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Experiment title: High pressure investigation of the magnetic Compton profile of strongly correlated electronic systems	Experiment number: HE-671

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Report:

The investigation of the effect of strong correlations on the physical properties of metals is currently of much interest because such correlations are believed to be responsible for the anomalous physical properties of some compounds which lead sometimes to the appearance of a metal-insulator or a superconducting phase transition at low temperature.

One key feature of the strongly correlated compounds is that their physical properties are strongly dependent on an applied pressure. Usually, their magnetic phase transition is suppressed by a relatively modest pressure (below 10 GPa). For example $CeRh_3B_2$ looses its ferromagnetic ground state at $\simeq$ 6.5 GPa. In many cases, the critical pressure is even smaller: 1.3 GPa for UGe_2.

With this experiment we aimed to test the possibility of measuring magnetic Compton profiles at high pressure. The investigated sample was a single crystal of $CeRh_3B_2$. In 1997, we run a successful magnetic Compton scattering (MCS) experiment at room pressure on this system. $CeRh_3B_2$ undergoes a ferromagnetic transition below 115 K. This is by far the highest Curie temperature for Ce intermetallics with no other magnetic constituent. Using MCS, we showed that the spin moments of the $4f$ and $5d$ electrons of the Ce atoms are coupled ferromagnetically [1]. Therefore, unlike in other Ce compounds the Kondo effect does not play a key role for $CeRh_3B_2$.

We used a Bridgman pressure cell which is intensively used in our laboratory. It is a cylinder of diameter ~30 mm and height ~70 mm. The gasket is made of pyrophyllite ($Al_2(Si_4O_{10})(OH)_2$) and the pressure transmitting medium is steatite ($Mg_3(Si_4O_{10}(OH)_2)$. The pressure cell allows to reach 8 GPa in quasi-hydrostatic condition. The difficulty of the experiment resides in the relatively small size of the sample which can be loaded in the cell: the sample can only be a disk of ~1 mm diameter and ~0.12 mm thickness. Therefore, special optics is needed to focus the beam in this volume.

We used a monochromatic incident beam of 150 keV obtained from an asymmetrically cut Si [111] crystal. The Laue geometry and a vertical scattering plane were used. The crystal was bent to get a focus at the sample position. Optimizing the different parameters we reached a vertical size of the beam of $\sim$ 40 μm.

In order to get a finite circular polarization, vertical slits positioned upstream the monochromator were used to select a 1 mm beam height with an offset of 1 mm with respect to the center of the incoming beam.
Horizontally, the beam was collimated by slits to the sample diameter (~1 mm). The scattered radiation was detected with the new 13-element Ge-detector in a close to backscattering geometry. The beamline electromagnet was used to magnetically polarize the sample and the field was reverted every 5 minutes.
We note that (i) the incident radiation impiges the gasket of the pressure cell (about 0.5 mm of thickness) (ii) the pressure transmitting medium and (iii) fine collimation is not possible for the scattered radiation. Therefore Compton scattered radiation from the gasket and medium is detected. However, this cancels out in magnetic Compton profile.
We first tested the experimental setup with a polycrystalline sample of iron mounted in the pressure cell with no force applied to it (i.e. at room pressure). We got the nice magnetic signal which is shown in Fig. 1, after 80 minutes of acquisition time. Fig. 1 combines the signals from the 13 elements of the detector.
We then turned to the measurement on $CeRh_3B_2$. Fig. 2 shows the obtained signals after a day of data acquisition. No magnetic effect is observed. Given the fact that the flipping ratio is about 20 times smaller than in iron [1], a magnetic signal should have been obtained during this recording time.
We could, in some sense, monitor the actual position of the incident beam during the experiment through the intensity of the fluorescence lines of Ce and W. The fluorescence lines of Ce originate from photons impiging the sample whereas the W ones originate from photons hiting the clamps of the pressure cell, i.e. slightly above and below the sample position. During the acquisition of the data we noticed an increase of the intensity of the W fluorescence lines at the expense of the Ce ones. This indicates a small drift of the monochromatic beam with a characteristic time of the order of a few hours. Although we periodically tuned the experimental setup to compensate for this small drift, we could not get a better signal than in Fig. 2. The amplitude of the magnetic effect is large enough and the characteristic time of the drift is sufficiently small to allow the measurement of a magnetic signal for iron but not for $CeRh_3B_2$. A way of improving the setup could be to set up the monochromator and the sample on the same table. However this could notably increase the noise of the experiment.

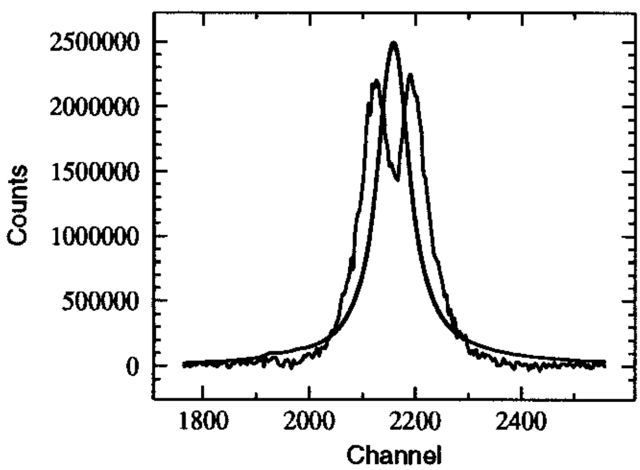

Fig. 1: Compton cross-section and difference for the two opposite polarization of the sample meaured on polycrystalline iron in the pressure cell at room pressure and temperature. The channel binning factor is 4. The difference signal has been multiplied by a factor 50.

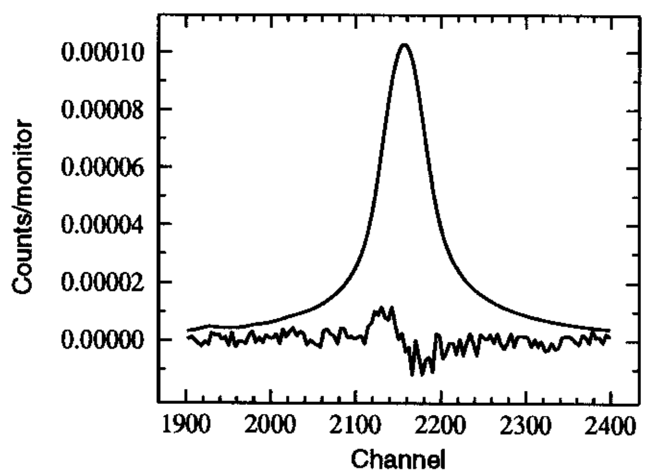

Fig. 2: Compton cross-section and difference for the two opposite polarization of the sample measured on a single crystal of $CeRh_3B_2$ in the pressure cell at room pressure and at ~ 70 K. The data are normalized to the monitor and the channel binning factor is 4. The difference signal has been multiplied by a factor 100. No magnetic signal is seen.

References

[1] A. Yaouanc *et al.*, Phys. Rev. **B 57**, R681 (1998).