ESRF	**Experiment title:** Inelastic nuclear resonant *scattering* from ^{57}*Fe single crystals*	**Experiment number:** HC369
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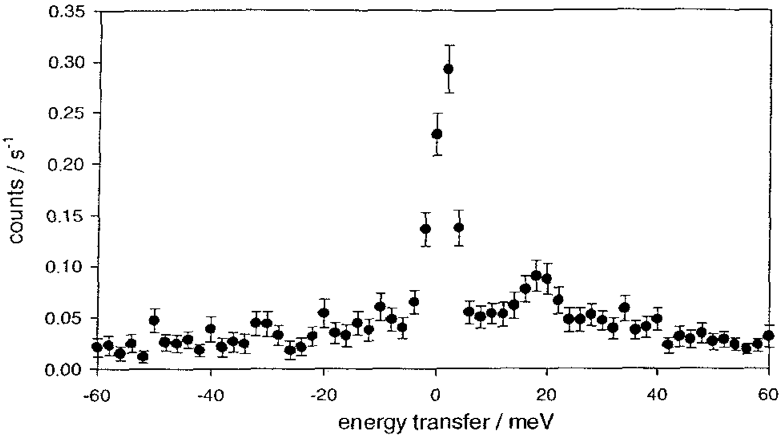
Report:

In recent experiments [1,2,3] it has been demonstrated that nuclear resonant scattering may be used to perform inelastic measurements in order to determine the phonon density of states (DOS). In our experiment we tried to show that this method may also be used to measure single phonons and in this way obtain a dispersion relation. This means that instead of doing an incoherent scattering experiment based on the internal conversion yielding fluorescence radiation we use the **coherent** scattering channel. As most promising systems to do this study we chose a-Fe and $FeBO_3$, both highly enriched in ^{57}Fe. The a-Fe crystal was grown in our laboratory by recrystallization, the $FeBO_3$ was available on the nuclear resonant beamline ID18.

To measure a phonon-spectrum the high resolution nested monochromator[4] is scanned near the energy of the resonance (14.4 keV). In the case of elastic scattering resonant quanta, identified by there time delay, are observed only when the incident energy coincides with the resonance. In case of inelastic scattering the resonance is excited also when the incident energy differs by some meV from the resonance. This difference is then compensated by phonon creation or annihilation and delayed quanta are observed.



The figure shows the dynamic structure factor of the $FeB0_3$ crystal, which proofed to give higher inelastic intensity, measured at a momentum transfer of q = (10.3,10.3,10.3) in reduced units. While a peak at the position expected[5] (ΔE = 20 meV) is visible at the energy gain side of the spectrum, the corresponding peak on the loss side (ΔE = -20 meV) is very weak. This may be due to the insufficient statistics, which makes it difficult to extract the peak reliably from the background. Due to the detailed balance factor the intensity of the „loss-peak“ is reduced by a factor 2.2 compared to the ‚gain-peak“. The peak is slightly broader (6.5 meV) then the instrumental resolution (5.5 meV) due to smearing effects of the relatively poor q-resolution. The background is mainly due to incoherent scattering, caused by internal conversion, isotope incoherence and spin incoherence. Only part of it could be reduced by absorbing most of the 6.4 keV fluorescence radiation with a thin Al-foil. An attempt to discriminate the fluorescence radiation via the detectors energy-threshold failed due to the low energy resolution of the fast APD-detectors.

The peak at 20 meV is interpreted as a longitudinal acoustic phonon. A second spectrum taken at the zone center - were this phonon should not be visible - was dominated by the huge elastic intensity of the bragg-peak, so that the inelastic intensity was completely masked by the wings of the elastic one. However, there is an extra intensity on the energy-gain side of the spectrum, i.e. the peak shows some asymmetry. Whether this is due to excitations in the sample or has instrumental origins remains to be determined. A third position at the Brillouin-zone boundary could not be measured due to problems of the synchrotron.

References:

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2: W. Sturhahn et al., Phys.Rev.Lett. 74, 3832, (1995)
3: A.I. Chumakov et al., Phys.Rev.B 54, R9596 (1996)
4: T. Ishikawa et al Rev.Sci.Instrum. 63, 1015 (1992)
5: AI. Chumakov, privat communication