the lowest situated at 1637 kev in fair agreement with the threshold found by Richards *et al.*

Six of these resonances, i.e., 1928, 1974, 2014, 2028, 2079, and 2108 kev, have been detected in Cl^{37} targets, whereas none was found in Cl^{35}. This is in accordance with the highly negative Q-value calculated from accepted mass values for the $Cl^{35}(p, n)A^{35}$ process.

α-particles have been looked for (at a right angle to the proton beam) with a proportional counter, magnetic deflection being used to separate α-particles from scattered protons. In the interval from 1450 to 2040 kev, 10 resonances giving rise to α-emission have been found. The energy of the α-particles has been estimated from pulse size and gives a Q-value of 3.2 Mev. As the Q-value for the process $S^{32}(\alpha, p)Cl^{35}$ is known to be -2.1 Mev,[11,12] the α-particles are ascribed to the process $Cl^{37}(p, \alpha)S^{34}$.

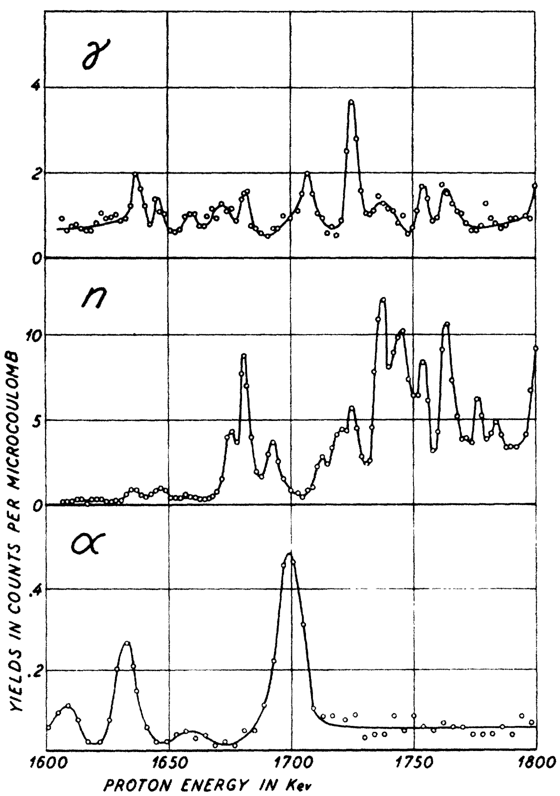

FIG. 1. Section of α-, n-, and γ-yield curves of a $PbCl_2$-target of about 4-kev stopping power.

At most resonance voltages more than one sort of radiation has been observed, e.g., at 1838 kev, 1928 kev, and at 1974 kev we have found conspicuous peaks in both the α-, γ- and n-curves, but a few strong peaks (e.g., the n-peak at 1693, the γ-peak at 1707, and the α-peak at 1699 kev) show up only in one of the yield curves.

In order to decrease the effect of voltage uncertainties, measurements were always made either of the n- and γ-yields simultaneously or of the n- and α-yields simultaneously.

In the whole voltage region the resonance widths are smaller than the experimental widths, which are for γ- and neutron peak 6–8 kev and for α-peaks 15 kev.

The average distance between the observed neutron peaks is about 14 kev. For the γ-peaks the distance is the same in the interval from 800 to 1500 kev whereas it is 25 kev from 1500 to 2150 kev. From this, however, it cannot be inferred that the density of γ-levels decreases with increasing energy, as the number of small peaks which are concealed by the background rises markedly with voltage. This is not the case with the neutron curve, where the background is much smaller. A more detailed account of the experiments and a closer discussion of the results will shortly appear in the Communications of the Copenhagen Academy (Kgl. Danske Videnskab. Selskab. Mat.-fys. Medd.).

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A Note on the Theory of Directional Correlation

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As a general formula for the correlation of 2 successive emissions of any nuclear particles, Falkoff and Uhlenbeck[1] found

$$W(\vartheta)=\Sigma_{M_aM_bM_c}P_{M_aM_b}(0)P_{M_bM_c}(\vartheta)=Q+R\cos^2\vartheta+S\cos^4\vartheta+\cdots, \quad (1)$$

where M_a, M_b, M_c are the magnetic quantum numbers of the 3 energy levels A, B, C. $P_{M_aM_b}$ is the relative probability for the transition $M_a\rightarrow M_b$ in the notation of F.U. In a more natural way $W(\vartheta)$ can be expanded in Legendre polynomials:

$$W(\vartheta)=\Sigma a_kP_k(\cos\vartheta). \quad (2)$$

Here a_k is a product of 2 factors I_k and II_k, which are dependent only upon the first and upon the second of the two transitions, respectively,

$$a_k=\mathrm{I}_k\mathrm{II}_k. \quad (3)$$

For pure transitions

$$\mathrm{I}_k=\{\Sigma_mC_{LmL-m}{}^{k0}(-1)^mF_L{}^M(0)\}W(I_BI_AkL|LI_C), \quad (4)$$

and the same formula holds for II_k with I_C replacing I_A. $W(I_BI_AkL|LI_B)$ is the Racah coefficient,[2] $C_{LmL-m}{}^{k0}$ the Clebsch-Gordon coefficient as used, for example, in the paper of Gardner.[3] If the influence of the magnetic field of the electronic shells on the angular correlation has to be taken into account, the general formula is

$$a_k=\mathrm{I}_k\mathrm{II}_kG_k, \quad (5)$$

where G_k is an attenuation factor, given by

$$G_k=\sum_{FF'}\frac{(2F+1)(2F'+1)|W(I_BJkF|F'I_B)|^2}{1+(\nu_{FF'}|2\gamma)^2}. \quad (6)$$

Following Goertzel,[4] J denotes the electronic angular momentum, F the total angular momentum, $\nu_{FF'}$ the hyperfine splitting, and $4\pi\gamma$ the total transition probability of the intermediate nuclear state B. G_k is completely independent of multipole order and of the spins of initial and final state. G_k can be split up into a part $F=F'$ and into interference terms $F\neq F'$. The latter are negligible when the interaction is strong $\nu_{FF'}\gg2\gamma$. We are left then with a minimum correlation.

$$(G_k)_{\min}=\Sigma_F(2F+1)^2|W(I_BJkF|FI_B)|^2.$$

The case $J=\frac{1}{2}$ can be easily discussed. The sum of the Racah coefficients gives

$$G_k = 1 - \frac{k(k+1)}{(2I_B+1)^2}T, \quad T = \frac{(\Delta\nu/2\gamma)^2}{1+(\Delta\nu/2\gamma)^2},$$

with the minimum value

$$(G_k)_{\min} = 1 - k(k+1)/(2I_B+1)^2.$$

For $\Delta\nu/2\gamma = 2\pi\Delta\nu c\tau_B = 1$ (τ_B mean life of the level B) the attenuation is exactly half of its maximal value; $(2\pi\Delta\nu c)^{-1} = \tau_0$ is a characteristic time for this attenuation. The values of τ_0 for different values of $\Delta\nu$ is shown in Table I. The variation of $G_{k,\min}$ as a function of k and I_B may be seen in Table II. An application of

TABLE I. τ_0 as a function of $\Delta\nu$.

$\Delta\nu$	0.001 cm^{-1}	0.01 cm^{-1}	0.1 cm^{-1}	1 cm^{-1}	10 cm^{-1}
τ_0	$5.3\cdot10^{-9}$ sec	$5.3\cdot10^{-10}$ sec	$5.3\cdot10^{-11}$ sec	$5.3\cdot10^{-12}$ sec	$5.3\cdot10^{-13}$ sec

formula (4) which permits the determination of the multipole order and the character of an electromagnetic transition is the following.

TABLE II. $G_{k,\min}$ as a function of k and I_B.

I_B \ k	2	4	6	8	10
1	0.33				
3/2	0.52				
2	0.76	0.20			
5/2	0.83	0.44			
3	0.88	0.59	0.15		
7/2	0.91	0.68	0.34		
4	0.93	0.75	0.48	0.11	
9/2	0.94	0.80	0.58	0.28	
5	0.95	0.84	0.65	0.40	0.09

If in addition to the correlation of the $\gamma - X$ transition (where X stands for any particle) it is possible to measure the $e^- - X$ correlation of the respective $e^- - X$ transition (e^- conversion electrons), then the ratio A_k/B_k is dependent only upon k and the multipole order. A_k and B_k are the coefficients of the Legendre polynomials for the $\gamma - X$ and $e^- - X$ transition, respectively.

For an electric 2^l transition we get, with $A_0 = B_0 = 1$,

$$A_k/B_k = 1 - [k(k+1)/2l(l+1)].$$

For a magnetic 2^l transition we get

$$\frac{A_k}{B_k} = \frac{l+1}{2l+1}\,\frac{k(k+1)-2l(2l+1)}{k(k+1)-2l(l+1)}.$$

Both formulas are valid for low Z and nonrelativistic energies.

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Properties of Plutonium-243

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To build up an appreciable concentration of higher plutonium isotopes by successive neutron capture, a sample of Pu^{239} was subjected to a prolonged neutron irradiation. After irradiation the plutonium was isolated from fission products and other impurities by extraction with di-ethyl ether. The isotopic composition of this plutonium was determined mass-spectrometrically by Inghram and Hess.[1] In addition to Pu^{239} they found measurable amounts of Pu^{240}, Pu^{241}, and Pu^{242}.

Samples of a nitrate solution of this plutonium were evaporated to dryness in a quartz tube and irradiated in the thimble of the Argonne heavy water reactor for periods of time varying from two to twenty-four hours. At the end of each irradiation the plutonium was rapidly purified from all extraneous activity by a series of precipitations and solvent extractions. The purifications were continued until the ratio of beta-activity (corrected for decay) to alpha-activity became constant. A five-hour beta-activity remained with the plutonium despite many attempted separations, and was formed with the same cross section in each of the irradiations.

Samples of Pu^{239} containing negligible quantities of higher plutonium isotopes, when subjected to irradiation and subsequent chemical purification under conditions identical to the test samples, showed no traces of the induced five-hour activity.

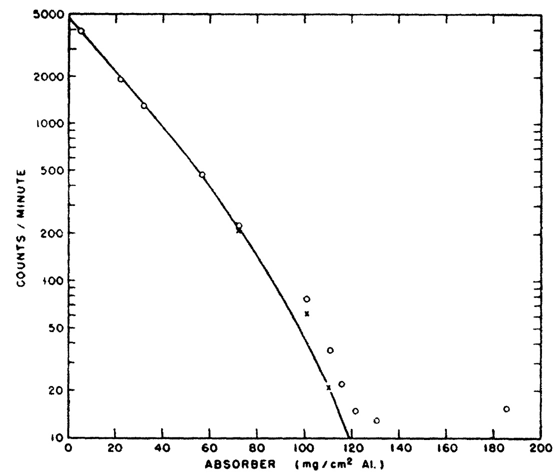

FIG. 1. Aluminum absorption curve with a helium filled, mica end-window tube. The circles represent values corrected for decay, and the crosses represent values corrected for both decay and the constant Geiger background of the plutonium.

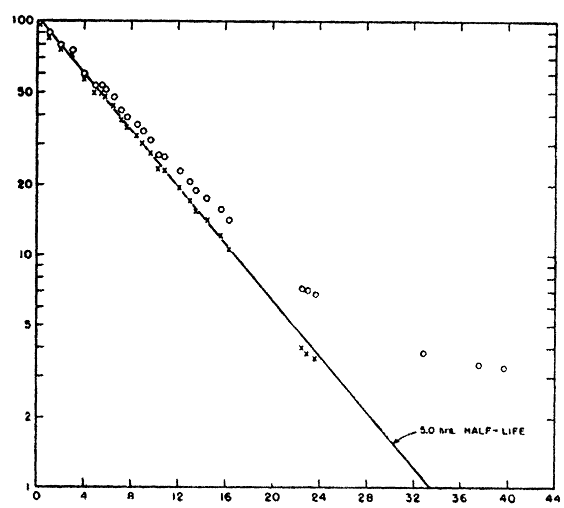

FIG. 2. Decay of Pu^{243}. The circles represent the actual values obtained, while the crosses are these values corrected for the constant Geiger background of the plutonium.