hydrogen events" were examined under high magnification to determine whether one or more light tracks were also associated. One example of a pair of light tracks, assumed to be electrons, was found (Fig. 1).

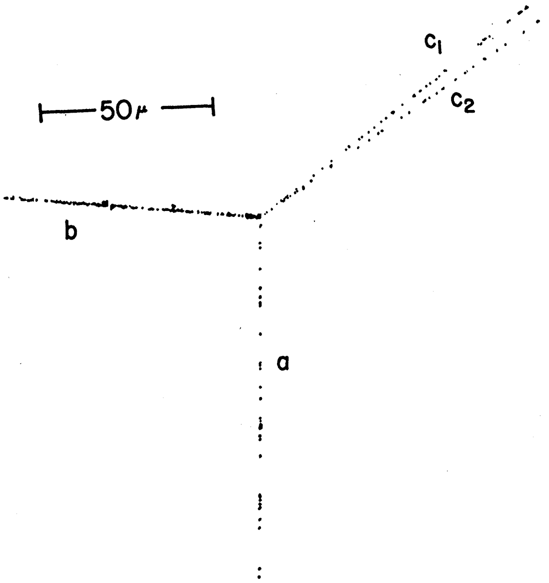

FIG. 1. Electron pair produced by 113-Mev positive pion: *a*, incident pion; *b*, proton of 75±10 Mev or other fragment of same ionization; c_1, c_2 electrons of 27±9 and 56±14 Mev, respectively.

The angle between the two electron tracks θ is 5.2 ±1.0° and the angle between the direction of the incident pion and the direction of the center of mass of the pair ϕ is 62±2°. The energies of the two electrons are 27±9 Mev and 56±14 Mev. These data are consistent with the earlier results obtained on the negative-pion-produced pairs[2] except for the angle ϕ, which is smaller than any of the angles reported earlier and which seemed in the earlier work to have an improbably sharp distribution centered around 115° in the laboratory system. Since this is the only case in the positive beam, the significance of the occurrence of such an angle is not clear.

In the area scanned for this experiment, there were $(1.56\pm0.05)\times10^5$ cm of pion track.[2] Since the mean free path for pions at very nearly the same energy[3] is 33.6±17 cm, approximately 4600 interactions must have occurred. Approximately one-eighth of these would be "possible hydrogen events" as described earlier. Thus one pair was found in about 600 stars examined.

There is no visible gap on this pair, and a gap would have been seen if it were as large as one micron.

It is suggested that this pair can be interpreted as the result of the charge-exchange scattering of a pion on a neutron in a nucleus of the emulsion:

$$\pi^+ + n \rightarrow \pi^0 + p, \qquad (1)$$

followed by the direct decay of the neutral pion, as predicted by Dalitz[4] and as observed by various authors:[5]

$$\pi^0 \rightarrow e^+ + e^- + \gamma. \qquad (2)$$

Process (1) is the charge-symmetric analog of the process which was used to explain the pairs in the negative pion beam:

$$\pi^- + p \rightarrow \pi^0 + n. \qquad (3)$$

Since there are approximately as many neutrons as protons in the emulsion the cross sections for (1) and (3) should be nearly the same, which is not inconsistent with the results reported here. The lack of a visible gap between the pair and the star is in agreement with the short lifetime reported earlier.

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[†] Institute for Nuclear Studies. Now at Department of Physics, Columbia University, New York, New York.

[‡] Department of Physics.

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Long-Lived Radioactive Aluminum 26*

JAMES R. SIMANTON, ROBERT A. RIGHTMIRE, ALTON L. LONG, AND TRUMAN P. KOHMAN

Department of Chemistry, Carnegie Institute of Technology, Pittsburgh, Pennsylvania

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THERE are experimental[1–5] and theoretical[6–9] indications of a state in Al^{26} lying below the 6-second positron-emitting 0^+ state. The ground state apparently[4,5] lies 4.0 Mev above that of Mg^{26} and is expected[6–9] to have a 5^+ configuration. If the Mg^{26} states at 1.83 and 2.97 Mev[10] both have 2+ configurations, Al^{26g} should decay predominantly by positron emission to the 1.83-Mev state with a half-life estimated[4,9] at 10^4–10^6 years, with smaller amounts of electron capture to both states.

We have sought radioactivity in aluminum carrier isolated from a target of commercial magnesium bombarded with 400 μa-hr of 15-Mev deuterons in the University of Pittsburgh cyclotron. After numerous NH_4OH precipitations at pH∼6, numerous NaOH precipitations of $Fe(OH)_3$, and two 8-hydroxyquinoline precipitations, the aluminum was weighed and counted as Al_2O_3 ("Al_X"). It was then dissolved by a $Na_2B_4O_7$ fusion and put through a cycle consisting of: NH_4OH precipitation at pH∼6 with Zn hold-back carrier; CuS precipitation in dilute HCl; $BaSO_4$ precipitation in dilute HCl; 8-hydroxyquinoline precipitation at *p*H$\sim$5 with Be and phosphate hold-back carriers; precipitation of $Fe(OH)_3$ in 0.1*N* NaOH; NH_4OH precipitation at *p*H$\sim$6; and ignition to Al_2O_3 ("Al_Y"). After weighing and counting it was put through the same cycle plus a LaF_3 precipitation in dilute HCl, and again weighted and counted ("Al_Z").

Beta activities were measured with a mica-window Geiger counter at a counting yield of 0.2 count/disintegration. Gamma activities were measured with a NaI(Tl) scintillation spectrometer, all pulses above $\sim$0.25 Mev being counted. The results are summarized in Table I. The constancy of the specific activity through the variety of chamical separations indicates that the residual activity is definitely aluminum, and that sample Al_X was already essentially radiochemically pure.

TABLE I. Activity of successively purified aluminum samples.

Sample	Al_X	Al_Y	Al_Z
Wt. AL_2O_3(mg)	38.6	29.0	16.0
β activity[a] (counts/min)	26.4±1.2	19.7±1.3	10.3±1.4
γ activity[a] (counts/min)	14.5±1.5	>9.1±1.0[b]	4.5±1.2
Spec. β activity[a] (counts/min mg)	0.68±0.03	0.68±0.04	0.64±0.09
Spec. γ activity[a] (counts/min mg)	0.38±0.04	>0.31±0.03[b]	0.28±0.08

[a] Precision indices are standard deviations calculated from counting statistics only; true uncertainties are somewhat greater.
[b] γ activity low because bias was $\sim$0.33 Mev instead of $\sim$0.25 Mev.

Absorption measurements on Al_X indicated $\sim$1-Mev electrons; the weakness of the sample prevented an end-point determination. A low-resolution pulse analysis of the γ-activity present after the first 8-hydroxyquinoline precipitation ("Al_W") showed peaks at 0.5 and 1.9 Mev, a band from 0.1 to 0.3 Mev, and a band from 0.8 to 1.6 Mev which seemed to contain some unresolved peaks. Broad-channel measurements of the smaller and weaker Al_X showed the same distribution of pulses as in Al_W, indicating that the Al_W γ activity was essentially the same as that surviving the subsequent purifications. These observations are consistent with a dominant mode of disintegration of Al^{26g} by positron emission to the 1.83-Mev first excited state of Mg^{26}. The 0.5-Mev peak is presumably due to annihilation radiation, and the two bands principally to secondary effects. More definite characterization of the disintegration awaits the preparation of a more intense source.

The reactions responsible for Al^{26g} production are $Mg^{25}(d,n)$ and $Mg^{26}(d,2n)$. In the absence of (d,n) and $(d,2n)$ cross sections for comparable elements, we take the yield of each to be similar to that of $Mg^{24}(d,\alpha)Na^{22}$ in the same cyclotron. The latter is 0.28 millicurie per 150 μa-hr.[11] The specific β activity found indicates a total Al^{26g} activity of $\sim$600 disintegrations/minute in the 100 mg of Al carrier added to the target. Assuming that equal amounts of Al^{26m} and Al^{26g} were produced and considering the relative abundances of the Mg isotopes, the above yield corresponds to a half-life of $\sim 10^6$ years.

The occurrence of positrons in series with 1.83-Mev gammas eliminates the possibility[1] that $Al^{26g}-Mg^{26g} = 2.5$ Mev. If, as follows from the most precise reaction data,[5] $Al^{26g}-Mg^{26g}=4.01\pm0.02$ Mev, the maximum positron energy is 1.16 Mev. The comparative lifetime is then $\sim 10^{14}$ seconds, consistent with second-order forbiddenness, which would result if the Al^{26g} configuration is 5+ and that of the first excited Mg^{26} level is 2+ (rather than 1+ as favored by others[12]). The slowness of the transition eliminates the possibility[9] that the second excited state of Mg^{26} has a 4+ configuration.

Hitherto, aluminum has been the only element without either a radioactive or stable isotope suitable for tracing. If the problem of producing sufficient quantities of Al^{26} can be solved, this nuclide should be of considerable value in chemistry, metallurgy, and related fields.

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Orbital Electron Excitation Associated with Electron Capture in A^{37}†

MAX WOLFSBERG
Chemistry Department, Brookhaven National Laboratory,
Upton, Long Island, New York

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RECENTLY, Miskel and Perlman[1] have analyzed in a proportional counter the pulse-height spectrum produced by the decay of A^{37}, which consists mainly of one peak, centered at 2.83 kev, the *K* binding energy of chlorine. They interpreted the processes giving rise to pulses in the region between 5.4 and 9.7 kev, after appropriately correcting the data, as *K*-electron excitation and ejection accompanying *K* capture. Thoeretical computations on such processes had previously been carried out by Primakoff and Porter.[2] It is the purpose of this note to investigate the