XAS of cadmium vapor in L-edge region

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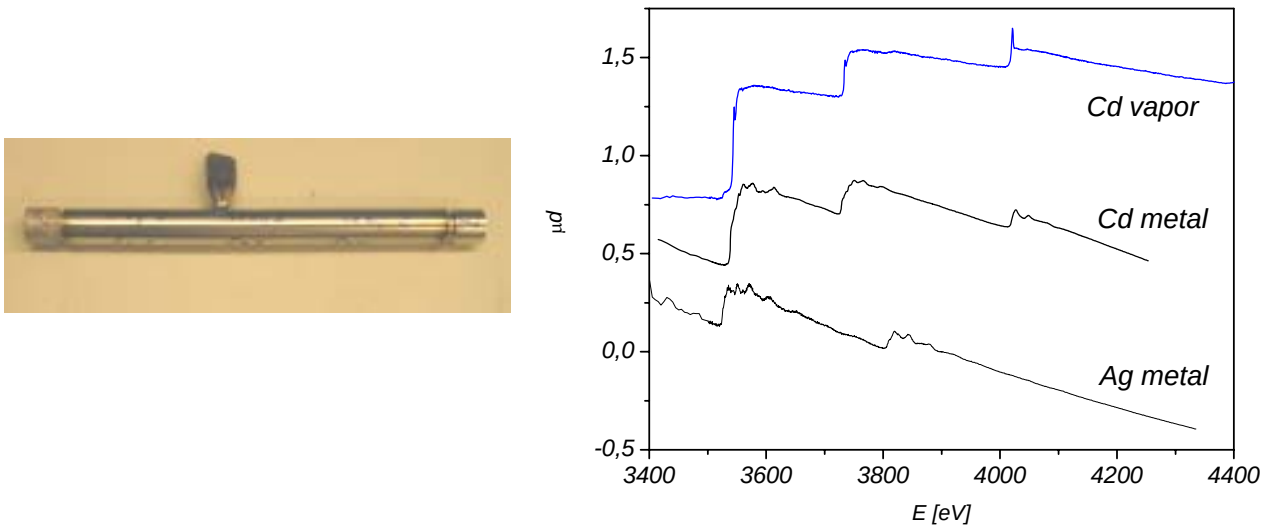
X ray absorption cross section measured on a monatomic metal vapor measures the intensity of photon interaction with free atoms, without the obscuring effects of molecular or solid-state structure, and provides a direct test of theoretical models and quantum-mechanical calculations of the atomic system.

X-ray absorption of cadmium vapor in the energy region of L edges was measured at HASYLAB stations E4 and A1. The preliminary test at the first station showed that the experiment is extremely demanding in view of the low energy (3500 – 4200 eV) of the Cd L region. The definite data were obtained at the A1 beamline with a better luminosity at the lowest energies, using the two-crystal Si 111 monochromator with the resolution of ~0.7 eV. As in earlier low energy atomic absorption experiments on potassium K edge and cesium L edges [1, 2], the vapor was contained in a 10 cm long stainless steel absorption cell with 50 μm beryllium windows (Fig.1a), heated to 800 ^{o}C in a tubular oven with a protecting He atmosphere. The intensity of the beam was measured with three ionization detectors, filled with 180 mbar, 1000 mbar and 1000 mbar of nitrogen. Owing to the high quality of the A1-station beam, the absorption in the entire energy region has been determined with a uniform accuracy, as shown in the panoramic view of Fig. 1b.

The result – cadmium atomic x-ray absorption – is a fundamental atomic property, a test case for theoretical models. For the purpose, the energy scale of the monochromator was carefully calibrated with the L_2 and L_1 edge of Ag (3524 eV and 3806 eV, respectively). In addition, the absorption of metallic Cd was measured in the same energy interval. The edge shifts between the metallic and atomic Cd provide a sensitive test for solid-state models.



a) b)

Figure 1: a) Absorption cell. b) Cadmium vapor absorption in the region of the L edges, together with the absorption of metallic Cd. The scan silver metal foil for exact energy calibration is also shown.

The comparison of the edge profiles and the subsequent smooth regions of the absorption spectrum shows an essential difference in the intensity of the "white line", the leading resonance in the [2s]np or [2p]nd Rydberg series. In a further analysis small sharp features can be isolated out of the noise in the smooth region within ~ 100 eV above the edges. These are the fingerprints of coexcitation of electrons from the valence and subvalence shells in the main photoabsorption process.

The vapor absorption also represents the exact "atomic absorption background" for the EXAFS analysis at cadmium L_3 edge, to improve on the spline approximation of standard EXAFS analysis software in the critical cases of strongly disordered samples with very low structural signal. Although for Cd itself, K shell EXAFS is preferably measured if the beamline energy range allows, the measurement on Cd may be helpful in construction of model backgrounds for the adjacent region of elements, providing one of the lowest-Z atomic absorption spectra in the L-shell region, accessible with the present x-ray absorption technique.

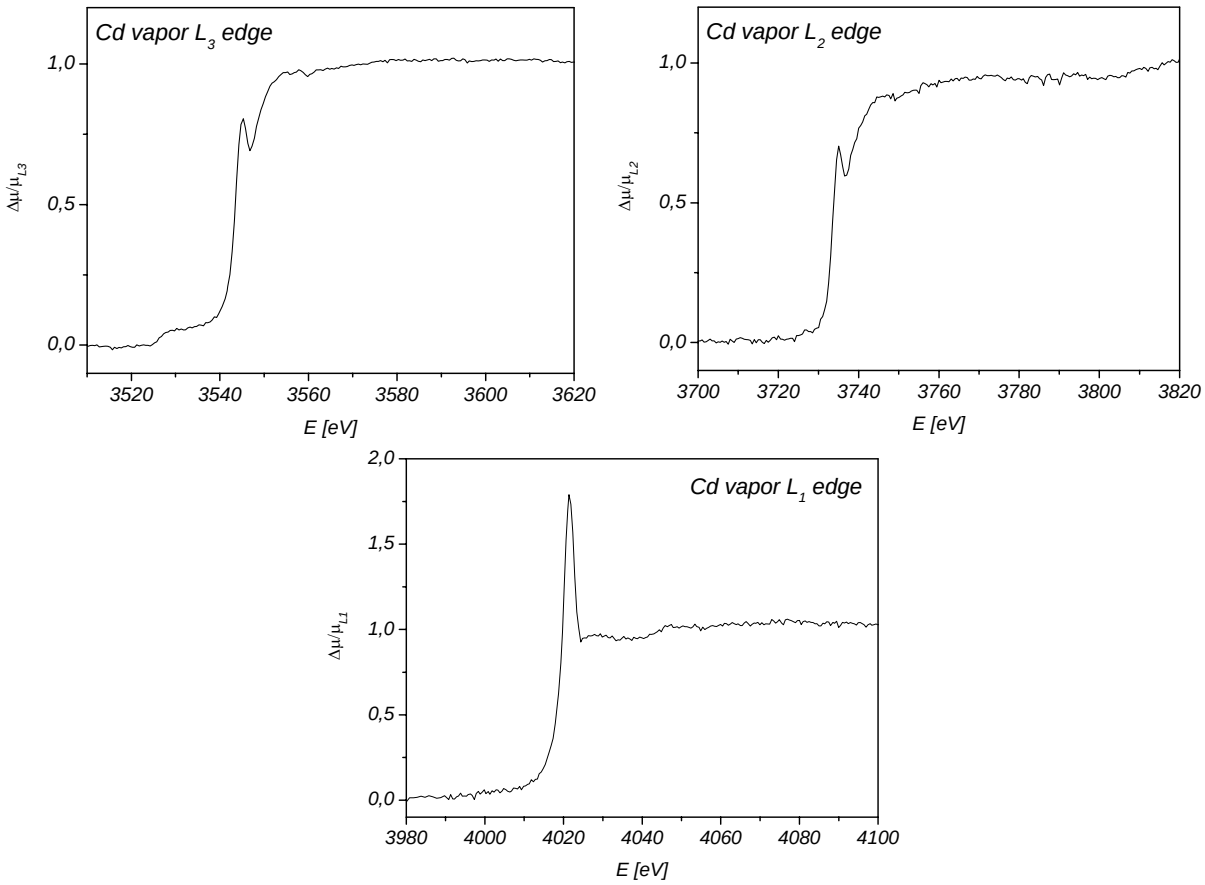


Figure 2: The comparison of the L edge regions, with the strikingly different white lines. The small edge at 3524 eV is Ag L_2 edge from a slight contamination of the Be windows with silver solder.

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