In calculating the cross section, data from only those channels representing pions removed from the beam by nuclear interactions, i.e., from those channels in which the contamination was small, were used.

The curve of Fig. 2 shows the efficiency for observing removal of pions from the beam in the attenuator as a function of the pion scattering angle, determined from the geometry of the counters. The measured cross section, based on 9×10^5 pions, is after correcting for muon contamination, 12.4 ± 3 millibarns. If the scattering at this energy is assumed to be isotropic in the center-of-mass system, the total cross section is 16.6 ± 4 millibarns; a $\cos^2\theta$ distribution gives a σ_t of 20.8 mb; a $\sin^2\theta$ distribution yields 14.9 mb.

The work is being extended to lower pion energies.

* Work performed under the auspices of the AEC.

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The Decay of Am^{241}

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STUDIES of the low energy gamma-rays and L rays from the decay of Am^{241}, reported in a previous letter,[1] have been continued. Coincidence measurements, using a resolving time of 2 μsec between the 59.7-kev gamma-rays detected in a sodium iodide crystal and the other radiation detected in a proportional counter, showed that (6 ± 0.8) percent of the radiation in the three low energy groups was coincident and that an upper limit of 3.6 percent could be set to the amount of coincident 26.3-kev radiation. The level sequence in Np^{237} deduced from the measured alpha-particle groups[2] is given in Fig. 1. The method of decay shown is

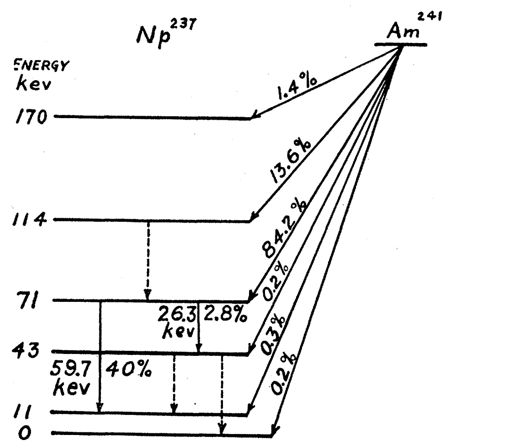

Fig. 1. Tentative decay scheme of Am^{241}. Intensities of alpha-particles and gamma-rays are expressed in percentages of Am^{241} disintegrations. Dotted lines denote highly converted transitions. The relative intensities of the two possible transitions from the 43-kev level have not been determined.

consistent with the above results if the 114-kev state decays by internal conversion to the 71-kev state with a lifetime of less than 2 μsec and if the low energy groups are due predominantly to L radiation.

A measurement of the lifetime of the 71-kev state was made by the delayed coincidence method, using a sodium iodide crystal to detect the 59.7-kev gamma-rays, zinc sulfide to detect the alpha-particles, and a conventional coincidence circuit of resolving time 0.1 μsec. The result shown in Fig. 2 gives a half-life of $(6.3\pm0.5)\times10^{-8}$ sec. (This may be too high by up to 40 percent in the unlikely event of a lifetime between 0.03 and 0.15 μsec for the 114-kev state.) A series of measurements were made using different phosphors; substantially the same result was obtained for all of them. A curve obtained in a similar way but using the $\alpha-L$ ray coincidences from the decay[3] of Pu^{239} is given for comparison. This shows that the form of the alpha-gamma delay curve is not a property of the equipment and also that the half-life of the Pu^{239} radiation is less than 2×10^{-8} sec. In order to eliminate the possibility of any systematic error arising from the use of a slow coincidence circuit and slow phosphors a further measurement was made using a "fast" circuit of resolving time 2×10^{-8} sec with anthracene scintillators. The relatively low gamma-ray detection efficiency obtainable with this arrangement made accurate measurements difficult, but the value of $(7\pm1)\times10^{-8}$ second obtained is a satisfactory check on that given above.

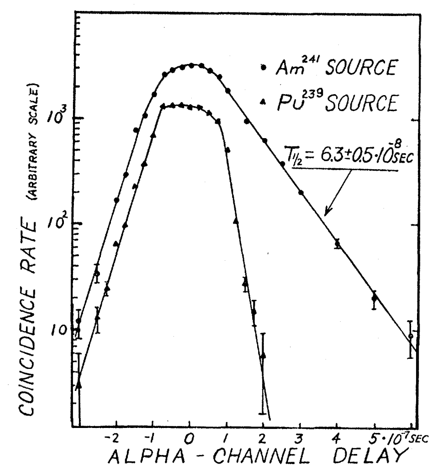

Fig. 2. Alpha-gamma coincidence delay curves.

From the fact that the right-hand side of the delay curve has constant slope to within the accuracy of measurement it can be deduced that the half-life of the 114-kev state must either be less than 0.15 μsec or more than 1.5 μsec. The latter possibility was excluded in the following way. The product of the alpha-particle and 59.7-kev gamma-ray rates divided by the coincidence rate, was determined from an alpha-gamma coincidence experiment using a resolving time of 1 μsec, and was compared with the alpha-particle source strength as measured in a counter with well defined geometry. The agreement between these values indicated that the lifetime of the transition from the 114-kev state was less than 1 μsec. By similar measurements on the total radiation it was possible to set an upper limit of 0.3 μsec on the half-life of the 43-kev state. We can therefore conclude that these states decay mainly by $M1$, $M2$, or $E2$ transitions, $E1$ being eliminated since no gamma-rays of the corresponding energies were observed.

Without assuming anything other than that the observed 59.7-kev gamma-radiation is due to a single transition, we can set an upper limit of 1.5 on its conversion coefficient since there are 0.40 of these gamma-rays per alpha-particle.[1] If we assume the decay scheme of Fig. 1 then an upper limit to the conversion coefficient of the 26.3-kev gamma-ray is 20. By interpolation and extrapolation from the tables of L conversion coefficients of Gellman *et al.*,[4] it can then be deduced that both of these gamma-rays arise mainly from electric dipole ($E1$) transitions.

Weisskopf's lifetime formula[5] is not expected to give accurate results for $E1$ transitions; nevertheless, the discrepancy of $\sim4\times10^5$ between the values calculated from it and the measured gamma-ray lifetimes is interesting. The observed ratio of lifetimes for the 59.7- and 26.3-kev gamma-rays is, however, in good agreement with that calculated from the formula.

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Experimental Demonstration in the Laboratory of the Existence of Magneto-Hydrodynamic Waves in Ionized Helium*

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THIS laboratory has been investigating the properties of ionized gases at low pressures in a toroidal discharge tube where ion diffusion to the walls can be retarded by a magnetic field co-annular with the toroidal tube. The discharge is excited by a 2-microsecond pulse applied to a primary winding of 10 turns of wire on a pulse transformer core which links the toroid. The secondary of the pulse transformer is effectively the ionized gas in the toroidal discharge tube; the peak current in this gas under some circumstances goes as high as 8000 amperes. The densities of electrons and ions and the electron temperature can be measured in the afterglow period in this discharge tube by means of a probe which is connected mechanically to the amplifier of a synchroscope only during an "examining interval" of about 1000 microseconds. Except during this examining interval, which can be variably delayed with respect to the excitation pulse, the probe floats in the plasma and is decoupled from both the amplifier and the voltage source.

With a short probe (3-mm effective length) inserted into the region of high ion-density gradient near the tube wall, oscillations can be observed on synchroscope traces of both the positive ion current [Fig. 1(a)] and the electron current [Figs. 1(b) and 1(c)]. These oscillations are either subdued or absent when the probe is inserted to the center of the discharge tube. These oscillations are entirely absent when no dc magnetic field is present [Fig. 1(d)]. The synchroscope photographs represent the traces of several pulses on the same exposure. Although the phases of the oscillations are, in general, not coherent from pulse to pulse, it is nevertheless possible to delineate from the photographs oscillations involving several cycles of definite periods of approximately 100 microseconds. These oscillations in ion and electron density near the wall of the tube suggest the presence of standing magneto-hydrodynamic waves set up around the toroid whose length L is approximately 100 cm. The propagation velocity V of such a wave[1] is given by $V=H_0(1/4\pi\rho)^{\frac{1}{2}}$, where H_0 is the value of the dc magnetic field in gauss and ρ is the density of the gas. For a standing wave $L=n\lambda/2=nV/2\nu=nH_0/2\nu(4\pi\rho)^{\frac{1}{2}}$, so the frequency of the standing wave $\nu=nH_0/2L(4\pi\rho)^{\frac{1}{2}}$, where n is an integer. With our experimental conditions of $\rho=3\times10^{-9}$ g/cc and $H_0\cong400$ gauss the computed $\nu\cong400n/[2\times100\times(4\pi\times3\times10^{-9})^{\frac{1}{2}}]\cong10^4n$. If $n=1$ this value of the frequency ν agrees reasonably well with the observed frequency of 10^4 cycles/sec. Furthermore, if the wave is to be undamped to the extent that a standing wave can be set up in the length L, it can be computed from Alfven's relationship[1] that $LH_0>\pi^{\frac{1}{2}}c^2(\rho)^{\frac{1}{2}}/\sigma$, where σ is the conductivity of the gas in cgs units and c is the speed of light in cm/sec. If we take a reasonable value of $\sigma=10^{13}$ cgs units, the inequality is maintained for our circumstances, and we should expect to observe standing waves.

Attempts to demonstrate quantitatively the dependence of V on H_0 for these waves have not yet met with success in this toroid because of the difficulty of setting up standing wave patterns at several values of the field H_0. It has been observed qualitatively however, that at the higher values of H_0 it is frequently difficult to set up a good standing wave pattern and that the pattern presented contains noise of frequency higher than is generally observed at the lower values of H_0. The amplitude of the oscillations is lower with the higher values of H_0.

These oscillations in ionization density at the plasma periphery are ascribed to displacements associated with magneto-hydrodynamic waves. These oscillations have also been observed in H_2 and N_2.

Magneto-hydrodynamic waves very likely play a role[2] in increasing the rate of ion diffusion perpendicular to the magnetic field.

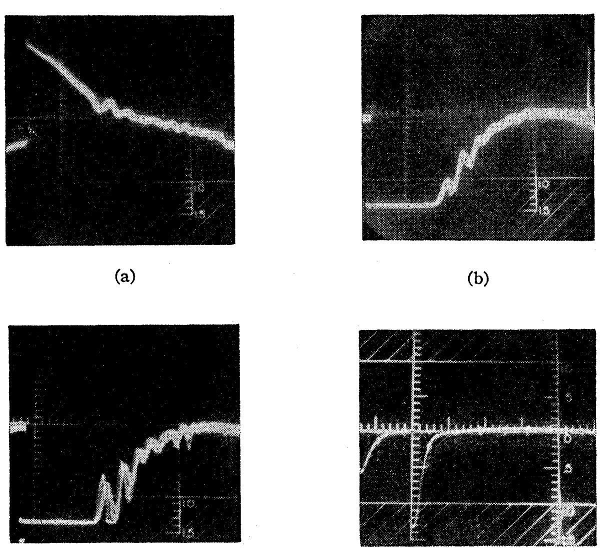

FIG. 1. Oscillations on current to probe in He at a pressure of 0.020 mm. The examining interval begins 600 microseconds after the excitation pulse. (a) Positive-ion current, $H_0=530$ gauss; (b) electron current, $H_0=530$ gauss; (c) electron current, $H_0=410$ gauss; (d) $H_0=0$, when no oscillations occur anywhere in the afterglow period.

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Acceleration of Beryllium and Carbon Ions in a Synchrocyclotron*

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NUCLEAR emulsions have been exposed to carbon and beryllium ions in the University of Chicago synchrocyclotron. Carbon ions of energies as high as 1.1 Bev have been directly observed in photographic plates. The acceleration of carbon and oxygen ions in the Berkeley 60-inch cyclotron has been previously reported.[1–5] In the present experiment CO_2 gas was introduced into the ion source of the Chicago cyclotron in place of the hydrogen which is normally used. In order to eliminate the large number of $(H_2)^+$ ions originating from the water vapor inside the cyclotron tank, the upper frequency limit of the oscillator and the magnetic field were adjusted so that $(H_2)^+$ would not be accelerated near the center of the cyclotron. However, under these conditions, carbon ions with 5 electrons removed and Be atoms completely stripped could be accelerated. The beryllium ions are