ESRF	**Experiment title:** Studies on dynamics in phase change materials using nuclear inelastic scattering on 125-Te at 35.5 keV	**Experiment number:** HS-3563
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Report:

In our experiment we observed nuclear resonant scattering from ^{125}Te at 35.49 keV. To our knowledge this has been the first observation of nuclear resonant forward scattering (NFS) from ^{125}Te and also the first dynamical studies on Te compounds using nuclear inelastic scattering (NIS). Tellurium is a constituent of many interesting compounds that are of current interest, notably $Ge_xSb_yTe_z$ phase change materials used for rewriteable data storage devices, many thermoelectric materials, and more recently, iron-tellurium based parent compounds of superconducting materials. Here, a NFS spectrum from Te metal and nuclear inelastic studies on Sb_2Te_3 and on amorphous and crystalline $GeSb_2Te_4$ have been performed. The studies were carried out using a sapphire Bragg backscattering monochromator[1] using the $(20\,6\,\overline{26}\,2)$ reflection in Al_2O_3. At a crystal temperature of $T_0 = 206.22(70)$ K, the temperature corresponds to the transition energy of the ^{125}Te nuclear resonance of $E_0 = 35.493123(70)$ keV.

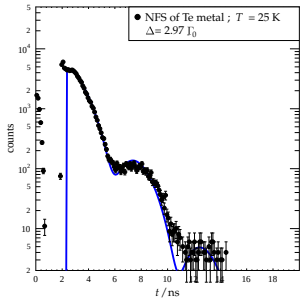

Fig. 1: Time spectrum of NFS from Te metal at a sample temperature of 25 K, open symbols, and the data fit using the theory of NFS with the program MOTIF, solid line. The quadrupole splitting is given in values of the natural linewidth $\gamma_0 = 0.313\,\mu$eV of the nuclear transition. The ^{125}Te lifetime is determined to be 2.1 ns.

To measure the NFS spectrum in Te metal, shown in Fig. 1, the temperature was stabilized at T_0 and the delayed quanta were counted.

Counting could start as early as 2 ns after the prompt synchrotron pulse due to a recently developped APD array detector system and fast electronics.
To perform the energy scans to collect the nuclear inelastic scattering (NIS) spectra the energy of the reflected radiation is modulated by changing the temperature of the sapphire crystal around T_0. The variation in the backscattered photon energy is -114 meV/K. The NIS spectrum of Sb_2Te_3 at about 25 K and the experimental resolution function from the NFS signal are shown in Fig. 2. The achieved resolution of the monochromator is $\Delta E = 7.5$ meV.

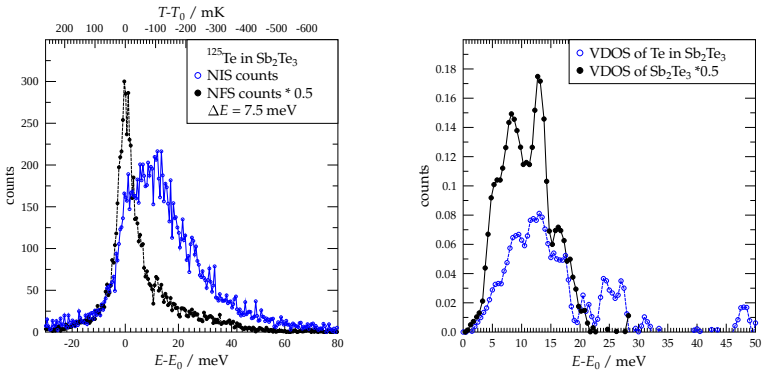

Fig. 2: To the left: The ^{125}Te NIS spectra of Sb_2Te_3 (open circles) and the instrumental resolution function (filled circles). To the right: The VDOS of Te in Sb_2Te_3 (open circles) and the VDOS of Sb_2Te_3 from neutron scattering scaled by a factor of 0.5 (filled circles).

From the NIS spectrum the vibrational density of states (VDOS) of Te in Sb_2Te_3 has been calculated. It is shown in comparison to the VDOS of Sb_2Te_3 measured by inelastic neutron scattering in the right part of Fig. 3. The achieved resolution of the monochromator of $\Delta E = 7.5$ meV is far from the theoretical value of 0.2 meV and also much larger than reported earlier [2] due to an error in the data analysis. The large resolution in combination with the low statistics at higher E results in artefacts in the calculation of the VDOS and we believe that this is the reason for the peaks appearing around 25 meV in the VDOS. In a recent experiment it has been shown, that the resolution can be drastically improved to smaller values (see report on HE3051). A repetition of parts of our measurements with better resolution could clarify the situation. Fig. 3 shows the NIS spectra of amourphous and crystalline $GeSb_2Te_4$ at about 25 K. Data evaluation is ongoing.

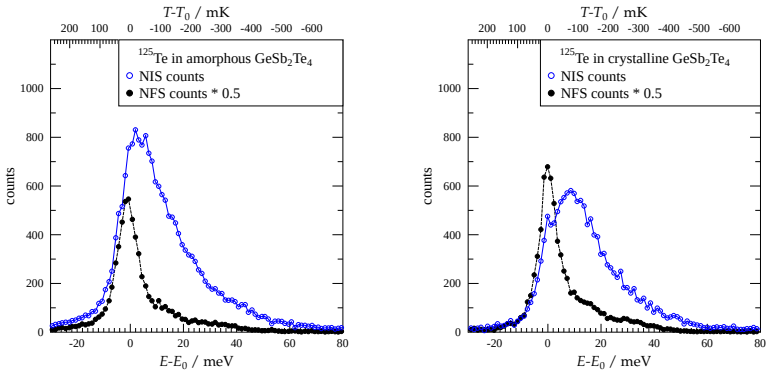

Fig. 3: To the left: The ^{125}Te NIS spectra of amourphous $GeSb_2Te_4$ (open circles) and the instrumental resolution function (filled circles). To the right: The ^{125}Te NIS spectra of crystalline $GeSb_2Te_4$ (open circles) and the instrumental resolution function (filled circles).

References

[1] H.-C. Wille, R.P. Herrmann, I. Sergueev, O. Leupold, P. van der Linden, B.C. Sales, F. Grandjean, Gary J. Long, R. Rüffer, Yu. V. Shvyd'ko, Phys. Rev. B 76, 140301(R) (2007)

[2] H.-C. Wille et al., ESRF highlights 2008