Relation between the K Absorption Edge and the $K\beta_2$ Line of Ni, Cu and Zn

By

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(Received November 15, 1930)

Abstract

The relation between the K absorption limit and the K_{β_2} line was investigated for the elements Ni, Cu and Zn by the method of comparison to get some light on the process by which X-rays are absorbed. For Zn and Ni the K limit is on the shorter wave-length side of the K_{β_2} line by the amount of 3.0 volts and 2.0 volts respectively, while in the case of Cu the K limit and the K_{β_2} line are just coincident. The result is compared with that which has been reported just recently by Kievit and Lindsay.[1]

Introduction

Recently evidence has been brought forward by several authors[2] to prove that the X-ray absorption edge does not correspond to the complete removal of an inner electron from the atom, but rather corresponds to the transition to an outer unoccupied orbit. Then, to the question "What is the outer level which gives the main edge?" the answer may be given that for the K absorption edge of the elements here considered it would be the $N_{II,\,III}$ level.[3] But the transition from the $N_{II,\,III}$ to the K level gives the line $K\beta_2$. So, if the above consideration is correct the K absorption edge and the $K\beta_2$ line will be just or very nearly coincident. The writer therefore attempted to investigate their relative position by taking photographs of the emission and the absorption spectra on different horizontal

1. B. Kievit and G. A. Lindsay: Phys. Rev., **36**, 648 (1930).

2. See, for example, E. C. Stoner: Phil. Mag., **2**, 97 (1926); K. Chamberlain and G. A. Lindsay: Phys. Rev., **30**, 369 (1927).

3. Cf. D. Coster and J. H. van der Tuuk: Nature, **117**, 586 (1926).

portions of one plate. At the beginning of the experiment he wondered whether the K electron of Cu might pass to the N_I level, because such a transition would form a Zn-like atom, and Cu might behave peculiarly in contrast to other elements. The experiment was first carried out for the elements from Fe to Zn with somewhat bad dispersion and a wide slit[1] to see the general trend. The result was that for all the elements, except Cu, the absorption limit was distinctly on the shorter wave-length side of the $K\beta_2$ line, but in the case of Cu the $K\beta_2$ line and the absorption limit fell so near each other that it could not be decided which was on the shorter side. Hence, he again studied the problem with much higher dispersion and a narrower slit. When the experiment for the elements Ni, Cu and Zn had just been finished a report was published by Kievit and Lindsay[2] showing similar results to those obtained in the present investigation. But in the case of Ni they reported that they found the K edge slightly longer in wave-length than the $K\beta_2$ line. This is quite different in the case of the present writer. It seems probable to the writer that the resolution of the line $K\beta_2$ and the satellite $K(\beta''')$[3] was not sufficient in the case of Lindsay and Kievit.

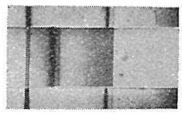
Experimental Method and the Results

The apparatus and method were the same as in the former research on the satellites of $K\beta_1$ except that the photographic plate was placed further from the slit, and the slit was made narrower to get higher accuracy. As analysing crystal, zinc blende (110) was used in the case of Ni and Cu, and calcite in the case of Zn. As the absorption screen, rolled metal foil was used in every case, the thickness being about 0.01 mm. The dispersion was 9.1 x. u. per mm. for Ni, 9.2 x. u. per mm. for Cu and 13.8 x. u. per mm. for Zn. The width of the slit was such that the width of the $K\beta_2$ line was about 0.06 mm. on the plate throughout. The most difficult thing was to determine which portion was to be considered the real absorption edge. The writer made the measurement by setting the microscope of a comparator on the shortest wave-length limit of the blackening. The point of the intensity maximum of the blackening was also measured as a check in the case of Zn, where the $K\beta_1$ line is

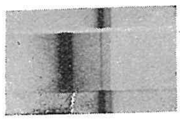
1. S. Kawata: These Memoirs, **13**, 383 (1930).
2. loc. cit.
3. S. Kawata: loc. cit.

sufficiently suppressed on the absorption spectrum, and it was found that that point was on the longer wave-length side of the limit by about half the width of the slit. The error in the measurement of the relative position of the K limit and the $K\beta_2$ line can not be much more than ± 0.1 x. u. Thus, the result was that for *Cu*, the $K\beta_2$ line and the K limit are just coincident, but for *Ni* and *Zn* the K limit is on the shorter wave-length side of the $K\beta_2$ line, the amount of the separation being about 0.36 x. u. and 0.4 x. u. or 2.0 volts and 3.0 volts respectively. Hence, from the above results, it seems probable that the K electron of *Cu* passes to the $N_{II, III}$ level but those of *Ni* and *Zn* (and also of *Fe* and *Co*) pass to some other outer levels, and it will be remarkable if the first permissible outer orbit of a K electron is more deeply situated for *Cu* than for other elements. To get more light on this point, the writer intends to study this problem again with the L absorption limit of the elements here considered.

In conclusion, the writer wishes to express his sincere thanks to Prof. Ishino for his kind guidance throughout the research.



Zn



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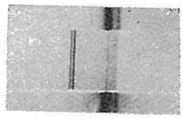

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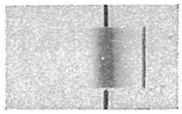
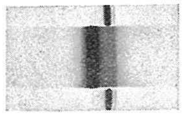


Co



Fe