Title
USE OF THE NUCLEOMETER SCALAR AND THE FOUR PI CHAMBER TO MEASURE ELECTRON CAPTURE RADIATIONS

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ABSTRACT

Here are reported the results of an investigation concerning the applicability of the four pi geometry proportional counter for absolute counting of simple electron capture decay. The isotope chosen for this study was At^{211}, where the absolute electron capture disintegration rate is calculable from the alpha disintegration rate. The proportional counter chamber was filled with methane at atmospheric pressure and various thin mounting films for the sample were used. The counting efficiency was found to vary greatly with type of mounting films and in only one case was greater than 74 percent. It is concluded that the four pi proportional counter is not particularly suited to absolute counting of simple electron capture decay.

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*This work was performed under the auspices of the AEC.

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We have continued our investigation to determine whether or not the four pi counter can be used to determine absolute electron capture disintegration rates. The four pi counting chamber, which was used as a methane flow type chamber, is the one shown in the pamphlet, "Conference on Absolute Beta Counting," with a two mil wire substituted for the one mil high voltage wire to bring the alpha plateau into the range of the nucleometer.[1] The amplifier and scaler are those of the Mark 9 Nucleometer with a 6AH6 pentode clipper at the input of the first amplifier tube to prevent overloading by the large alpha pulses and a 12AX7 triode between the two cathode follower stages to restore the gain to its original value. With this arrangement, a 0.3 microsecond pulse of amplitude 7 mv. - 20 v. gives less than one percent double pulsing.

At^{211}, formed by the (alpha, 2n) reaction on Bi metal with approximately 28 Mev alphas, was separated from the target by heating the target and collecting the At on a cold finger. The At on the finger

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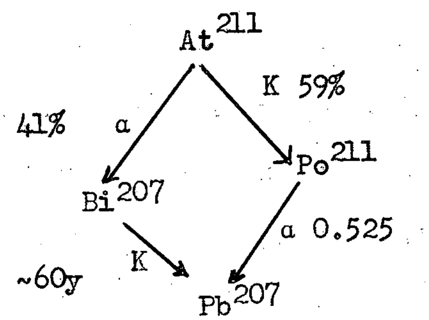
[1]"Conference on Absolute Beta Counting," National Research Council, February 28, 1949.

was dissolved with water and extracted with isopropyl ether, which solution was used in preparing samples 1-11. Because of contamination of the four pi chamber by sample 11, dilute nitric acid was added to the ether and the ether evaporated leaving the At in the nitric acid which was used in preparing samples 12-18. This operation left the At in a non-volatile form.[2]

The decay scheme of At^{211} is shown below. From a knowledge of the branching ratio and the counting rates for alpha decay, and electron capture plus alpha decay, the counting yield of the four pi counter for electron capture can be determined. The results are given in Table I.

At^{211} Decay Scheme



It was observed in the April experiments that the counter broke down at counting rates above approximately 10,000 counts per minute when only one surface of the tygon was made conducting by vaporizing metal on the surface, so both surfaces were covered in later experiments. However, difficulty was encountered in attempting both to make the surfaces conducting and to keep the thickness of metal small

[2]Johnson, Leininger, and Segré, "Chemical Properties of Astatine," AECD 1952, pg. 3, June 1, 1948.

Table I. Counting Yield in Percent for Electron Capture For Four Pi Counter Assuming 59 percent Electron Capture Branching in At^{211}.

Sample	1	3	4	5	6	8	9	10	12	14	15	16	16a	17	18
Date Prepared	4/17	4/17	4/18	4/18	4/18	4/20	5/21	5/21	5/22	8/8	8/8	8/9	8/9	8/9	8/9
Approximate Alpha Activity that Date (c/m)	45,500	9,600	8,100	16,000	25,000	730	51,000	9,500	17,400	85,000	19,400	5,300	9,000	15,500	22,500
Type of Backing	Au, one side tygon	Same	Same	Same	Same	Same	Ag, both sides tygon	Same	Au foil	Same	Same	Same	Same	Same	Same
Thickness of Conductor	Medium	Heavy	Light	Light	Heavy	Medium	Medium	Heavy	$4 \cdot 10^{-5}$ cm	Same	$1 \cdot 10^{-5}$ cm	Same	Same	Same	Same
Date 4/17	✓	88±2													
4/18	68±9	68±5	~0	~0	✓										
4/19	73±15			42±15	71±9										
4/20					71±9	56±10									
5/21							11±2	68±2							
5/22							27±3		✓						
5/23									20±2						
8/8										45.1 ±1.4	76±3				
8/9										46.1 ±1.4		67±4	(a) 72±3 (b) 74±3	58±2	60.0 ±1.2

(a) Bottom chamber walls of four pi counter covered with approximately 1 mm Pb.
(b) Both chamber walls of four pi counter covered with approximately 1 mm Pb.

and of the same thickness for all samples, so thin gold foils were used in later experiments. The fluctuation of the yields of samples 1-11 were probably caused principally by variations in the sample mounting. It was noted that solutions 12, 17, and 18 were colored yellow due possibly to the formation of a polymer which may account for the decreased yields of these samples due to absorbtion by the polymer. Also, the atomic number of the counter wall is a parameter of only small consequence as shown by sample 16a.

Gold of thickness 10^{-5} cm partially absorbs the L Auger electrons in At, whereas gold of thickness 4×10^{-5} absorbs all of these electrons. Thus by using a thinner backing, an increased counting yield can be obtained from the additional L Auger electrons passed through the backing, evidenced by the difference in counting yield between samples 12 and 14 and 15-18. Also, x-radiation soft enough to be appreciably absorbed by methane is absorbed by the gold. The sensitivity for soft Auger electrons and x-radiation is further decreased because the normal alpha plateau ends at a lower counter voltage than the normal beta plateau.

For an increased electron capture yield then (1) very thin Al films could be used, and (2) the determination of counting yields for electron capture could be carried out on an isotope having no alpha radiations.

It is evident from the erratic variation and generally low values of counting yields for electron capture in At^{211}, varying from sample to sample and even sometimes from day to day, that the four pi proportional counter is not suited for absolute electron capture disintegration rate determinations. At least this is true for At^{211} with a simple (no gamma) decay scheme. For electron capture decay involving at least one conversion electron of energy greater than 100 kev for each disintegration, essentially 100 percent counting yields should be obtainable in the four pi counter.