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Report:

The proposed experiment was aimed at studying the effect of pressure P and temperature T on the electronic structure of Yb heavy fermion compounds $YbNi_2Ge_2$, $YbRh_2Si_2$ and $YbRh_2Ge_2$. The long time required by experiments at high P allowed us to study two of the proposed samples, $YbNi_2Ge_2$ and $YbRh_2Si_2$.

$YbNi_2Ge_2$ and $YbRh_2Si_2$ are Kondo lattice systems. Their ground state properties depend on the competition between the Kondo and the RKKY interaction. Both interactions are related to the coupling of the nearly localized *f* moments and the extended conduction electrons. In heavy fermions the two interactions are of the same order of magnitude, so that these systems are very close to a magnetic instability. Pressure and temperature influence the hybridization strength and can drive these compounds through a magnetic quantum critical point. So far the evolution of these compounds has been studied by resistivity, specific heat and magnetic measurements [1,2]. Resisitivity shows that $YbNi_2Ge_2$ is tuned by increasing pressure from an intermediate valence state to a magnetically ordered Kondo lattice, and the magnetic ordering temperature increases with pressure. The low Kondo temperature (T_K~25 K) of $YbRh_2Si_2$ indicates that Yb is nearly trivalent. A transition toward a high magnetic moment occurs at ~10 GPa, together with a decrease of T_K.

Direct information on the valence evolution as a function of P and T was missing.We performed an experiment of Resonant Inelastic X-ray Scattering (RIXS), which has proven to give very direct and sensitive information about valence changes [3]. The final aim was to study valence changes in the whole P-T space, but (as anticipated in the proposal) the sample environment where P could be changed also at low T did not become available on time. We therefore performed experiments as a function of T (at ambient P) and as a function of P (at room T). The experiment at high pressure was performed with a cell adapted for a cryostat, and we have asked an extension of the proposal to complete the important results already obtained, by measuring the effect of P also at low T. The results of the experiment are summarized in the figures below. Figures 1 and 2 refer to $YbNi_2Ge_2$ and $YbRh_2Si_2$ respectively.

We measured the $L\alpha_1$ (*3d-2p*) RIXS excited along the L_3 edge of ytterbium. Spectra of the fluorescent emission at 300 and 10 K are shown in the right inset to Figs. 1A and 2A. The arrows indicate the incident energy values of the RIXS spectra in the main panel ($h\nu_{IN}$=8.937 keV) and in the left inset ($h\nu_{IN}$=8.933 keV). Spectra in the main panel show the evolution with temperature (at ambient pressure) of the spectral contributions of *Yb2+* and *Yb3+* for $h\nu_{IN}$ where the divalent configuration resonates. Spectra were normalized to the peak of *Yb3+* for comparison. The

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[1] J. Custers et al., Nature **424**, 524 (2003). S. Paschen et al., Nature **432**, 881 (2004).
[2] G. Knebel et al., Journal of Physics: Condensed Matter **13**, 10935 (2001).
[3] C. Dallera et al., Phys. Rev. Lett. 88, 196403 (2002). C. Dallera et al., **68**, 245114 (2003). Report HE1593 on SmS under pressure

left inset reports spectra excited well below the absorption edge. These show an additional feature (at low energy transfer), that derives from quadrupolar (*2p-4f*) excitation of *Yb3+*.

Figs. 1B and 2B report spectra as a function of applied pressure, at room temperature.

The compared qualitative analysis of the results points to a strong effect of P and T. $YbNi_2Ge_2$ is found to have a stronger divalent component than $YbRh_2Si_2$. Pressure provokes a strong suppression of the divalent configuration. In $YbRh_2Si_2$ starting from 8.5 GPa we observe a practically trivalent state. The enhancement of the divalent intensity at low temperature in both systems calls for an extension of the present measurements as a function of pressure also at low temperature. This is the object of an experimental proposal submitted at the same time as this report.

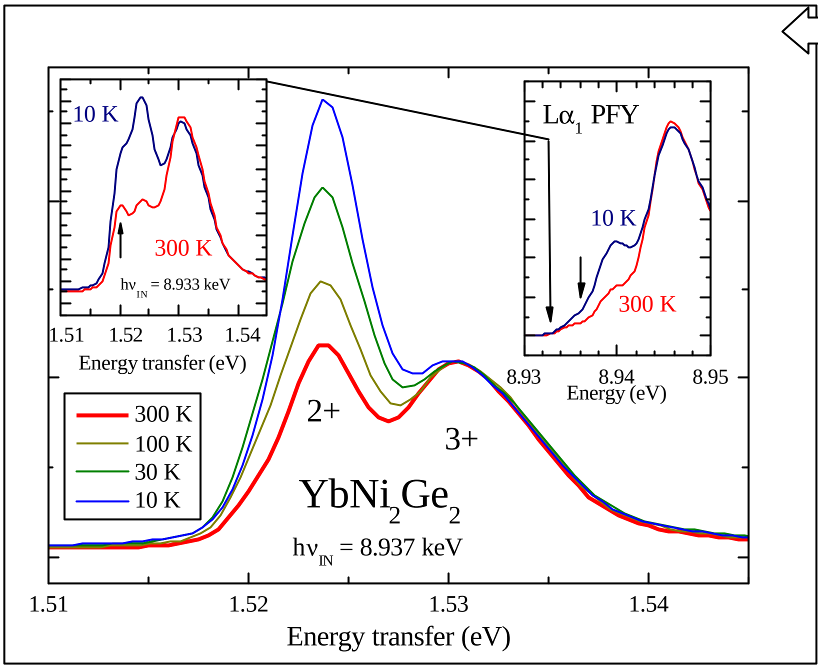
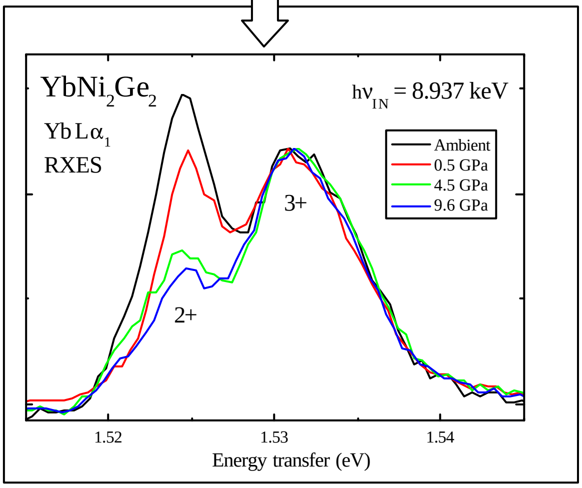


Fig. 1A. RIXS spectra of $YbNi_2Ge_2$ vs. T at ambient pressure. Spectra are normalized to *3+* peak.

Fig. 1B. RIXS spectra of $YbNi_2Ge_2$ vs. P at room temperature. Spectra are normalized to *3+* peak.



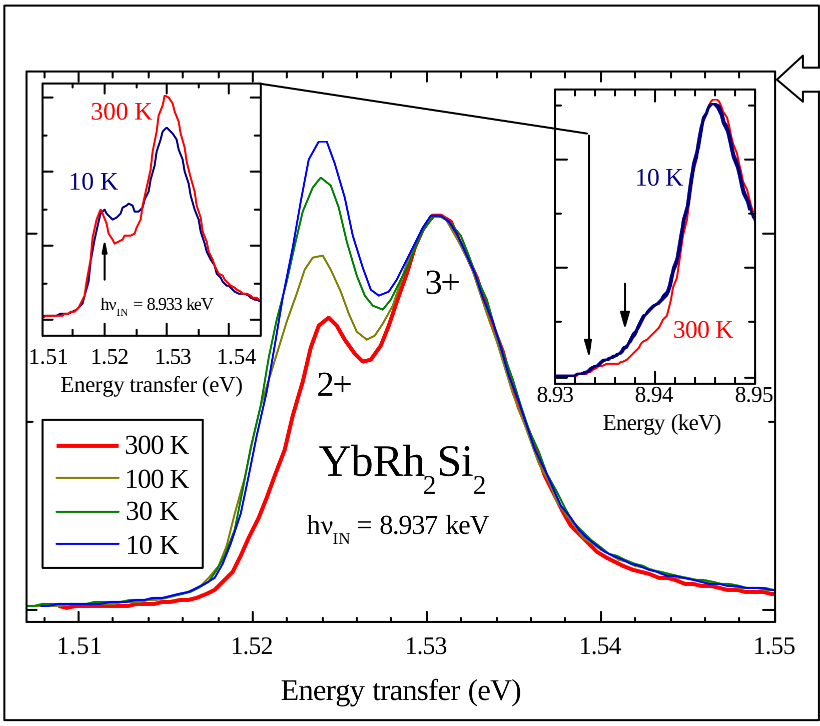


Fig. 2A. RIXS spectra of $YbRh_2Si_2$ vs. T at ambient pressure. Spectra are normalized to *3+* peak.

Fig. 2B. RIXS spectra of $YbRh_2Si_2$ vs. P at room temperature. Spectra are normalized to *3+* peak.