EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

# Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF. This double-page report will be reduced by ESRF to a one page, A4 format, and will be published in the Annex to the ESRF Annual Report.

Should you wish to make more general comments on the experiment, enclose these on a separate sheet, and send both the Report and comments to the User Office.

When preparing your report, please follow the instructions below:

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- make sure the report does not exceed the space available; tables and figures may be included if you wish.
- for work which is published or which is in press, you may simply include a copy of the abstract together with full reference details. If the abstract is in a language other than English, ensure that you include an English translation.
- bear in mind that the report will be reduced to 71% of its original size. A type-face such as "Times", 14 points, with a 1.5 line spacing between lines for the text produces a report which can be read easily.

Note that requests for further beam time must always be accompanied by a report on previous measurements.

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| ESRF | **Experiment title:** Delocalisation of the 4f-electrons of Sm metal at high pressure | **Experiment number**: HE1377 |
|---|---|---|
| **Beamline**: ID22N | **Date of experiment**: from: 30/10/2002 to: 5/11/2002 | **Date of report**: 23/2/2003 |
| **Shifts: 18** | **Local contact(s)**: A. Barla | *Received at ESRF:* |


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**Report**:

The experiment HE1377 was aimed at investigating the effect of external pressure on the stability of the 4f-magnetism in Sm metal by using Nuclear Forward Scattering (NFS) of synchrotron radiation. The measurements have been carried out in 16-bunch mode at beamline ID22N. A new high resolution monochromator has been designed for the energy of the $^{149}$Sm resonance (22.494 keV). This delivers a flux of $2 \times 10^7$ photons/s in a bandwidth of ~0.9 meV and is therefore perfectly suited for high-pressure NFS and for Nuclear Inelastic Scattering studies. The beam was vertically collimated by using a Be compound refractive lens and focused horizontally to a size of ~150 µm, matching the size of the sample in the Diamond Anvil Cell. The sample was a Sm metal foil, enriched to 97% in $^{149}$Sm. The typical counting rates were 1-500 counts per second, allowing us to measure a single spectrum in 5-60 minutes. For this beamtime it has been possible to measure ~100 NFS spectra in the pressure range 0-18 GPa. X-ray diffraction patterns of the Sm foil have been measured at all pressures and at low temperatures to follow all structural phase transitions.

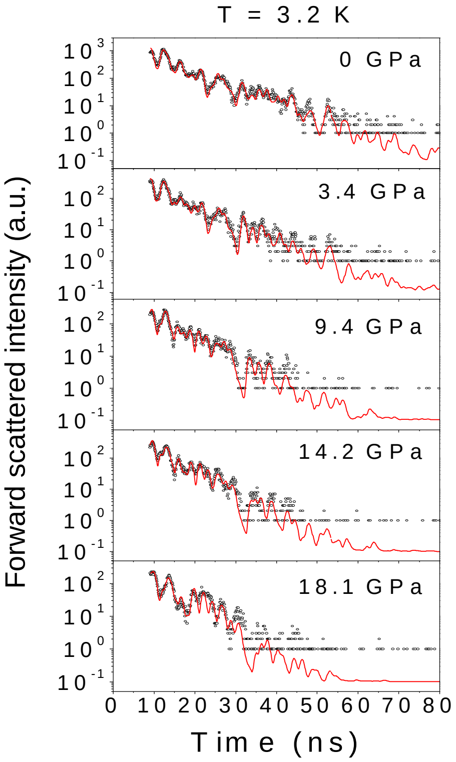


*Figure 1 – NFS spectra of Sm metal at 3.2 K and different pressures. The circles are the experimental data points, while the continuous lines are the fits.*

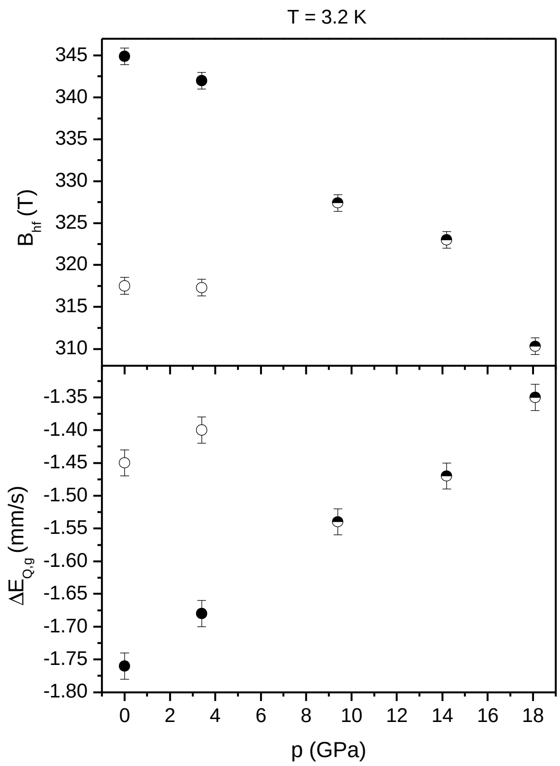


*Figure 2 – Pressure dependence of the hyperfine magnetic field ($B_{hf}$) and of the quadrupole interaction ($DE_{Q,g}$) at 3.2 K. The filled circles refer to the hexagonal sites and the empty to the cubic sites in the Sm-type structure while the half filled circles refer to both sites in the dhcp structure.*

Fig. 1 shows the NFS spectra measured at 3.2 K and various pressures. At ambient pressure and at p=3.4 GPa, Sm metal has the Sm-type hexagonal structure, whose unit cell consists of nine planes stacked along the c-axis. In six of these planes, the Sm atoms have a hexagonal coordination, while in the remaining three the coordination is cubic. The NFS spectra are best fitted if one assumes at the cubic sites slightly reduced hyperfine interactions with respect to those at the hexagonal sites. The magnetic hyperfine field of the hexagonal sites at ambient pressure has approximately the value of the $Sm^{3+}$ free ion. It decreases when pressure is increased to 3.4 GPa. The magnitude of the electric quadrupole interaction follows the same behaviour. When pressure is increased further, above 4 GPa (at room temperature) the structure changes to dhcp and the ratio of hexagonal and cubic sites becomes 1:1. The NFS spectra show that in this structure both types of sites have the same hyperfine interactions, probably because of the stronger interaction between planes of different coordination. The magnitudes of the hyperfine magnetic field and of the quadrupole interaction decrease as pressure increases, owing to the possible interplay of crystal field effects and conduction electron contributions. A further analysis of the spectra measured as a function of temperature at each pressure will allow us to determine the pressure dependence of the magnetic ordering temperature.