ESRF	**Experiment title:** Comparative Study of Bulk and Surface Electronic Properties of Kondo Systems with Tuned Transition Temperature	**Experiment number**: **HE-3171**
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Report:

The main goal of our experiment was to explore the electronic structure of the Yb-based intermetallics, which exhibit the astonishing properties at the low-temperature regime ranging from magnetism via superconductivity to Kondo and heavy-fermion (HF) behavior. It is generally believed that the sited above phenomena are governed by the delicate interaction of localized 4f and delocalized valence electrons of the system. In the frame of our proposed experiment, we intended to perform the comprehensive analysis of the electronic properties of the famous Yb-based family isoelectronic materials $YbRh_2Si_2$, $YbIr_2Si_2$ and $YbCo_2Si_2$. It should be noted that Rh- and Ir-based systems exhibit heavy-fermion behavior accompanied with Kondo scenario with transition T_K temperature ~ 25K and 40K respectively, while $YbCo_2Si_2$ shows pure Yb^{3+} state in a wide temperature range (5-300K) as it was indicated by the specific heat experiments.
In this sense, we intended to investigate the modification the valence of the Yb ions in these systems using truly bulk spectroscopic technique as resonant inelastic x-ray scattering (RIXS).

Carrying out the RIXS, we concentrated on the measurements and evaluation of the temperature-dependent (20-300 K, across T_K) changes of the spectral weight of Yb^{2+} and Yb^{3+} features in the partial fluorescence yield X-ray absorption spectroscopy (PFY-XAS) spectra recorded at the L_3 edge of Yb atom. To gain deep insight into the valence changes and occupation of the 4*f* states we carried out comprehensive series of the temperature-dependent measurements of the Yb^{2+} $L\alpha_1$ RIXS signal recorded at $h\nu_{in}$ =8.941keV for all cited above materials.

Figure 1a shows the PFY signal obtained from an $YbRh_2Si_2$ sample which is mapped as a function of the excitation and transfered energies. Apparently, the appearnce of the two well-resolved distinct features due to de-excitation process and the stabilization of the $2p^6 3d^9 4f^{14}$ (Yb 2+) and $2p^6 3d^9 4f^{13}$ (Yb 3+) electron configurations (marked by white arrows) was detected. A closer look at the PFY signal maps recorded at lowest ~5K and room temperatures demonstrates that the relative intensity of the Yb 2+ and Yb 3+ components is changed upon a temperature variation, showing the different strength of the 4f-VB electron

hopping. Appropriate cuts of the presented two dimensional PFY maps gives a XAS or RIXS spectra which will be analyzed on the subject of the manifestation of the Kondo scenario and the evaluation of the corresponding T_K using the truly bulk sensitive spectroscopic approach . Figure 2 shows RIXS spectra as a function of the temperature for all studied Yb intermetallics, including trivalenet reference sample $YbCo_2Si_2$. The RIXS spectra were taken at the incident energy hν =8941 eV where the Yb2+ XAS and RIXS signals are largest, since the small valence changes have a larger effect on the Yb2+ weight.

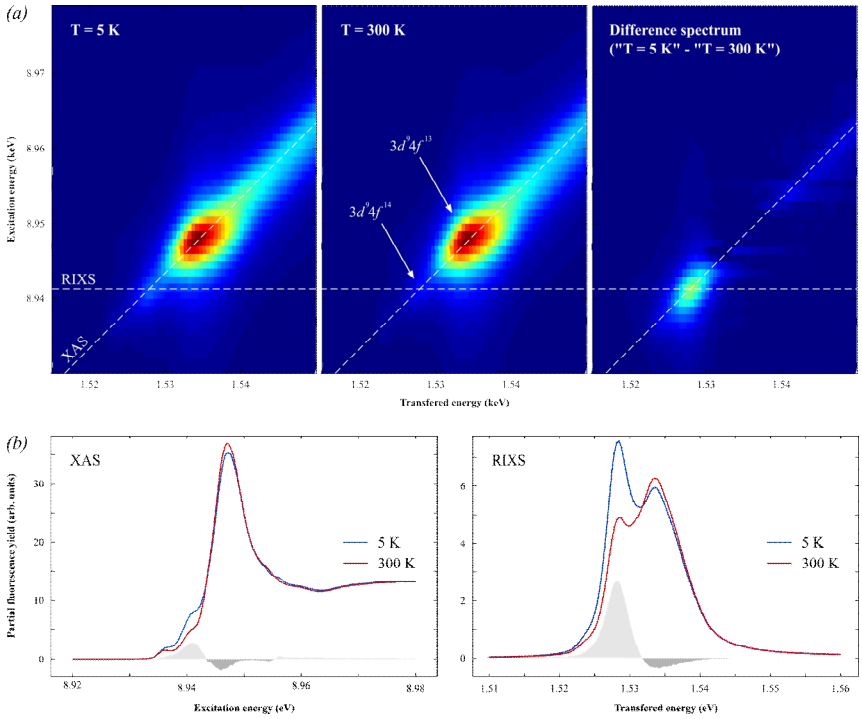

Figure 1: (**a**) Partial fluorescence yield signal obtained from an $YbRh_2Si_2$ sample for the $2p^6\ 3d^{10}$ VB -> $2p^5\ 3d^{10}$ VB+1 -> $2p^6\ 3d^9$ VB+1 excitation-disexcitation channel and mapped as a function of excitation and transfered energy. The appearance of two distinct resonances that can be assigned to the $4f^{14}$ and $4f^{13}$ Yb configuration points to a mixed-valent ground state. Comparing the 6K and 300 K data the divalent, $4f^{14}$ admixture in the ground state appears to be enhanced at lower temperature. (**b**) Constant emission energy and constant excitation energy spectra taken along the dashed lines in (a).

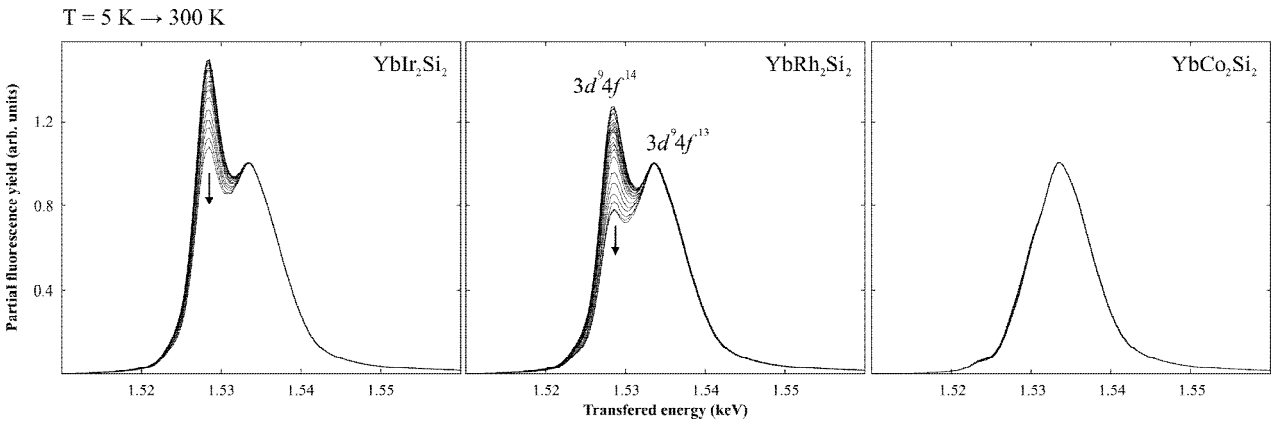

Figure 2: Temperature-dependent changes in the RIXS spectra of $YbRh_2Si_2$ and the two isoelectronic compounds $YbIr_2Si_2$ and $YbCo_2Si_2$. $YbRh_2Si_2$ and $YbIr_2Si_2$ show a similar decrease in the divalent contributions with rising temperature whereas not temperature-dependence has been observed for $YbCo_2Si_2$.