} [3]. At each temperature around the Néel point, wide range and narrow range rocking curves of the reflection were measured.

For the evaluation of the measurements theoretical models and calculations are presently developed. The dynamical theory predicts a narrowing of the Bragg reflection rocking curves with decreasing susceptibility (determined by the scattering amplitude). In parallel, however, critical spin fluctuations cause an effective reduction of the characteristic scattering volumes, resulting in a broadening of the rocking curves. It was intended to exploit this effect for probing the fluctuations. In our case, however, the decrease of the nuclear susceptibility is of special nature. The initial four lines of the Mössbauer reflection spectrum at room temperature collapse near the Néel point into a nearly-single-line with finally vanishing amplitude. Since this process [4] relies on the geometrical antiphase relation between the scattering amplitudes of the two ^{57}Fe -nuclei in the unit cell, it depends on the angular deviation from the exact Bragg position, and might also lead to an effective broadening of the rocking curves.

Characteristic wide range rocking curves at about -2, 0 and +0.7 °C with respect to the Néel temperature are shown in Figs.1a-1c, respectively. In this region the reflection peak intensity falls from 2000/s to 2/s, and the width of the reflection changes in a characteristic way. Details of this behaviour still have to be evaluated. It is obvious that in the present measurements a background of 1/s conceals any possibly far reaching wings of the Bragg reflection. However, just the behaviour of these wings might be decisive for the interpretation of the rocking curves. Therefore future measurements have to be performed in a timing mode, where the background in the delayed window is much lower, characteristically about 0.02/s.

Besides the rocking curves, first tests of an angular exit analysis were performed. In this method the crystal under study is either at Bragg position or set off Bragg by an angle α , and the angular dependence of the reflected radiation is scanned by means of another perfect crystal Bragg reflection. This analysis allows to distinguish a main peak displaced by 2α , a pseudo peak displaced by α and possibly a diffusive peak without displacement $\alpha/5$. An example for a strong diffusive peak probably due to a destroyed surface is shown in Fig.2a, where an exit analysis was performed for the reflection (111) of a Si crystal set at $\alpha=60^\circ$. Figs.2b and 2c show the corresponding exit analyses for the X-ray allowed reflection (222) of our $^{57}\text{FeBO}_3$ crystal under study, measured below and above the Néel point at about the same temperatures as the rocking curves of Figs.1a and 1c, respectively. No sign of critical fluctuations was observed in this test.

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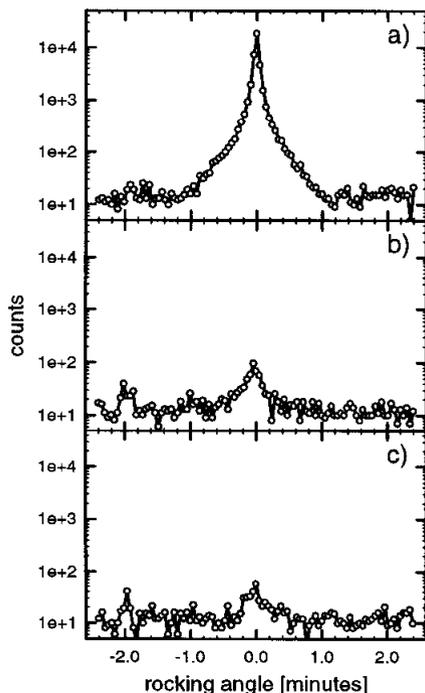


Fig.1 Rocking curves of $^{57}\text{FeBO}_3(333)$ at different temperatures below (a), at (b) and above (c) T_N .

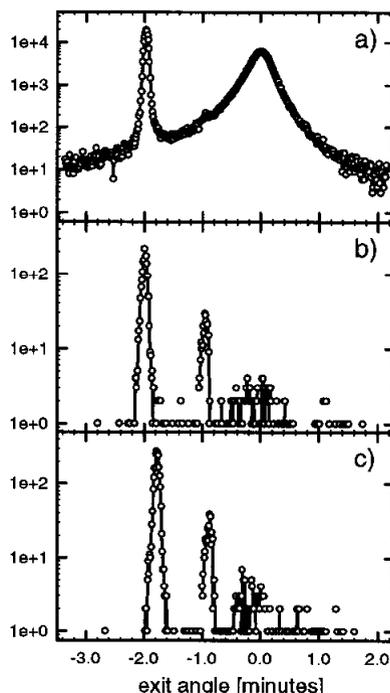


Fig.2 Exit analyses of Si(111) (a) and of $^{57}\text{FeBO}_3(222)$ at two temperatures below (b) and above (c) T_N .