A resonant inelastic X-ray emission study of $YbAl_2$ under pressure

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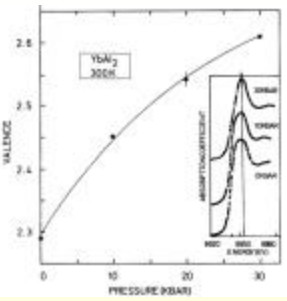
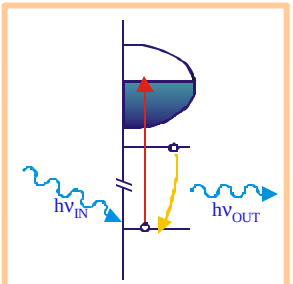
The issue

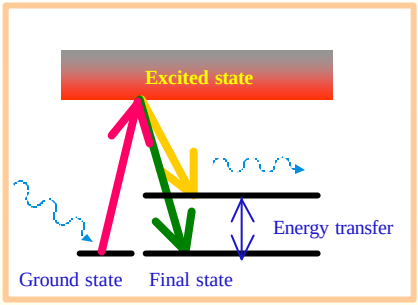
Yb and Ytterbium compounds undergo **valence changes** as a function of temperature and pressure. These changes have been investigated by studying the Pressure-Volume relation, the lattice constant, and the change of lineshape of L_3 X-Ray absorption spectra. This method gives the most direct information on the electronic population but suffers from the large lifetime width of the final state of the *2p , 5d* XAS process.

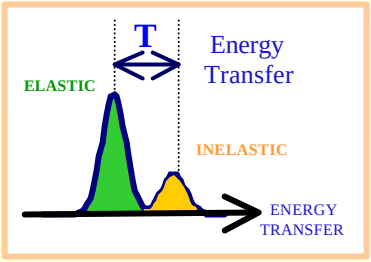


Röhler et al., Valence instabilities, (1982)

A new approach: Resonant X-Ray Emission Spectroscopy



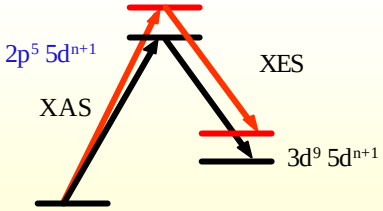




Resonant Inelastic X-Ray Emission measures the photons emitted following resonant excitation at a core level. The energy transfer to the solid is dictated by the **characteristic energy scales** of the system. We chose L_3 resonant excitation ($h\nu_{IN}$ ~ 8950 eV) and followed the process $2p^6 5d^n$, $2p^5 5d^{n+1}$, $2p^6 3d^9 5d^{n+1}$ ($h\nu_{IN}$ ~ 8950 eV). At these energies the probing depth is ~ 1 μm .

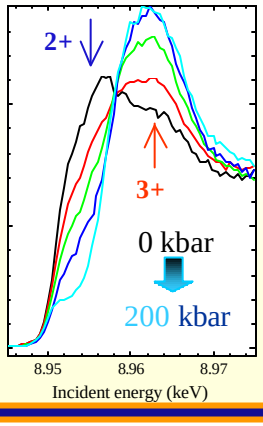
Yb absorption and emission at the L_3 edge

Yb^{2+} ($4f^{14}$) and Yb^{3+} ($4f^{13}$) are split by the interaction with the core-hole. The energy splitting is around 7 eV in the final state of the XAS and XES process



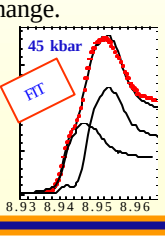
$|\Psi_G> = \alpha|Yb^{2+}> + \beta|Yb^{3+}>$

Partial Fluorescence Yield spectra

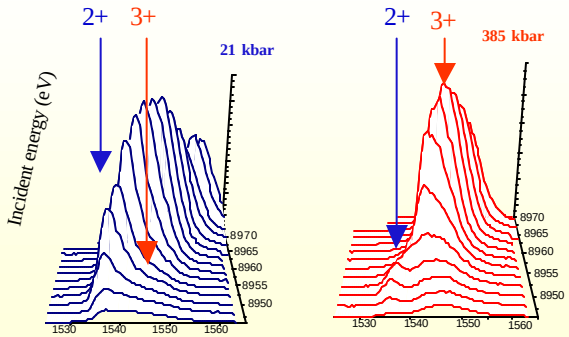


In a PFY spectrum the intensity of the chosen emission channel ($L\alpha_1$ in our case) is recorded *vs.* $h\nu_{IN}$. The spectral change is a signature of the valence change.

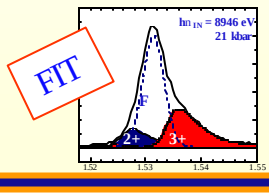
A fit (two replicas) provides the **Yb^{2+} and Yb^{3+} weight.**



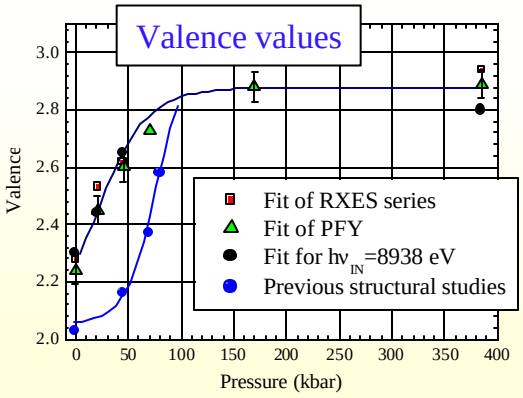
Resonant X-ray Emission spectra



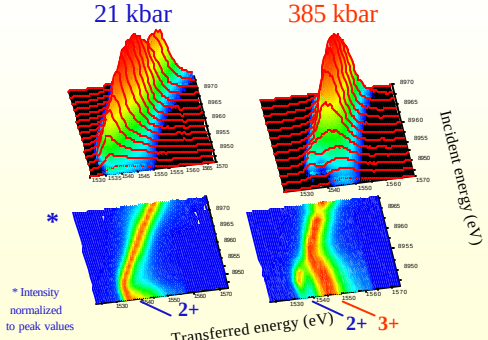
X-Ray emission spectra were measured at $h\nu_{IN}$ values along the L_3 edge. Spectra were decomposed in the 2+ and 3+ component (at constant $h\nu_T$). Past the resonance a fluorescent component appears (constant $h\nu_{OUT}$).



Valence values



"Raman" *vs.* "dispersive" behavior



Conclusions

- We studied the pressure dependence of Yb valence in the intermediate valence compound $YbAl_2$ by resonant inelastic x-ray emission
- The combined analysis of spectra measured vs. $h\nu_{IN}$ and $h\nu_{OUT}$ considerably improves the valence estimate.

[C. Dallera et al., Physical Review B 68, 245114 (2003)]