The Probability of K Shell Ionizaton of Silver by Cathode Rays

In a very interesting paper[1] recently published, J. C. Clark describes the measurement of the absolute probability of K shell ionization of silver by cathode rays of different energies. The observed values are compared with certain theoretical values. In particular, in Fig. 5 comparison is made with three so-called wave-mechanical theories, one due to Wetzel, one to Soden, and the other is attributed to us. Unfortunately because of an oversight the wrong absolute values of our calculated probabilities were forwarded by us in our correspondence with Dr. Clark and the true values agree very closely with the observed—as shown in Fig. 1. and certainly better than do the other curves given in Clark's paper. This is to be expected, as the results of Wetzel and Soden do not represent wave-mechanical theories different from ours, but simply different and less accurate approximations to the integrals which arise in the wave-mechanical theory of collisions when applied in the first approximation. These integrals involve the average of the interaction energy between the ionizing electron and the atom over the wave functions of the initial and final states of the two electrons concerned (the incident and atomic electrons, respectively).

Wetzel[2] uses plane waves to represent the final wave function of the ejected electron and difficulties arise because of the lack of orthogonality between such a function and that representing the K shell states. We use final ejected electron wave functions which are exactly orthogonal to the K shell function, and must be quite accurate in the region of importance (screened hydrogenic functions being actually used). Soden[3] also uses orthogonal functions but does not evaluate the integrals involved exactly (an approximate method due to Bethe[4] being used)—and introduces a somewhat doubtful relativity correction.

It is of interest to point out that closer agreement is obtained between experiment and the first approximation of the wave-mechanical theory for the K ionization of silver than for the ionization of helium at corresponding energies (up to six times the ionization potential). This is to be expected, partly because the screened hydrogenic wave functions used are more accurate for silver than for helium and also because one would expect the second approximation of the theory (which allows of double collisions in which the excited atom is deactivated before the impinging electron passes out of the atomic field and so results in a reduction of probability) to be less important, the inelastic scattering from the K shell being small compared with the elastic scattering by the nucleus.

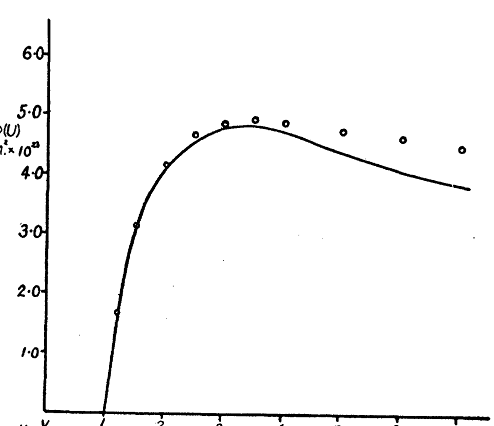

FIG. 1. Cross section $\phi(u)$ for k shell ionization *vs.* energy in case of silver. The circles represent Clark's experimental cross section. The full line is that calculated theoretically by the authors.

A more complete account will be published later and a correct relativistic treatment of the ionization probability is also being carried through.

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[1] J. C. Clark, Phys. Rev. **48**, 30 (1935).
[2] W. W. Wetzel, Phys. Rev. **44**, 25 (1933).
[3] D. Graf Soden, Ann. d. Physik **19**, 409 (1934).
[4] H. Bethe, Ann. d. Physik **5**, 325 (1930).

On the Stability of $_4Be^8$

Evidence for the formation of $_4Be^8$ in nuclear reactions has been obtained by various authors.[1, 2, 3] Since this isotope is spectroscopically as yet unknown, it was proposed that it is an unstable isotope of beryllium. From the gamma-ray spectrum resulting from the bombardment of Li by H, Crane and Lauritsen[1] come to the same conclusion; they deduce that Be has an excess of 0.0016 mass units and splits up therefore instantaneously into two alpha-particles of 3.5 mm range. These conclusions do not depend upon the assumed spectroscopic values of mass and are compatible with Bethe's[4] or Oliphant and others'[3] corrected values of mass.

Bonner and Brubaker[2] from the reaction $_1H^2+{}_3Li^7\rightarrow {}_4Be^8+{}_0n^1$ obtain for $_4Be^8$ a mass 0.3 ± 0.75 MEV greater than that of two alpha-particles. Recently Oliphant, Kempton and Rutherford[3] in a general revision of mass of light atoms assume that $_4Be^8$ is probably just stable.

It is known[5] that beryllium, when bombarded with gamma-rays, emits neutrons and it is probable that $_4Be^8$ is formed in this reaction.* We have therefore attempted, by using a linear amplifier, to detect alpha-particles, which can be perhaps ejected from Be bombarded with gamma-rays. One of the electrodes of the ionization chamber was covered with a layer of Be. Photographic oscillographic records were taken every 10 minutes alternately in absence and in presence of gamma-rays; a source of about 45 mc in equilibrium was used. In spite of the very strong gamma-radiation we are able to detect a single particle which produces in the chamber 4000 ion pairs.

From some experiments on activation by slow neutrons it results that our source produces in a second 1000 neutrons per gram of Be at 1 cm distance. This datum has been kindly communicated to us from Professor E. Fermi and Dr. B. Pontecorvo. We want here to express our gratitude to them.

If we take into account geometrical conditions, on the hypothesis that the initial range of the particles is, re-