A Metastable State of 22 Microseconds in Ta^{181}

S. DEBENEDETTI AND F. K. MCGOWAN
Clinton Laboratories, Oak Ridge, Tennessee
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SHORT-LIVED metastable states can be detected by examining whether the β-rays from a radioactive source are followed, within a short but measurable time, by γ-rays or conversion elections. For this purpose a source deposited on a thin aluminum foil is introduced between the mica windows of two Geiger-Mueller counters A and B. The pulses of counter A are electronically delayed and fed into one channel of a coincidence circuit, while counter B is connected directly to the other channel. If we call T the delay time and τ the resolving time of the instrument, coincidences will be recorded only when a ray in counter B follows a ray in counter A after a time interval between $T-\tau$ and $T+\tau$. After each pulse in counter A the instrument is therefore sensitive during a time 2τ, which can be measured by counting random coincidences. The delay time T is measured by means of a calibrated oscilloscope.

The method fails for $T\lesssim 10^{-6}$ sec., because of the fluctuations in time lag between ionization and discharge in a G-M tube, and for $T\gtrsim 10^{-2}$ sec., because of competition from random coincidences.

Delayed coincidences well above the random coincidence background were detected with sources of Hf^{181}. In Fig. 1 the number of delayed coincidences is plotted as a function of delay time. It appears from this curve that the disintegration of Hf^{181} leads to a metastable state Ta^{181*} which in turn decays to the ground state with a half-life of 22 microseconds.

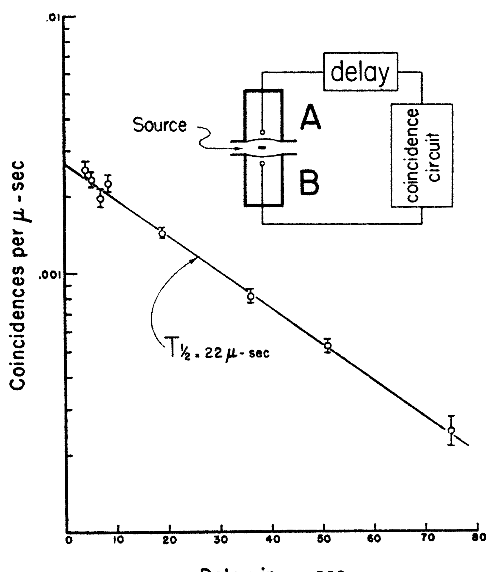

FIG. 1. Delayed coincidences as a function of delay time.

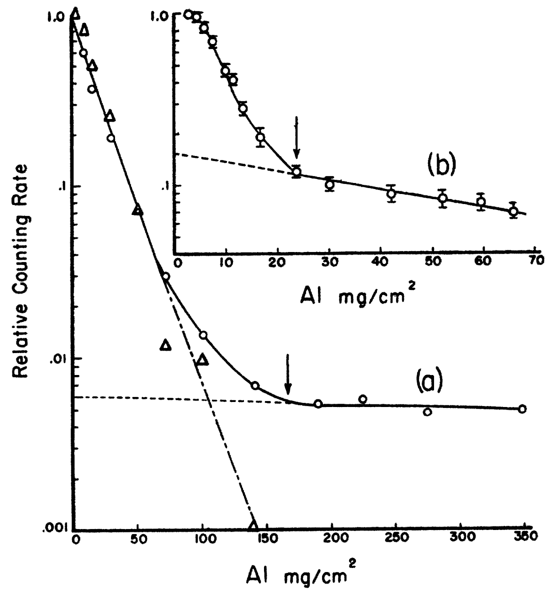

FIG. 2. Absorption of radiation from Hf^{181}.

Figure 2 shows the result of some absorption experiments, all performed under the geometrical conditions of Fig. 1. Such geometrical arrangement, obviously poor for energy determinations, was required for a sufficiently high counting rate. The circles of Fig. 2(a) were obtained by counting the single counts of counter A and represent the absorption of the radiation from Hf^{181}; this radiation seems to consist of a simple β-spectrum of maximum energy around 0.8 Mev, and of γ-rays of 0.5 Mev. The triangles in the same curve are obtained from delayed coincidence measurements when the absorber is located between the source and counter A, and represent the absorption of that part of the radiation which is followed by a delayed ray; it appears that the delayed rays follow the β-rays and not the γ-radiation. Finally Fig. 2(b) shows the result obtained from a measurement of delayed coincidences with the absorber between the source and counter B; this curve, which corresponds to the absorption of the delayed rays, can be interpreted by supposing that these consist mostly of electrons of 0.11 Mev. If such electrons are due to conversion in the K shell the excitation energy of the metastable level is about 0.18 Mev. As the result of a rough evaluation the number of conversion electrons per disintegration appears to be around 0.6.

From the half-life and the energy of the metastable state it seems probable that the transition involves a change of spin of 3 units. Since the spin of Ta^{181} is 7/2 the spin of the metastable level can be assumed to be $\frac{1}{2}$.

A search for short-lived isomers in the other isotopes of reported spin 7/2 and in more than 20 other nuclei has given negative results.

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