$0^+ - 0^+$ *TRANSITION IN THE DECAY* $Pr^{140} \rightarrow Ce^{140}$

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IN 1958 it was established[1] that the Ce^{140} nucleus has a 0^+ excited level with excitation energy 1902 kev. This level resulted from the decay of La^{140}. The ground and excited states of Ce^{140} can also result from electron capture and β^+ decay of Pr^{140} (see Fig. 1).

We attempted to find out whether the 1902 kev level of Ce^{140} is excited in the decay of Pr^{140}. We expected this level to be excited by allowed β^+ decay and electron capture since the ground state of Pr^{140} is of the 1^+ type.[2]

To this end we placed an equilibrium preparation of $Nd^{140} + Pr^{140}$ in a beta spectrometer with triple focusing (radius of curvature 14.5 cm). The pressure in the apparatus was 5×10^{-5} mm Hg. The thickness of the celluloid films on the windows of the first counter was ~ 0.2 mg/cm^2. The counters were filled with a mixture of argon plus 15% alcohol to a total pressure of 100 mm Hg.

In Fig. 2a we show the conversion line K = 1902 kev (the energy determination is that of reference 1), and Fig. 2b is the Kurie plot of the end of the β^+ spectrum of Pr^{140}. It is known[4,5] that the β^+ spectrum of Pr^{140} has an allowed shape. Since our apparatus, using coincidences, could distort the spectrum at low energies we measured only the high energy part of the spectrum and from it reconstructed the entire spectrum. The e^-/β^+ ratio turned out to be 0.2%.

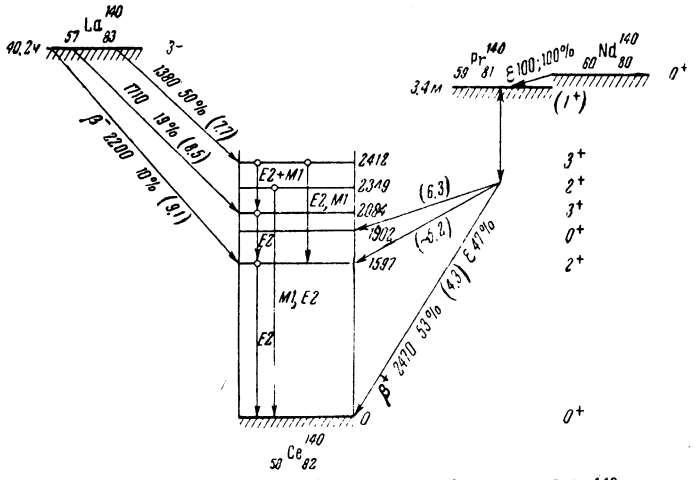

FIG. 1. Decay scheme to lower excited states of Ce^{140}; the log (ft) value is given in brackets for lines due to β transitions.

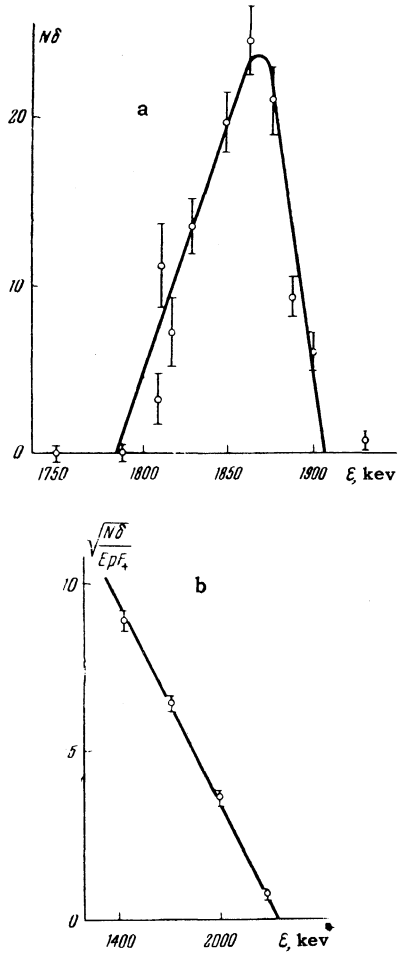

FIG. 2

To determine e^- (1902) per decay it is necessary to take into account the fact that K and L capture for an allowed transition to the ground level should amount to $\sim 47\%$.[6] It then follows that the number of conversion electrons amounts to 0.1% per decay. Consequently the level Ce^{140} (0^+) 1902 kev is excited much more frequently in the decay of Pr^{140} than in the decay of La^{140} (0.013% according to the data of references 1 and 7).

The 1902-kev level of Ce^{140} probably results from both e^- capture and β^+ decay of Pr^{140}. Taking into account values of f_K, f_L and f_+ for allowed transitions we find that $ft = 2 \times 10^6$.

Consequently, two β^+ decays from the ground level of Pr^{140} to two 0^+ levels of Ce^{140} differ in reduced time by a factor of approximately 100 (Fig. 1). This is evidence of a different intrinsic structure of these levels.

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Translated by A. M. Bincer
162

SPONTANEOUS FISSION OF Am^{241}

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AMONG the nuclei which undergo spontaneous fission those with an odd number of protons or neutrons are usually distinguished by the low probability of such fission, their half-lives being a few orders of magnitude longer than those of neighboring even-even isotopes.

Most of our information about the spontaneous fission of odd nuclei was obtained at different times by groups at Los Alamos and Berkeley. Segre and his group[1] determined the spontaneous fission half-lives of $U^{233,235}$, $Np^{237,239}$, Pu^{239}, and Am^{241}. In most instances they gave only the upper limit of the fission probability, because of the small samples available and the difficulty of working with these isotopes, whose low fission probability is accompanied by large specific α activity. Ghiorso and his group[2] studied the spontaneous fission of Bk^{249}, Cf^{249}, $E^{253,254}$ and Fm^{255}. Their careful experiments enabled them to determine the half-lives to within 25%; only in the case of Fm^{255} was merely the lower limit of $T_{1/2}$ established.

The recent development of a technique[3,4] employing detectors with high resolving power and millimicrosecond pulses permits experimentation under more favorable conditions. The work can now be done with large samples and an appreciable effect can be observed in a considerably shorter time.

The fragment detector used in the presènt work was a gaseous scintillation counter, with a xenon-filled chamber constructed of the high-vacuum materials copper and teflon. A photomultiplier was mounted in contact with a glass-covered window of the chamber; a layer of quaterphenyl (~ 50 $\mu g/cm^2$) on the inner surface of the glass served to transform ultraviolet radiation into visible light. Reflection from the magnesium oxide coating of the chamber wall enhanced light collection. The seal between the glass and the chamber was a teflon gasket. The chamber was evacuated to 5×10^{-6} mm Hg and was filled with xenon to 2 atmos. During vacuum conditioning, the chamber was heated by water vapor. A thin layer of americium was deposited electrolytically on a platinum backing; the amount of material (~ 60 μg on an area of 1.8 cm^2) was determined by measuring the α activity of the layer.

A FEU-33 photomultiplier with $\sim 3 \times 10^{-9}$ sec resolution was used. Fission fragments were detected against the large alpha-particle background by means of a high-speed discriminator of the Moody type.[5] A DGTs-7 crystal diode was the nonlinear element of the circuit, which was triggered by a LP-34 secondary-emission tube sensitive to small signals.

A preliminary test was conducted with a Pu^{240} target, using the same geometry as with Am^{241} in the subsequent experiments. 1.20×10^{11} years was obtained for the spontaneous fission half-life of this plutonium isotope, in good agreement with other data.[6] A 30% reduction of pulse amplitude was observed after a month of work.

For the work with Am^{241} the apparatus was calibrated by placing in the chamber a target (~ 200 μg) of U^{235}, which possesses a large slow-neutron fission cross section. The entire counter was surrounded by paraffin, and a (Po+Be) neutron source was used to study the counting response (see the figure). The response was found to be essentially the same for Pu^{240} and for Am^{241}, when fragments were counted against a strong α-particle background. These experiments estab-