	Experiment title: High-pressure nuclear forward scattering on GdSb	Experiment number: HE-2155
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Report:

GdSb is an antiferromagnetic insulator which crystallizes in the NaCl structure. The magentic moment of the Gd^{3+} ions is due to the partially filled 4f-electron shell forming the electron configuration $^8S_{7/2}$, i.e. the total magnetic moment is a spin-only moment without contributions from orbital moments. On the other hand, the electron shells of the Sb ions do not carry a magentic moment. Due to the simple crystal structure and the spin-only moment of Gd, GdSb can be regarded as model system for Heisenberg magnetism. Allthough the Sb ions do not participate in magnetic ordering, magnetic ordering can be detected at the Sb sites via the transferred magnetic hyperfine fields.

The initial aim of this proposal was to study the transferred magnetic hyperfine fields on the Sb site as function of temperature and pressure using nuclear forward scattering at the ^{121}Sb resonance (37.13 keV) [1]. GdSb is an type-II antiferromagent and hence the transferred hyperfine field on the Sb cancel out each other in first order. However, hyperfine interactions should be as second order effects and especially a possible transition from an antiferromagnetic phase to a ferromagnetic phase.

After setting up the high-resolution back-scattering monochromator and the detector we found that the countrate for nuclear forward scattering was about 6 Hz with an electronic background in the order of 0.8 Hz together with a beam size of $0.6 \cdot 1$ mm^2. However, the diameter of the sample in a diamond anvil high-pressure cell is 0.2 mm. In transmission geometry, this would result in a reduction of countrate by a factor of 10. Hence it was not

possible to carry out high-pressure experiments since no focussing is availlable in the present set-up for the high-resolution monochromator in backscattering geometry. Therefore, the originally proposed experiment would have been too time-demanding and we decided to study the magnetic properties of MnSb at low temperature instead. MnSb is a ferromagnetic semiconductor with one of the largest transferred hyperfine fields ever observed for an Sb compound. In addtion, MnSb received special attention because of the magnetoresistive swith effect found in MnSb/GaAs films and its possible application for data-storage devices [2]. The powdered sample was glued to a kapton foil and subsequently mounted in a closed-cycle cryostat. We recorded a time spectrum of MnSb at a temperature of 15 K. The actual counting time was about 4 hours.

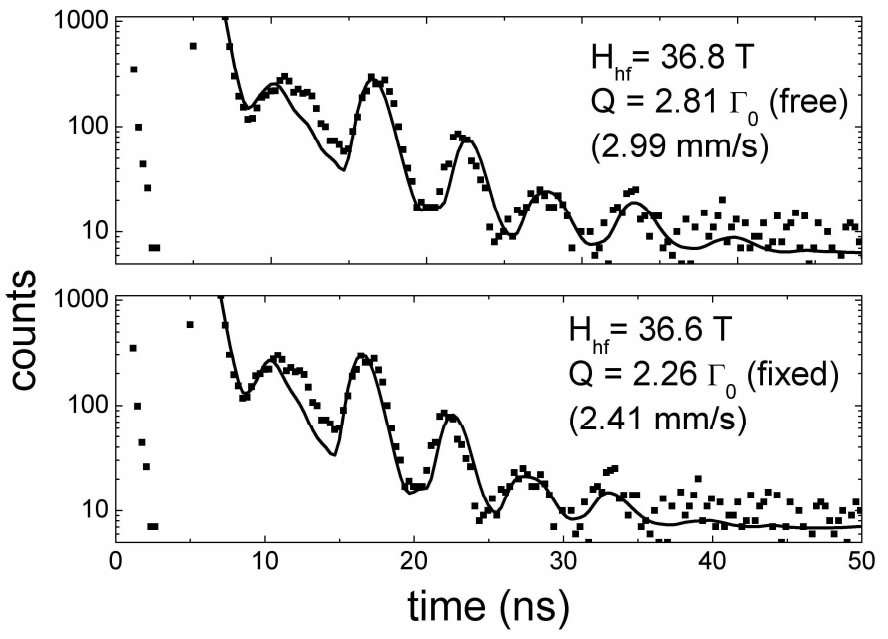

Fig. 1: ^{121}Sb Nuclear forward scattering spectra on MnSb at 15 K. The fits were carried out in two ways; with the value of the quadrupole splitting being fixed (bottom) and as free fitting parameter (top).

The hyperfine parameters of MnSb are well known from nuclear magnetic resonance spectroscopy. The results reported in [3] are H_{hf} = 35.26 T and Q = 2.26 Γ_0. When analyzing the data we found that the main contribution to the oberved beating is due to magnetic hyperfine splitting. Therefore, we performed the data analysis in two ways: Once we kept the quadrupole splitting fixed to the literature value, the other time we used it as a fitting parameter. The results are shown in Fig. 1. In both cases the calculated time spectra describe the observed data very well. The fit magnetic hyperfine fields H_{hf} = 36.8 T and H_{hf} = 36.6 T agree with each other better than 1 %. Both values from the present study at 15 K are lower than the H_{hf} = 35.26 T determined by nuclear magnetic resonance [2] at 273 K. Between 12 ns and 15 ns there is a slight disagreement between the experimental data and the calculated time spectrum. This disagreement could be due to sample texture. This is very likely in the present case since powders of materials with hexagonal structure like MnSb have a strong tendency to show some preferred orientation.

References:

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[2] H. Akinaga, J. Magn. Magn. Mat. 239, 145 (2002)
[3] A. Tsujimura, T. Hihara, Y. Koi, J. Phys. Soc. Japan 17, 1078 (1962)