The Electro-Disintegration of Cu^{63}, Ag^{107}, and Ag^{109}*

L. S. Skaggs**
Tumor Clinic, Michael Reese Hospital, Chicago, Illinois
AND
J. S. Laughlin and A. O. Hanson
Department of Physics, University of Illinois, Urbana, Illinois
AND
J. J. Orlin**
Bergen's Museum, Bergen, Norway
January 8, 1948

The electrons from the 22-Mev betatron have been used to study the disintegration of Cu^{63}, Ag^{107}, and Ag^{109} by the direct action of electrons having energies of 13 to 17½ Mev. This action gives rise to the same reactions as those produced by photons. The disintegration of Be^9 by direct electron bombardment has been reported and the cross section for electro-disintegration measured.[1]

The electrons are brought out of the donut by means of a magnetic shunt as a parallel monoenergetic beam.[2] The beam emerges from the donut through a 0.0015-inch Duralumin window. The current is of the order of 10^{-8} ampere and is concentrated in an area 5 cm wide and 2 cm high at a distance of 45 cm from the window.

A set of uniform foils placed in the path of an electron beam of energy greater than threshold energy should be activated due to both electro- and photo-disintegrations. If the total thickness of the foil assembly is small compared to the range of the electrons, then the number of electro-disintegrations will be approximately the same in each foil. Since the x-rays produced at these energies are almost entirely in the forward direction, the photo-disintegration in the assembly will increase linearly, to a first approximation, with foil position in the direction of the beam. The intercept of this linear increase of activity at the midpoint of the first foil represents the electro-disintegration effect plus the effect of any general x-ray background.

Sets of foils ¾ inch high and 1 inch wide were placed in the electron beam at a distance of 45 cm from the window of the donut. Additional single foils were placed just below the electron beam to measure the background x-ray effect. An open air ionization chamber placed just behind the foils measured the ionization produced by those electrons which passed through the foils. The electron current was determined from the ionization produced, assuming that electrons of this energy range give rise to 60 ion pairs per cm.[3]

In the case of Cu^{63} the reaction $Cu^{63}(e; n, e')Cu^{62}$ is expected above a threshold of 10.9 Mev.[4] Bombardments were made at 17½, 16, and 13 Mev with 0.005-inch foils and at 16 Mev with 0.002-inch foils. Ag^{107} and Ag^{109} have thresholds of 9.5 and 9.3 Mev, respectively. The activities induced in the foils were counted on thin-walled Geiger counters. Figure 1 shows a plot of the activity of Cu^{62} *versus* foil position for a set of 0.002-inch foils bombarded with 16-Mev electrons. The activities of Ag^{106} (24.5 min.) and Ag^{108} (2.3 min.) obtained by bombarding 0.001-inch foils with 16-Mev electrons are also shown. The electro-disintegration intercepts and the rate of increase of activity caused by the photo-effect were nearly the same for the two silver isotopes.

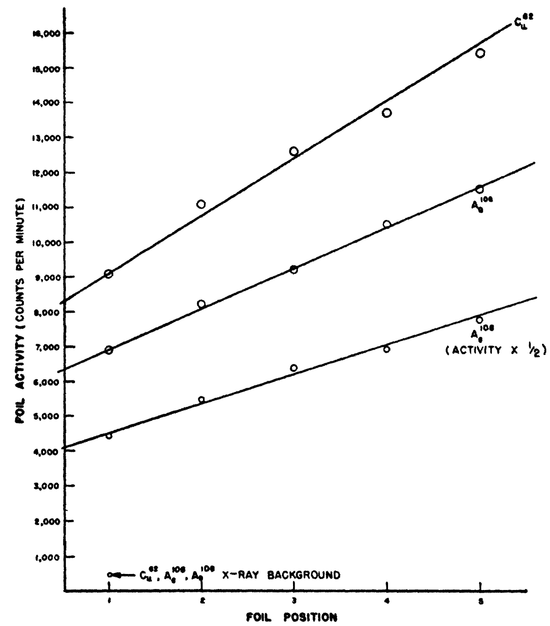

Fig. 1. The activity of Cu^{62}, Ag^{106}, and Ag^{108} as a function of foil position.

The calculated cross sections are given in Table I. The absolute values may be in error by a factor of two but the relative values are somewhat more accurate. The slopes of the lines in Fig. 1 with the theoretical value for the radiation cross section and the x-ray spectrum[5] can be used to estimate the photo-disintegration cross section. The average cross sections for photo-disintegration by x-rays above the threshold energy were consistently found to be 400 times that for electro-disintegration. This ratio is approximately that expected on the basis of calculations in which the interaction of the electron with a nucleus is represented entirely by its electromagnetic field.

Table I. Electro-disintegration cross sections in 10^{-29} cm².

Electron energy	Cu^{63}	Ag^{107}	Ag^{109}
13 Mev	1.4		
16 Mev	16	54	79
17½ Mev	32		

* This work was in part supported by ONR Contract N6ori-71, T. O. 1.
** Now on leave at the University of Illinois, Urbana, Illinois.

[1] G. B. Collins, B. Waldman, and E. Guth, Phys. Rev. 56, 876 (1939); M. L. Wiedenbeck, Phys. Rev. 69, 235 (1946).
[2] L. S. Skaggs, G. M. Almy, D. W. Kerst, and L. H. Lanzl, Phys. Rev. 70, 95 (1946).
[3] R. B. Brode, Rev. Mod. Phys. 11, 222 (1939).
[4] G. C. Baldwin and H. W. Koch, Phys. Rev. 67, 1 (1945).
[5] W. Heitler, *The Quantum Theory of Radiation* (Oxford University Press, London 1944), pp. 170–173.