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Cross Section in ALuminum**

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Contribution of L Shell to the Total Photon
Absorption Cross Section in Aluminum

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Some years ago the optical properties of aluminum, derived by Kramers-Kronig analysis of absorption coefficient data from 10^{-3} to 10^6 eV, were published in this journal by Ehrenreich and Philipp.¹ It was the first survey of the optical properties of a single material throughout the entire photon-energy region important for electronic processes.

The result for the effective number of electrons taking part in the photoabsorption was 8.2, far from the expected value of $Z = 13$. The deviation appeared to be mainly

due to the data of Tomboulian and Pell² which Ehrenreich and Philipp used for the L_{II,III} absorption region. The recent measurements by Fomichev³ yield μ values a factor of more than five higher than the earlier results of Tomboulian and Pell.

To check the values of the two previous reports and to study the contribution of the L_{II,III} band to the entire absorption cross section, transmittance data with foils of various thicknesses have been obtained at DESY using the synchrotron radiation as a light source. The experimental arrangement and analysis of the data were similar to those used in our measurements on other metals.⁴ The present resolution was better than 1 Å. 12 aluminum foils with thickness ranging from 50 Å to 4000 Å have been prepared on zapon. Figure 1 shows the measured absorption coefficient μ , in cm^{-1} , as a function of photon energy from 35 to 310 eV. Below the onset of L_{II,III} absorption at 73 eV the uncertainty of the μ values is estimated to be $\pm 30\%$ and $\pm 15\%$ above the edge. The general agreement of the values and structure of our results with those of Fomichev is excellent, although the relative heights of the three prominent peaks are slightly different in the two measurements.

The behavior of $n_{\text{eff}}(e)$ is shown in Fig. 2. It was calculated from the μ values with the formula

$$n_{\text{eff}}(E) = \frac{mc}{\pi e^2 Lh} \frac{A}{\rho} \int_0^E \mu(E') n(E') dE' \quad ;$$

where A is the atomic weight, ρ the density, n the index of refraction, and L is Avogadro's number. We set $n_{\text{eff}} = 3$ at the onset of $L_{\text{II,III}}$ absorption, as did Ehrenreich and Philipp, and extended the evaluation up to just below the onset of K absorption. Throughout the calculation, n was assumed to be unity.¹ The absorption coefficient for photon energies above those of our measurements was taken from references 6, 7, and 8. We find that n_{eff} is saturating toward the onset of K absorption, where it has reached 12.8. This value seems to be a little too high, because the summation over the whole K region should add ~ 1 to 2 to this value; n_{eff} would then exceed Z for the total sum by 10 % - 15 %. This is well within the experimental errors.

Although it is hard to conclude from this kind of analysis how the oscillator strength is divided among subshells, or whether there is enhancement in a particular subshell, this result gives a rough indication that both our and Fomichev's values of the observed absorption coefficient are reasonable in absolute magnitude. The sum rule holds within the accuracy of the experimental data.

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Figure Captions

Fig. 1 Spectral behavior of the absorption coefficient of aluminum in the $L_{II,III}$ band
The vertical bars indicate the onset of $L_{II,III}$ and L_I absorption according to Bearden and Burr.⁵

Fig. 2 n_{eff} of aluminum between the $L_{II,III}$ and K edges.



