The Half-Life of the 1.3-Mev Excited State in K^{41}

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The ground state of K^{41} is classified as a $d_{3/2}$ level,[1] while the first excited state of the 19th proton would be expected to be an $f_{7/2}$ level. A gamma-ray transition between these levels would then be magnetic quadrupole ($M2$).

About 99.3 percent of A^{41} beta-disintegrations lead to a 1.3-Mev excited state in K^{41}, and 0.7 perent lead to the ground state.[2] An assignment of $f_{7/2}$ to this excited state is consistent with these observed beta-transition probabilities. The theoretical half-life given by Weisskopf's formula[3] for such a 1.3-Mev $M2$ transition is 0.45×10^{-9} second.

The half-life of this 1.3-Mev excited state in K^{41} has been measured by the following delayed coincidence experiment. A source of the 109-minute A^{41} activity was prepared by thermal neutron irradiation of a sample of 99.6 percent tank argon sealed in a thin quartz bulb. After a 20-minute neutron irradiation, the source was placed between two *trans*-stilbene scintillation counters using $IP21$ photomultipliers. One counter was sensitive to beta-rays, while the other was covered with sufficient absorber to stop the beta-radiation and leave the counter sensitive to gamma-radiation. The counter pulses were led to a coincidence apparatus consisting of four coincidence mixers arranged with beta-pulse delays of 4×10^{-9} second inserted between successive mixers. The individual mixers are similar in principle to that described by Bell and Petch[4] and were adjusted to have a resolving time of about $2\tau_0=4\times10^{-9}$ second. Coincidence counts were then recorded in the four mixing channels for a series of delays in either the beta- or the gamma-counter lines leading to the coincidence apparatus. In this way four independent sets of data were obtained in each run. The set of data obtained in one of the mixing channels during one run and corrected for A^{41} decay is shown in Fig. 1. Prompt coincidence curves were obtained by replacing the source of A^{41} by a source of Au^{198}. One such curve is also shown in Fig. 1 for comparison.

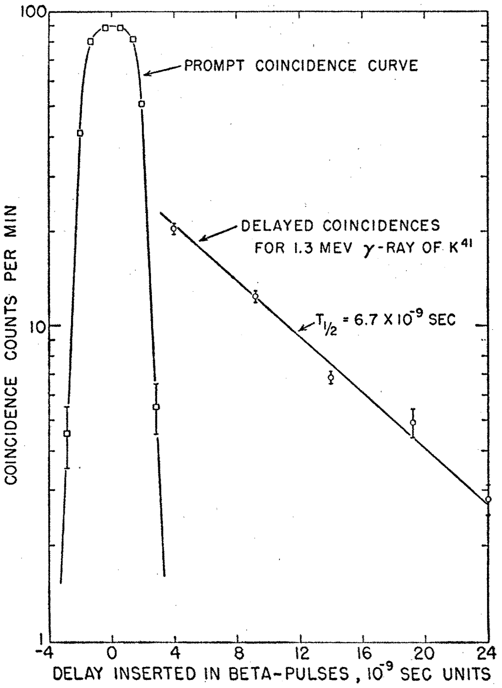

FIG. 1. The delayed coincidence curve taken in one mixing channel and showing the half-life of the 1.3-Mev gamma-transition in K^{41} with a prompt coincidence curve for comparison. The measured background of random coincidences was small and has been subtracted at each point.

The mean value of the half-life of the 1.3-Mev excited state in K^{41} obtained from two runs using different sources is $(6.7\pm0.5)\times10^{-9}$ second. This is seen to be appreciably longer than the theoretical half-life given by Weisskopf's formula.

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[3] V. F. Weisskopf, Phys. Rev. **83**, 1073 (1951).
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The Tetraneutron*

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It is known that a system of two protons and two neutrons has an unusually high binding energy. If one considers that the filling of neutrons and protons in a nucleus is, in general, independent of each other, one might infer that a certain amount of binding energy may be obtained if two neutrons are substituted for the two protons in the above case; thus forming a tetraneutron.

Assuming the tetraneutron is unstable with respect to a helium nucleus but stable with respect to free neutrons, one could set up an upper limit for the binding energy of the tetraneutron as follows:

$$4n\rightarrow n^4+Q_1 \qquad (1)$$

$$n^4\xrightarrow{\beta^-}H^4+Q_2 \qquad (2)$$

$$H^4\xrightarrow{\beta^-}He^4+Q_3. \qquad (3)$$

Combining these equations and using Breit and McIntosh's limiting values for Q_3,[1] one obtains

$$Q_1=[(9.4 \text{ to } 13.8)-Q_2] \text{ Mev}. \qquad (4)$$

If reaction (2) occurs, Q_2 is positive; then the maximum value of Q_1, the binding energy of the tetraneutron, will be about 14 Mev.

If one considers the following two exothermic reactions and combines them with reaction (1)

$$X^A+n\rightarrow Y^{A-3}+4n-|Q_5| \qquad (5)$$

$$X^A+n\rightarrow Y^{A-3}+n^4-|Q_6| \qquad (6)$$

one obtains

$$|Q_5|-|Q_6|=Q_1 \qquad (7)$$

It is obvious that if reaction (6) can be carried out before reaction (5) by using energies of impinging neutrons lower than that of the threshold for reaction (5), it should indicate the existence of the tetraneutron. This method of detection is particularly convenient if the binding energy of the tetraneutron is larger than, say, 3 Mev.

The maximum energy of neutrons produced by the 16-Mev deuterons from the University of Pittsburgh cyclotron on Be is about 18 Mev at a convenient angle where high intensity fast neutrons are available. These neutrons were used to bombard Rh^{103} and Bi^{209}. The thresholds for the reactions $Rh^{103}(n, 4n)Rh^{100}$ and $Bi^{209}(n, 4n)Bi^{206}$ are, respectively, 27.8 and 20.8 Mev (from the calculated mass data by Metropolis and Reitwiesner[2]). Many experiments were tried to search for the Rh^{100} and Bi^{206} activities; none were found. Some 20-hr activities were noted in the bombarded Rh-samples, but were attributed to the Pt impurities present in the Rh-samples. This indicates either that the tetra-