ESRF	Experiment title: Investigations of phase transitions on Eu compounds by nuclear resonance scattering on ^{151}Eu applying the crossed polarizer technique	Experiment number: HE 286
Beamline: ID18	Date of Experiment: from: 08-July-1997 to: 21-July-1997	Date of Report: August 21, 1997
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Names and affiliations of applicants (*indicates experimentalists):

0. Leupold*, E. Gerdau, M. Gerken*, H.D. Rüter*,
II. Institut für Experimentalphysik, Universitat Hamburg,
Luruper Chaussee 149, D-22761 Hamburg, Germany

G. Faigel,
Research Institute for Solid State Physics, P.O.B. 49, H-1525 Budapest, Hungary

Report:

After the first successful nuclear resonance scattering experiment at the 21.5 keV resonance of ^{151}Eu performed by us at the ESRF in October 1995 we report here on nuclear forward scattering (NFS) on Eu compounds undergoing phase transitions. Furtheron we performed the *first inelastic nuclear scattering experiment on the isotope* ^{151}Eu.
We used a highly monochromatized beam with a bandwidth of ≈7 meV, the time resolution of the detector system was ≈1.4 ns. The samples were Eu_3S_4 [b] and EuS (both polycrystalline) and a single crystal of EuP_5O_{14}, all with natural abundance of ^{151}Eu.
EuS which is ferromagnetic below 16.5 K was measured at room temperature (cf. Fig. la) and in a liquid helium cryostat at 4.2 K without magnetic field and in a field of 3.67 T applied parallel to the synchrotron beam. The spectra at low temperatures are shown in Fig. lb, c. The fits of these spectra prove that without external field the magnetic moments in the EuS powder are randomly oriented, while with applied field the mag-netization is perfectly aligned along the synchrotron beam.
Eu_3S_4 exhibits two different valence states (Eu^{2+} and Eu^{3+}), coexisting at low temperatures, leading to a pronounced modulation of the time decay of the nuclear excitation (cf. Fig. lf). At temperatures above ≈ 150 K charge fluctuations set in that drastically influence the time spectra (cf. Fig. Id, e), since the time scale of the dynamics of these processes fits excellent to the time window accessible in the NFS of synchrotron radiation on 151Eu The final "mixed valent" state is reached above room temperature and was not accessible in the present experimental setup. The much faster time decay of the nuclear excitation at higher temperatures indicates the presence of fluctuations. This can also be seen by comparison of Fig. Id with Fig. la where the decay of the EuS single resonance line proceeds much slower than that of Eu_3S_4 at the same temperature.

[a] 12 shifts in hybrid mode for adjustment of the setup and 5 shifts out of 15 in 16 bunch mode (shared with two other proposals: HE 289 and HE 175).

[b] We are grateful to Drs. K.-U. Neumann and K.R.A. Ziebeck (Loughborough University, Great Britain) for the loan of the Eu_3S_4 sample.

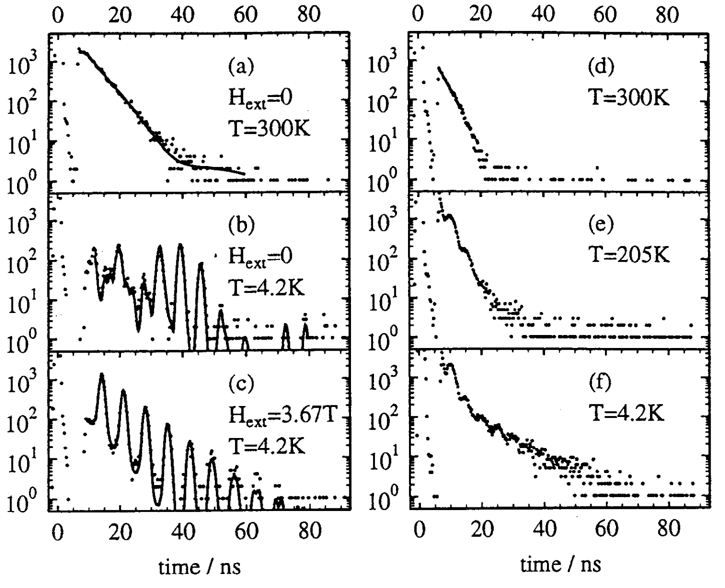

Fig. 1: NFS spectra of ^{151}Eu in two Eu compounds:
(a) paramagnetic EuS at room temperature; (b), (c) the ferromagnetic EuS at T = 4.2 K (solid lines are fits adopting the dynamical theory of nuclear resonance scattering).
(d), (e), (f) Eu_3S_4 at various temperatures as indicated.

EuP_5O_{14} is of special interest in optics and high pressure studies. Our inelastic nuclear scattering measurement on a single crystal (cf. Fig. 2) is the first experiment of this type at the ^{151}Eu resonance and proves the feasibility of this new technique at 21.54 keV.

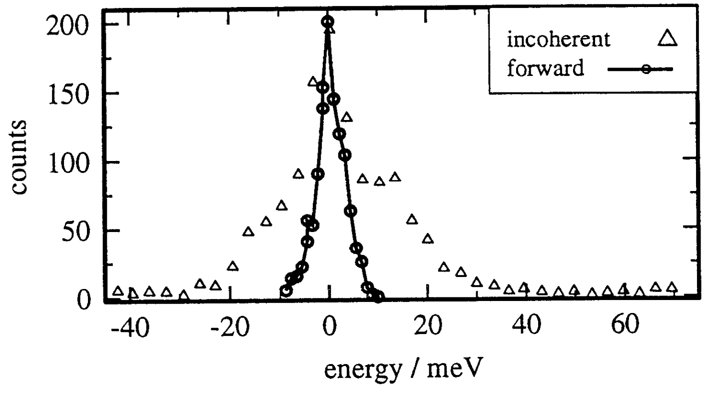

Fig. 2: Inelastic scattering on EuP_5O_{14} after excitation by synchrotron radiation.
a : Intensity of the incoherently reemitted radiation as a function of the energy shift of the incoming radiation relative to the resonance energy in NFS geometry.
o : Normalized NFS intensity; the width of the peak is a measure for the energy resolution of the setup (the full line is only to guide the eye).