High pressure XANES study of U_2Zn_{17} to 47 GPa

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Introduction

Changes in the charge distribution around a given atom in different chemical and physical environments can alter core-level binding energies and thus produce absorption edge shifts that show up in x-ray absorption near edge structure (XANES) measurements. Our goal was to measure the shift in edge energy of the uranium L_3 edge (see Figure 1) in powdered U_2Zn_{17} as a function of pressure at the Advanced Photon Source.

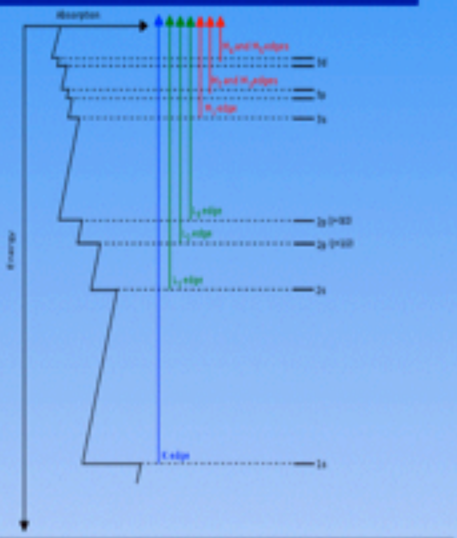


Figure 1. An energy level diagram showing the different absorption transitions of core electrons. The L_3 edge of uranium arises from a transition between the $2P_{3/2}$ state and the 6d states just past the fermi level[1].

Experimental Methods

The Advanced Photon Source at Argonne National Laboratory is a national synchrotron x-ray facility which has the brightest storage ring-generated x-ray beams in the western hemisphere[2]. The absorption measurement was taken by measuring the incoming intensity, before the x-ray beam reached the sample, and then measuring the outgoing intensity with ion chambers on each side of the pressure cell (Figure 6).

A Japanese symmetric diamond anvil cell with spherical seat for tilt adjustment was used along with a rhenium gasket and a 4:1 methanol:ethanol pressure medium (Figure 3).

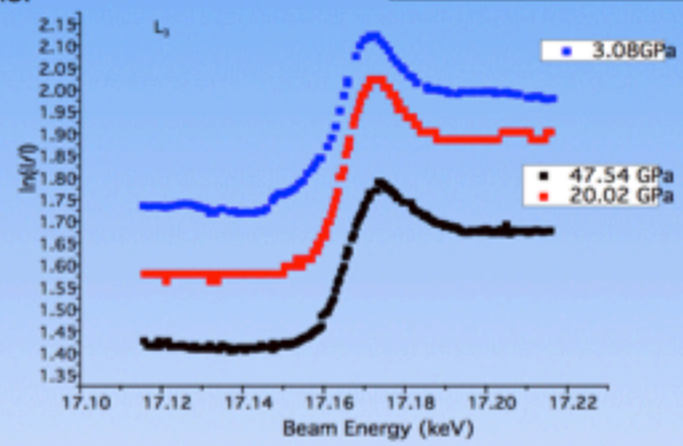
Figure 2. A top view of the Advanced Photon Source at Argonne National Laboratory[2]. The high pressure collaborative access team (HP-CAT) sector is outlined.

Figure 3. A view of the pressure cell that was used in this experiment.

Results

Preliminary analysis of the data shows no clear pressure dependence of the L_3 edge of uranium in U_2Zn_{17}. The background can be subtracted by fitting to an arctangent function and the peak can be fit to a Gaussian for a more accurate analysis.

Figure 4. Absorption of U_2Zn_{17} at varying pressure near the L_3 edge of uranium. The energy corresponding to the absorption peak is roughly 17,173 ± 2 eV.



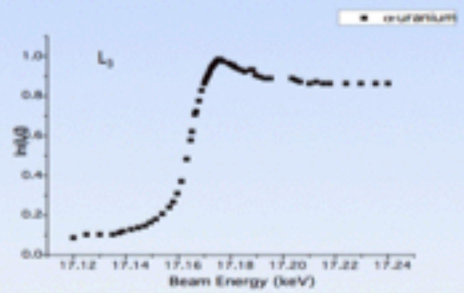
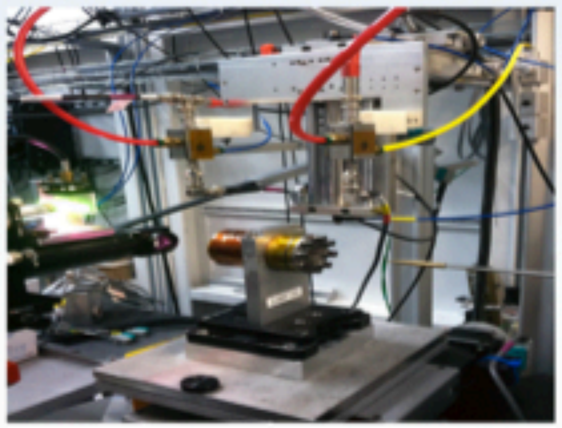


Figure 5. Absorption data of σ-uranium showing the L_3 edge at ambient pressure and temperature[3]. The energy corresponding to the peak is approximately 17,175 eV, about 2 eV less than U_2Zn_{17}.

Figure 6. A view inside the hutch showing the mounted pressure cell as well as the incoming beam and the ruby spectrometer used for pressure calibration. The x-ray beam comes from the needle-shaped piece on the right side of the image and is about 12 μm x 5 μm. The ion chambers are lifted above the pressure cell and have red tubes coming into them which are filled with argon gas.



Conclusion

XANES measurements have been performed on the heavy fermion compound U_2Zn_{17} in a diamond anvil cell at pressures up to 47 GPa.

The uranium L_3 edge has been studied from 3 GPa to 47 GPa and no significant pressure dependence has been observed. A XANES measurement through fluorescence rather than transmission might give higher resolution data making it easier to notice a shift in edge energy on the order of 1 eV.

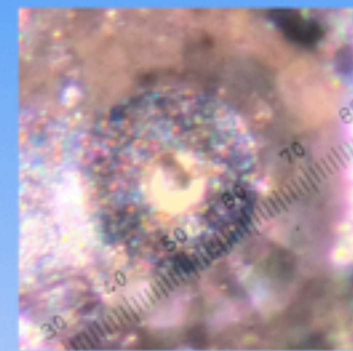


Figure 7. A view of the U_2Zn_{17} sample along with a ruby inside the gasket of the pressure cell. The gasket hole is ~75 μm and the diamond culets were 250 μm in diameter. The sample is ~10 μm thick. An average human hair diameter is about 80 μm.

Acknowledgements

I would like to thank the HiPSEC community at UNLV that helped guide me in my research as well as everyone who made the REU possible. A special thanks to Dr. Cornelius for sending me to Argonne National Lab and to all of the beamline scientists that helped get the experiment running smoothly.

Use of the Advanced Photon Source is supported by the DOE office of science, Office of Basic Energy Sciences, under Contract No. DE-AC02-06CH11357. HPCAT is supported by DOE-BES, DOE-NNSA, NSF, and the W.M Keck Foundation.

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