



Experiment title: Pressure dependence of magnetism in Eu compounds studied by nuclear scattering of Eu-151 21.5 keV radiation. (report II)	Experiment number: HE-289	
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Report:

According to our proposal, the first high-pressure experiments with nuclear-forward scattering (NFS) of the 21.5 keV radiation of Eu-151 were performed: In Report I we described studies on valence transitions connected with a new method to measure changes in isomer shifts (IS). Here in Report II magnetic studies performed on the two phases of EuTe at various pressures and temperatures are presented.

EuTe belongs to the series of NaCl-type Eu(II)-chalcogenides, which are considered as model compounds for Heisenberg magnetism because of the spin-only $J = S = 7/2$ 4f-moment of Eu^{2+} . EuTe orders antiferromagnetically at $T_N = 9.6$ K, in contrast to ferromagnetic EuO ($T_c = 69.3$ K) and EuS ($T_c = 16.5$ K). EuSe is antiferromagnetically ordered at $T_N = 4.6$ K and undergoes a transition to ferromagnetism already at modest pressures around 1.4 GPa. [2,3]. All EuX systems ($X = 0, S, Se, Te$) show a pressure-induced structural phase transition from the NaCl phase (fcc) to the CsCl phase (sc) at pressures of 40 GPa for EuO to 11 GPa for EuTe with broad transition regions [4]. Here we studied EuTe in both phases with the new Eu-151 NFS method; we know from earlier conventional Eu-151 Mössbauer studies up to 13 GPa [5] that the CsCl phase shows ferromagnetic order. In these studies it was, however, not possible to obtain the pure CsCl phase, since both NaCl and CsCl phase coexist over a rather large pressure range. Here we studied for the first time the magnetic properties of EuTe in the pure CsCl phase. The sample was pressurized in a diamond-anvil cell with 0.5 mm absorber diameter. The presence of the CsCl phase at 15 GPa was confirmed by XRD measurements performed before the NFS studies.

Fig 1 (a) shows NFS spectra of EuTe at 300 K and various pressures, measured against an EuF_3 reference absorber to obtain the relative isomer shifts. The NaCl-CsCl transition is accompanied by a change of the isomer shift by $\Delta IS = 28$ MHz = 1.6 mm/s at 15 GPa, which is clearly reflected in

the NFS spectra (see also bar diagram in Report I for the notations). The middle and the right columns show magnetic spectra of EuTe in the NaCl-phase and in the CsCl-phase (15 GPa) at low temperatures. The change of the magnetic ordering type from antiferromagnetic to ferromagnetic is reflected by a characteristic increase in the hyperfine field (B_{hf}) at low temperatures [6], here from 23.3(5) T (0 GPa, 4.2 K) to 35(1) T (15 GPa, 16 K). From a preliminary evaluation of $B_{hf}(T)$ we determine the magnetic ordering temperature as $T_c = 42(5)$ K at 15 GPa in the CsCl-type EuTe. This is a drastic increase from 16 K at 10 GPa and 23 K at 13 GPa [5]. It resembles the exponential increase of T_c in EuO and EuS with the reduction of the normalized lattice parameter [6] caused by the 4f-5d-4f exchange of the direct Eu-Eu overlap. On the other hand, the Neel temperature in NaCl type EuTe is almost pressure independent due to the antiferromagnetic exchange via the Te ligands [3,5].

The present high-pressure NFS results on EuTe (12 spectra) were obtained within about 12 hours. For comparison, one high-pressure spectrum of EuTe measured with normal Eu-151 Mossbauer effect at 300 K took 20 days. As in the case of Fe-57 (see our reports HE-99 and HC-373) this demonstrates again the superiority of the NFS method for high-pressure studies. In the proposed NFS studies pressures up to 50 GPa are envisaged.

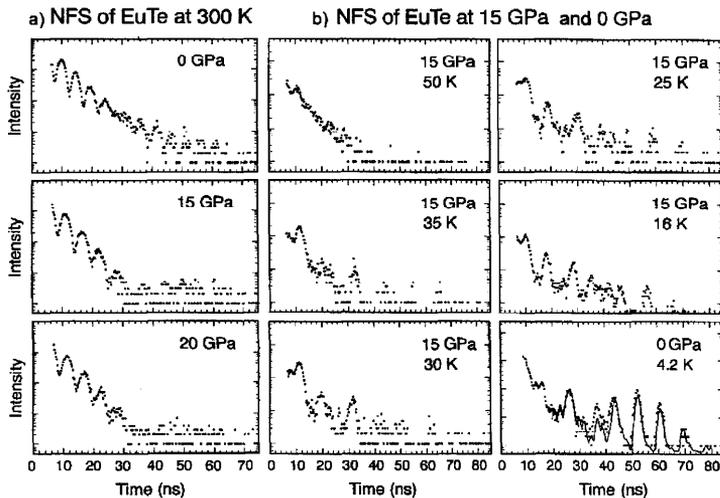


Fig. 1: (a) Eu-151 NFS spectra of EuTe vs. EuF_3 at 300 K. The change in isomer shift from the NaCl(0 GPa) to CsCl-phase (15 GPa) is reflected by a change in the beating frequency (see text and Report I). (b) Magnetic NFS spectra of CsCl-phase EuTe at 15 GPa and various temperatures as well as of NaCl-phase EuTe at ambient pressure and 4.2 K (lowest spectrum right column).

References: [1] O. Leupold et al., *Europhys. Lett.* 35,671 (1996). [2] Landolt Bornstein, **Vol12c** (Supplement to Vol. 4); [3] J. Moser et al., *JMMM* 12, 77 (1979); U.F. Klein et al., *JMMM* 3, 50 (1976); [4] A. Jayaraman et al., *PRB* 9,2513 (1974). [5] J. Moser, G. Wortmann, G.M. Kalvius, unpublished results. [6] Ch. Sauer, A.M. Zaker, W. Zinn, *JMMM* 38,225 (1983).