ESRF	**Experiment title:** Study of valence in heavy-fermion systems by XAS	**Experiment number**: HE3934
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Shifts:	**Local contact(s)**: STROHM Cornelius	*Received at ESRF:*

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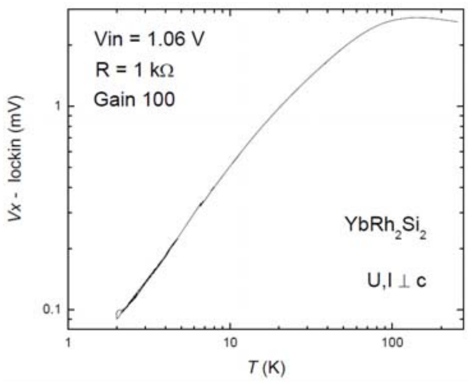
Report:

The experiment HE3934 consisted in a study of valence by XAS in the heavy-fermion materials $YbRh_2Si_2$ and $YbCu_2Si_2$ in pulsed magnetic fields up to 30 T applied parallel to their *c*-axis.

First part of the experiment was the study by XAS of a 20 µm thick plate of $YbRh_2Si_2$ with the x-ray beam and the magnetic field perpendicular to the plate, i.e., parallel to the *c*-axis of the crystal. Four electrical contacts (made by spot welding and reinforced by silver paint, cf. Fig. 1) on the sample enabled to measure its resistance using the standart 4-point technique (with a lock-in preamplifier) altogether with the XAS experiment. Fig. 1 shows the sample voltage vs temperature measured for an exciting current of 1 mA, within an amplification by 100. For the XAS measurement, the beam has been focused on the sample between the two voltage wires. At the lowest accessible temperature (2 K), the power of the beam has been adjusted (by



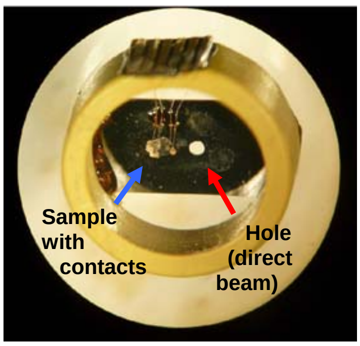


Fig.1: (left) Electrical resistance (here the raw data, i.e., the induced voltage on the sample) versus temperature measured on the $YbRh_2Si_2$ sample studied by XAS. Measurement of its resistance enabled us to define a synchrotron-beam configuration leading to no significant heating of the sample, i.e., with an acceptable change of its resistance.(right) Photo of the experimental set-up: the sample with four contacts glued on a silicon support, and a hole to measure the direct beam.

selecting a restricted range of incident energies and reducing the global intensity), so that, despite the heating of the sample by the beam, its temperature remains close to the temperature given by the thermometer. The resistance of the sample - heated by the beam - was considered as its more natural "thermometer" and used to check its temperature. Fig. 2 shows the XAS spectra extracted for $YbRh_2Si_2$ at zero field for T = 2 and 250 K. From a preliminarily analysis of the data, the valence is found to vary from 2.97 at 210 K to 2.92 at 3 K. We further obtain that, when a magnetic field is applied along the hard magnetic axis **c** of this system, there is no field-induced change of the valence, within our experimental error, as shown in Fig. 2.

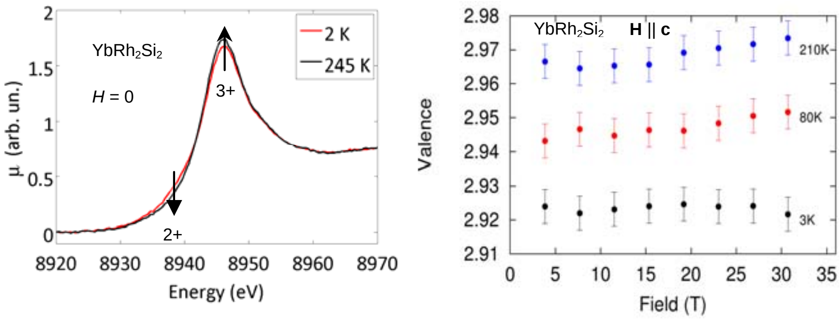


*Fig.2: (left) XAS spectra measured on $YbRh_2Si_2$ at T = 2 and 250 K at zero magnetic field, during the experiment HE3934, where the arrows indicate the effect of heating, and (right) Valence vs magnetic field deduced from the XAS spectra at different temperatures from 3 K to 210 K in a field **H** || **c** .*

The beam configuration defined for the first sample $YbRh_2Si_2$ has been kept for the second (an non-contacted) sample $YbCu_2Si_2$ measured by XAS, both having similar geometrical shape and physical characteristics. A 20 µm thick plate of $YbCu_2Si_2$ was studied with the x-ray beam and the magnetic field perpendicular to the plate, i.e., parallel to the *c*-axis of the crystal. Fig. 3 shows the XAS spectra obtained at zero-field for T = 2 and 250 K. A preliminarily analysis of these spectra shows that, when the temperature is decreased, the valence decreases slighlty, going from 2.94 at 250 K to 2.86 at 2 K. Under a pulsed magnetic field, the valence increases continuously with the field, its field-induced variation being stronger at low temperature, where it increases by 0.03 at 30 T.

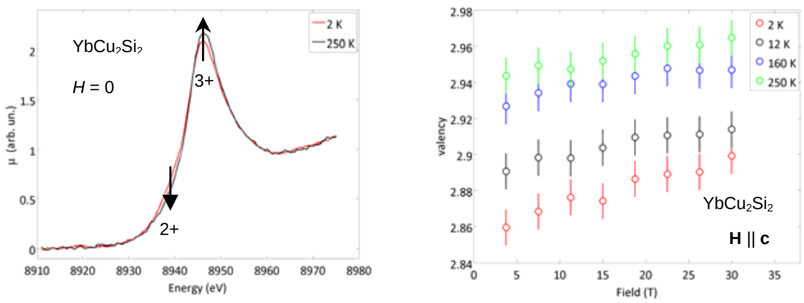


*Fig.3: (left) XAS spectra measured on $YbCu_2Si_2$ at T = 2 and 250 K at zero magnetic field, during the experiment HE3934, where the arrows indicate the effect of heating, and (right) Valence vs magnetic field deduced from the XAS spectra at different temperatures from 2 K to 250 K in a field **H** || **c** .*

After these measurements at the the L_3 edge of ytterbium, the last two days of the experiment have been devoted to a change of configuration to get access to the L_2 edge of cerium. A 15 µm thick $CeCoIn_5$ sample has been tested at room temperature. A XAS spectra (not shown here) has been successfully obtained at zero magnetic field, but with a recording time much longer than the few milliseconds avaible during a pulsed magnetic field. In the future, 5 µm thick samples will have to be prepared to have a chance to perform successfully XAS experiments on Ce-based heavy-fermion materials in a pulsed magnetic field.

This first experiment has shown that XAS can now be performed sucessfully using the slow pulsed magnetic fields developped at the LNCMI and the new ESRF Helium cryostat, on the ID24 line, to study the valence of Yb-based heavy-fermion materials in temperatures down to 2 K and magnetic fields up to 30 T. Next step will be to continue the study summarized here by investigating the change of valence of the two systems $YbCu_2Si_2$ and $YbRh_2Si_2$ in a magnetic field parallel to their *a*-axis. The challenge will be to check if measurable changes of valence are only obtained when the magnetic field is applied along the easy magnetic axis of the system, as suggested by the preliminarily (and yet not complete) results obtained here, and thus to show the presence of a strong interplay between the valence and magnetism in heavy-fermion materials.