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Edge of Sodium

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The absorption structure of sodium metals has been measured in the vicinity of the onset of 2p electron absorption. The results agree with theoretical investigations which claim a sharp absorption peak at the edge.

Recently interest in the absorption and emission structure near the onset of inner shell transitions in simple metals has been revived in a couple of theoretical papers.¹⁻⁹ Previously absorption at the edge was regarded as being due to transitions of core electrons into empty states just above the undisturbed Fermi level. This would explain a step in the absorption coefficient. The influence of the potential due to the deep state hole was considered to be negligible because

of immediate shielding by the conduction electrons. A more refined theoretical analysis yields the result that electron states in the vicinity of the Fermi surface are affected by the core potential in such a way that a singular behaviour of the absorption and emission occurs at the edge¹⁻⁹:

$$\mu \propto \frac{1}{|\Delta E|^\alpha} \quad (1)$$

where ΔE is the distance from the edge to higher (lower) energies in absorption (emission), μ is the absorption coefficient, respectively emission probability. α is expected to be positive for $L_{II,III}$ transitions whereas it can also achieve negative values for K transitions. In the latter case a smoothening of the edge instead of a peak should be observed.

We have considered Na as being an ideal metal to test these predictions because a peak near the onset could not be caused by a band singularity. Emission spectra of Na show a peak near the $L_{II,III}$ edge.¹⁰ The only older absorption measurements which came to our attention are those of O'Bryan.¹¹ Though some peaking near the edge was observed we felt that a re-measurement with better techniques was desirable.

Synchrotron light from the DESY accelerator served as the source of radiation. The Na films were evaporated from nickel boats onto substrate films of Mg and Al which were surrounded by surfaces cooled to 77° K. The base pressure in the system outside the cool trap was 10⁻⁶ Torr. The cooling served to

lower water vapor pressure and has been proved to be a good means¹² to get good metallic Na films without UHV. The samples themselves were maintained at 77° K. Absorption was measured immediately after evaporation and it was verified that none of the observed structures are caused by oxide.

Figure 1 shows our results. The absorption coefficient μ is given in arbitrary units since the film thicknesses were not determined. The reproducibility of curves from different samples which were fitted at two points was within 3 % of the total edge discontinuity. The accuracy of absolute energy calibration is ± 0.05 eV.

A peaking of the absorption towards the edge is clearly recognized. The structure is somewhat complicated by the spin orbit splitting of the edge showing up as a separation of 0.17 ± 0.02 eV. The observed intensity ratio of these two contributions is $L_{III}:L_{II} = 3.3:1$, whereas for independent levels this ratio is expected to be 2:1. This discrepancy indicates a coupling which is not included in the present theories yielding Eq. (1). The singularity showing up in Eq. (1) will be modified by Auger broadening of the ground state and temperature effects. The resolving power of our instrument as indicated in Fig. 1 was determined from the width of the zero order reflection. We do not believe that resolution was a limiting factor in the present experiments. The whole peak has a base width of approximately 1 eV. At

more than 1 eV above the onset the absorption coefficient becomes nearly constant with a broad maximum at 32.6 eV which is followed by some more structures not shown in Fig. 1. We shall come back to the complete absorption spectrum of Na elsewhere.

It should be noted that the peak height is about 40 % of the whole absorption discontinuity at the edge, whereas in the old O'Bryan¹¹ results only a small hump could be seen. In order to compare with the emission structure we have reversed the data of Crisp and Williams¹⁰ which are shown as a dashed line. The peak is similar in shape but less pronounced.

We have also carried through these experiments on other metals. Mg shows a peak very similar to that of Na. In Al, while still there, the effect is much weaker.

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Figure captions:

Fig. 1 Absorption coefficient μ versus photonenergy for sodium in the vicinity of the $L_{II,III}$ edge. The dashed curve gives emission results reflected in energy and adjusted at the edge.

Fig. 1

