The Disintegration of As^{74}

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THE 17.5-day activity of As^{74} is known to emit positrons, negatrons and γ-radiation.[1] Recently, Mei, Mitchell, and Huddleston[2] found that the negatron spectrum was complex, having the components $E\beta_2{}^-{}_{max}=0.82$ Mev and $E\beta_1{}^-{}_{max}=1.45$ Mev. The difference between the two β^- components (0.63) Mev did not agree with the observed γ-energy (0.593 ± 0.003 Mev), but this could possibly be explained from inaccuracies in the Fermi analysis. This circumstance, however, had also been observed in our laboratory together with the peculiar fact that not only the negatrons but also the positrons were accompanied by γ-radiation, in spite of the fact that only one γ-ray was known to exist. A detailed investigation of the disintegration was therefore performed.

The β^- spectrum of the 17.5-day activity was found to be complex, the upper limits for the two components being 0.69 Mev (49 percent) and 1.36 Mev (51 percent), respectively. In the β^+ spectrum a new hard component (1.53 Mev) of small intensity (11 percent) was found besides the main component of 0.92 Mev (89 percent). $\beta^-\gamma$- and $\beta^+\gamma$-coincidence spectra were also run in the spectrometer and it was found that the two softer components were followed by γ-radiation. The γ-spectrum (lead converter) taken with moderate resolution is given in Fig. 1 (upper curve).

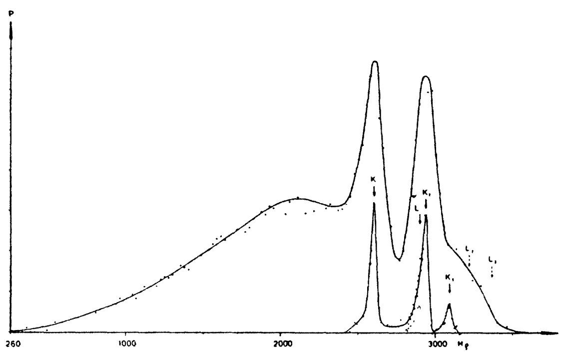

FIG. 1. Photoelectron spectrum of As^{74}. The lower curve was taken by means of the double-focusing spectrometer.

The intensity of the γ-line compared with the annihilation line is, however, far too great to be due to a transition from the soft β^- component to the ground state in Se^{74} as assumed before, but could instead be due to a transition from the soft β^+ component to the ground state in Ge^{74}. A new run with increased resolving power by means of the double-focusing spectrometer was made, with the result given below in Fig. 1. The line split up into two lines, having the energies 0.5963 ± 0.0010 Mev and 0.6352 ± 0.0010 Mev, respectively, with the intensity ratio of 4:1. The small intensity line is certainly emitted in the β^- decay and the high intensity line in the β^+ decay.

A disintegration scheme satisfying our data is presented in Fig. 2. By means of the measured intensities of the β^- and β^+ components and the two γ-lines the branching ratio of K-capture to β^+ for the excited level in Ge is calculated to be 1.5, in good agreement with the theoretical value of 1.3.

The ft value of the hard β^- component is 4×10^8, and the value of $(W_0{}^2-1)ft=0.5\times10^{10}$ brings this transition into the class of spectra of uniquely forbidden shape ($\Delta L=1$; $\Delta I=2$) according to Shull and Feenberg.[3] The Fermi analysis accordingly shows that the original S-shaped curve is transformed into a straight line when the α-factor is introduced in the analysis. The ft value of the hard, faint β^+ component is 5×10^8 and $(W_0{}^2-1)ft=0.8\times10^{10}$, which brings this transition into the same class of forbidden spectra.

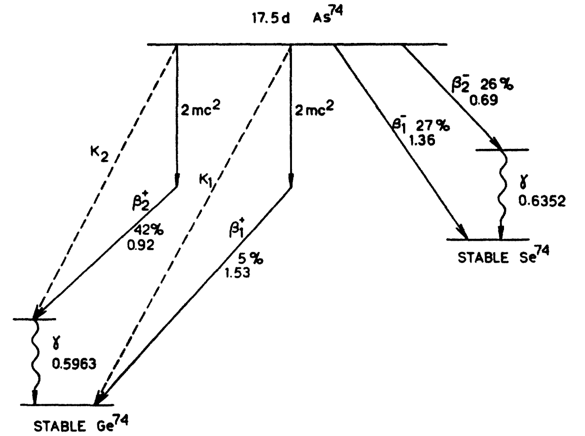

FIG. 2. Disintegration scheme of As^{74}. Energies are in Mev. The percentages shown do not include the K-branches.

The odd 33rd proton and the 41st neutron of the ground state in As^{74} may, according to the spin orbit coupling scheme of the nuclear shell model, be assumed to be in $f_{5/2}$ and $g_{9/2}$ states, respectively. The angular momenta of the odd proton and neutron may then add to form a resultant angular momentum of $2\cdots7$, the state having odd parity. According to Nordheim[4] one should expect that the minimum resultant spin of 2 is preferred here, since the intrinsic spins of the odd particles have different orientations relative to the orbital momenta. These rules agree with the present spin and parity assignment for the ground state of As^{74} based on the β-selection rule for the uniquely forbidden spectra and the fact that the end nuclei are of even-even type having even parity and zero spin.

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[1] For a complete list of references see G. T. Seaborg and I. Perlman, Revs. Modern Phys. **20**, 585 (1948).
[2] Mei, Mitchell, and Huddleston, Phys. Rev. **79**, 19 (1950).
[3] F. Shull and E. Feenberg, Phys. Rev. **75**, 1768 (1949).
[4] L. Nordheim, Phys. Rev. **78**, 294 (1950).

Retarded Nuclear Interaction

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THE canonical transformation applied by Van Hove[1] to the pseudoscalar meson theory yields, for pure pseudoscalar coupling, the following interaction between a proton and a neutron in an arbitrary coordinate system:

$$H_{n_1n_2,m_1m_2}=-\tfrac{1}{2}f^2\chi_{n_1}(1)\dagger\rho_2\chi_{m_1}(1)\chi_{n_2}(2)\dagger\rho_2\chi_{m_2}(2)\times\left\{\frac{1}{\epsilon_k{}^2-(\Delta E_1)^2}+\frac{1}{\epsilon_k{}^2-(\Delta E_2)^2}\right\},\quad(1)$$

where

$$\Delta E_i=E_{n_i}-E_{m_i}\quad(i=1,2).$$

Like Møller's formula for the electrons, (1) involves only Lorentz-invariant quantities, and it is tempting to take it as the potential energy of two nucleons in the energy-momentum space. The presence of the recoil energies in the denominators accounts for the retardation of the meson field. The usual way of dealing with the retarded interaction is the method of the lagrange expansion. The first approximation corresponds to the Yukawa potential $\exp(-\mu r)/r$. The second approximation has been evaluated by Toyoda.[2] For distances comparable with $1/\mu$ the result turns out to be of the same order of magnitude as the first approximation. For this reason it is desirable to treat (1) exactly without resorting