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STUDY OF THE ABSORPTION OF ULTRASOFT X RAYS BY BISMUTH AND LEAD USING THE ORBIT RADIATION OF THE FRASCATI SYNCHROTRON

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In a previous publication[1] we gave a graph of the mass absorption coefficient of gold as a function of the energy of incident photons in the wavelength region 26 to 120 Å. This graph showed a marked absorption minimum at 144 eV. In the same article we pointed out that the general aspect of the bismuth absorption curve was largely similar to that of gold but with a shift in the minimum towards the shorter wavelengths.

The precise shape of the bismuth curve is presented here with values for its mass absorption coefficient over the wavelength range 25 to 85 Å. It will also be shown that lead, in this spectral region, has features similar to those of gold and bismuth.

The experimental technique employed has already been described briefly elswhere.[1,2] It is based on the use of the orbit radiation of the Frascati synchrotron and a grazing-incidence grating spectrograph. The absorption samples are thin films without support, obtained by vacuum deposition, the thickness being determined by weighing.

The bismuth mass absorption-coefficient measurements were limited to below 85 Å. At greater wavelengths the intensity of the second order diffracted by the grating is not negligible without a suitable filter; the shape of the absorption curve is modified and a considerable error in the absorption coefficient occurs.

The results are shown in Fig. 1. The value for each point was obtained by taking the average of 40 measurements with samples of bismuth varying in thickness from 0.27 to 0.66 mg/cm². We estimate the errors to be less than 8 % over the whole curve.

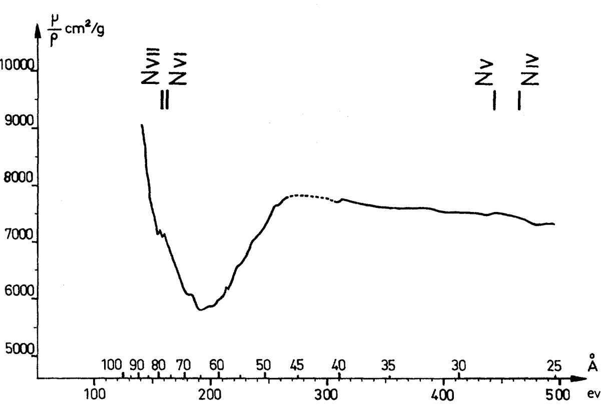

FIG. 1. Absorption by bismuth.

The lowest point on the curve is at 192 ± 2 eV while the corresponding value for gold is 144 ± 1.5 eV. The rise in the curve on the short-wavelength side of the minimum is less marked for bismuth than for gold. Some of the details on the original films are sufficiently reproducible to appear on the curve. There appear notably two small peaks at 158 and 162 eV. These energies are very close to the calculated values of the N_{VI} and N_{VII} levels[3,4] if the experimental errors (2 eV in this region) are taken into account. The calculated values[4] are indicated in the figure. It can therefore be assumed that the peaks are the weak N_{VI} and N_{VII} absorption discontinuities superimposed on a curve which is largely uniform in this region.

The experimental errors, in the energy region relevant to the N_{IV} and N_V levels, become large owing to the fall in resolving power of the spectrograph towards shorter wavelengths. The variations in the absorption coefficient observed in this region are small and cannot easily be attributed to these levels. We have already mentioned[1] the small peak at 214 ± 3 eV and suggested as a possible explanation a transition between the N_{III} and N_{IV} discrete levels, associated with a doubly excited atomic state. If such a hypothesis were confirmed, other particularities of the curve could be explained in a similar way.

At present, lead has not been studied in detail. We have simply shown in Fig. 2 the densitometer curve of a film obtained without an absorber (curve I) and that of a film obtained with the use of a 0.66-mg/cm^2 absorber of lead (curve II). They suffice to demonstrate the marked drop in absorption coefficient over a range comparable with that of gold and bismuth. Thus the observed drop is common to all three elements. This drop has been observed elsewhere[5] in the case of the lead, though less marked, it would seem, using the absorption of characteristic x-ray emission lines.

To explain this phenomenon, Combet Farnoux and Heno[6] have calculated the photoionization cross sections for the heavy elements, using a nonhydrogenlike model. Their calculation is in good agreement with the experimental results and account for both the existence and position of the minima we have observed so far.[7]

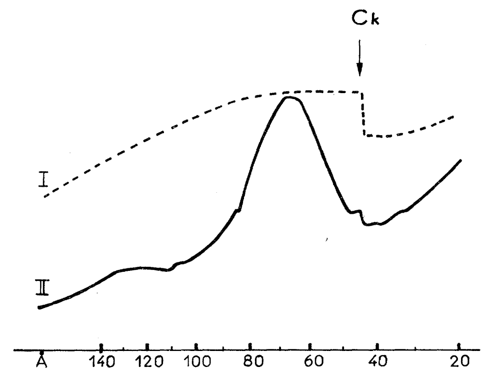

FIG. 2. Densitometer curve of a film without an absorber (curve I) and that of a film with the use of a 0.66-mg/cm^2 absorber of lead (curve II).

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[6]F. Combet Farnoux and Y. Heno, to be published.

[7]A more recent but similar work, carried out independently, also accounts for these minima: J. W. Cooper and S. Manson, private communication.