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A SEARCH FOR GAMMA RAYS FROM He^6 and F^{18}

William J. Knox

August 2, 1948

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A Search for Gamma Rays from He^6 and F^{18}

William J. Knox

August 2, 1948

The series of beta-active nuclei with (4n + 2) primary particles, He^6, Be^{10}, C^{14}, F^{18}, Na^{22}, etc. has created much discussion because some of its members show allowed transitions while others are forbidden. It seemed possible that the allowed cases might represent transitions to excited states; if so, a consistent rule would govern the transitions to the ground states. However, the results given below seem to exclude this explanation, unless the unlikely assumption of a very low energy gamma ray is made.

Absorption measurements[1] on F^{18} have shown a penetrating radiation which has the expected annihilation radiation energy of about 0.5 Mev. In order to exclude further the possibility of a true gamma ray of about 0.5 Mev energy, which would not be detected by half-thickness measurements, absorption curves on F^{18} and C^{11} have been compared to see if the ratio of positrons to photons is the same. C^{11} is assumed to have no gamma ray since the upper energy limit of its positron spectrum[2] corresponds very closely to both the mass difference[3] and the computed coulomb energy difference[2] between B^{11} and C^{11}, and the spectrum is apparently simple.

The C^{11} and F^{18} on which the measurements were made were produced by (n,2n) reactions on polystyrene foils and LiF using 90 Mev neutrons produced by the 184-inch cyclotron. The shorter lived activities (O^{15}, N^{13}, C^{11}) were allowed to decay out of the F^{18} samples before making measurements. The ratio of the number of counts coming

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1 Knight, Novey, Cannon, and Turkevich, Report CC-2605 (April 1945)

2 Delsasso, White, Barkas, and Creutz, Phys. Rev. 58, 586 (1940)

3 Haxby, Shoupp, Stephens, and Wells, Phys. Rev. 58, 1035 (1940)

from the sample when surrounded by 400 mg/cm^2 of Al to the number of counts extrapolated to zero absorber was observed to be .011 for C^{11} and .010 for F^{18}, both values with a probable error of about 10%. The brass walled, mica window Geiger tubes used for counting are expected to have a total counting efficiency of about 1% for the two 0.5 Mev photons from the annihilation process. It is concluded that greater than 80% of the positrons from F^{18} represent a transition to the ground state of O^{18}.

He^6 was obtained by bombardin powdered Be with 11 Mev neutrons produced by the 60-inch cyclotron. For the purpose of identification the half life was measured on an automatic photographic short half life measuring apparatus[4], and five determinations gave a value of 0.82 ± 0.06 seconds in agreement with previously reported values[5,6]. For absorption measurements a continuous flow method was used in which the He^6 was swept from the target with He^4, filtered through a fine glass wool plug, and transported through about 85 ft. of 3/16" tubing to the cyclotron control room where background radiation was low enough to make measurements while the cyclotron was operating. An end window Geiger tube suspended above a graphite block and surrounded by a lead shield was used for counting. The He^6 was swept through a chamber in the graphite block which was covered by a 1.5 mil Al window situated directly beneath the Geiger tube. In this manner essentially all of the He^6 beta particles emitted in the vicinity of the counter with the exception of those actually counted were absorbed in carbon, thus minimizing Bremstrahlung. Flat aluminum absorbers were interposed between the counting tube and the gas chamber and counting was done with the cyclotron operating at a constant level and with

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4 T. M. Putnam, to be published

5 Bjerge and Brostrom, Kgl. Danske. Videnskab. Selskab. Math-Fys. Medd. 16, No. 8 (1938)

6 Sommers and Sherr, Phys. Rev. 69, 21 (1946)

the He flowing at a constant rate. Under these operating conditions the reproducibility of a monitoring count using some standard amount of absorber was within ± 4% for a given set of measurements. The absorption curve obtained is reproduced below together with comparison curves taken under similar conditions of geometry and absorber arrangement on samples of P^{32} and UX_2. The initial portion of the curve was obtained with a (zero absorber) counting rate of about 10,000 c/m while the final portion was obtained with about five times this intensity. Coincidence corrections were made and all points were normalized to 100 at zero absorber. Probable errors due to counting are shown on the lowest points. The amount of radiation penetrating more than 2 gm/cm^2 of absorber is about 0.05% of the total number of counts, which is the magnitude expected due to production of Bremstrahlung. Hence, it is concluded that there is no gamma ray associated with the disintegration of the He^6 unless it is of very low energy ($<$ 100 Kev) or of low intensity ($<$ 10% of disintegrations if gamma ray were of 1 Mev). Feather comparison of the He^6 curve with the P^{32} and UX_2 curves gives ranges of 1.85 and 1.88 gm/cm^2 of aluminum, respectively. This corresponds to a maximum energy of 3.7 Mev, using the range-energy relationship $E_{max} = 1.85\ R + .245$[7], with an estimated possible error of ± 0.2 Mev. This value for the energy is in close agreement with previously reported values [5,6].

Appreciation is expressed to Professor E. M. Mcmillan for suggesting this problem. This paper is based on work performed under Contract No. W-7405-Eng-48 with the Atomic Energy Commission in connection with the Radiation Laboratory, University of California, Berkeley, California.

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7 Glendenin, Nucleonics 2 No. 1, (Jan. 1948)

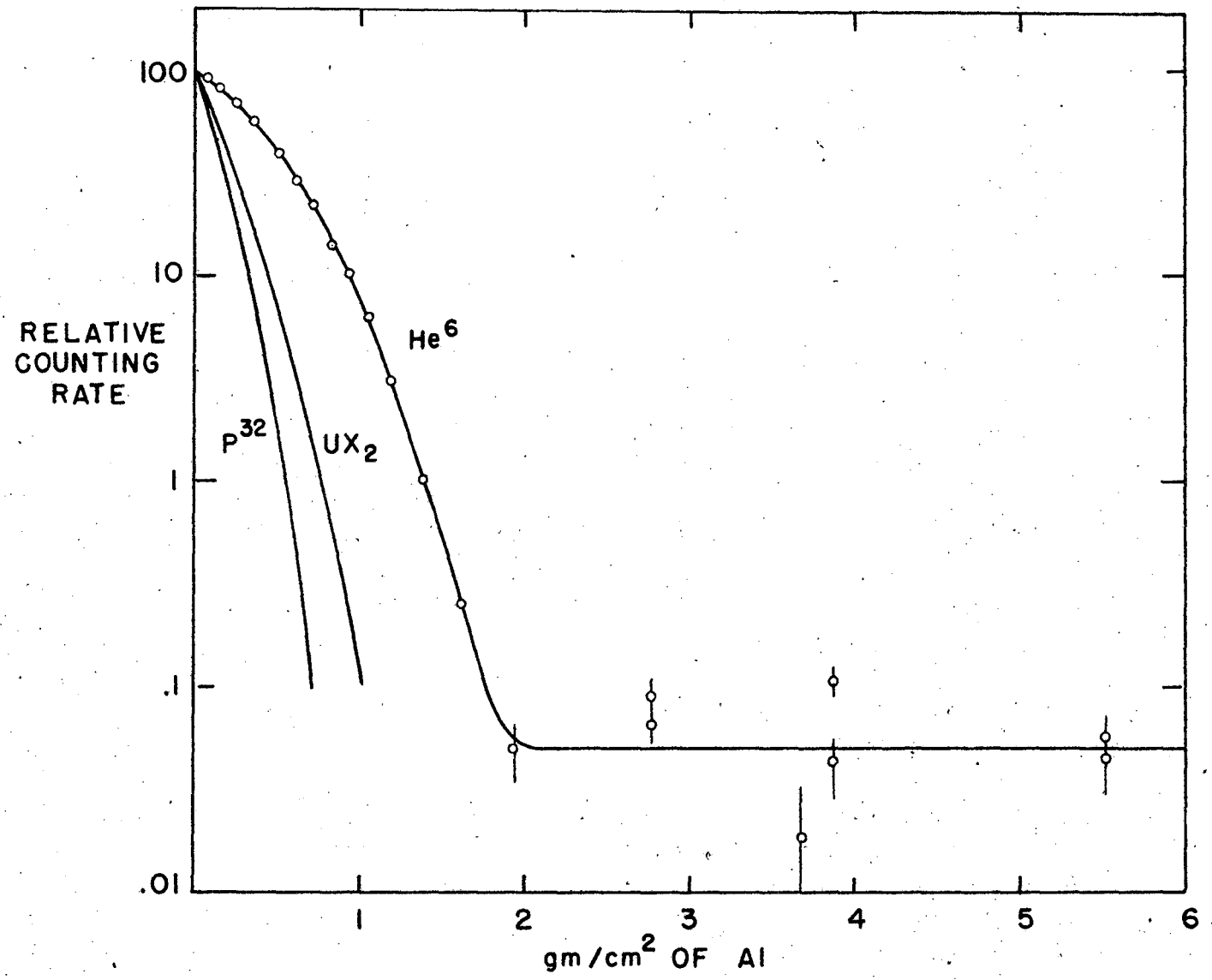

FIG. 1

ABSORPTION OF He^6 BETAS IN ALUMINUM AND COMPARISON CURVES ON P^{32} AND UX_2.

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