Nuclear Isomerism and Internal Conversion

According to Weizsäcker,[1] one may explain nuclear isomerism by assuming that the lowest excited state of the nucleus has an angular momentum differing by several units from that of the ground state. Selection rules may then be invoked to increase the lifetime of time of the excited level, against gamma-ray transitions to the ground state, to such a large value that the normally slower beta-processes may compete effectively in destroying the upper state. The γ-ray—β-ray branching ratio will depend on the relative lifetimes for the two modes of decay, but when the latter are of the same order of magnitude, the γ-ray transitions should be observable. Hebb and Uhlenbeck[2] have suggested that the failure of attempts to observe these gamma-rays is probably due to the high probability of internal conversion. (The internal conversion coefficient increases rapidly as the spin change increases, and as the energy difference decreases).[3]

We have therefore looked for a line spectrum of conversion electrons from one of the isomeric forms of Rh^{105}, formed from Rh by slow neutron capture. To decrease the absorption of slow electrons in the rhodium target as well as in the detector walls, the target was electrolytically deposited inside a Ni cylinder, and the counter walls were constructed of 0.005 mm Al. An absorption curve of the radiation from the 4.2 min. isomer showed the presence of two components; the harder one was identified through its absorption coefficient, with the well-known primary beta-rays of this period. The softer component, which accounted for about 30 percent of the total counts, had an energy of 35–60 kev. That this soft component was not instrumental could be demonstrated by the fact that no such soft group was observed to follow the 44 sec. Rh period under identical geometrical conditions.

From these data, we may draw the following conclusions regarding the 4.2 min. isomer:

(1) The radiation does not consist of *one* simple continuous beta-ray spectrum.

(2) The radiation does not consist of two simple beta-ray spectra superposed, since no hard γ-ray is observed. Also, the partial decay constant for the hypothetical soft beta-rays is too great for their energy.

(3) The soft component is therefore composed of conversion electrons from a γ-ray of about 80 kev. To prove that this gamma-ray transition precedes the beta-ray emission, it will be necessary to show that the characteristic x-rays which must follow the internal conversion are Rh $K\alpha$ and not Pd $K\alpha$. This will be attempted in the future. For the present, it should suffice to show that all the experimental results may be explained by assuming that *the soft radiation is an "electron line" emitted by internal conversion in the transition from the metastable state to the ground state of the* Rh^{105} *nucleus.*

On this assumption, the 44 sec. penetrating component arises in beta-transitions from the ground state of Rh^{105} to the ground state of Pd^{105}. This same transition gives the hard component of the longer period, but it proceeds at a slower rate, as the Rh^{105} ground state (44 sec.) is now formed by γ-ray decay from the 4.2 min. level. This assumption could be tested by examining the early part of the 4.2 minute decay curve, i.e., before the 44 sec. period was in equilibrium with the longer one. Unfortunately the high initial intensity of the 44 sec. period makes this test impossible. This simple picture requires that the beta-ray spectra of the two isomers be identical. The experimentally observed difference might be accounted for by assuming the existence of direct beta-transformations from the excited state of Rh^{105} to the ground state of Pd^{105}.

A detailed account of this work will appear in the *Journal de Physique.*

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[1] Weizsäcker, Naturwiss. **24**, 813 (1936).
[2] Hebb and Uhlenbeck, Physica **5**, 605 (1938).
[3] Pontecorvo, *Travaux du Congrès du Palais de la Decouverte* (Paris, 1937).

Preliminary Report on the Radioactivity Produced in Y, Zr, and Mo

A study of the radioactivity produced in Y, Zr, Cb and Mo started at the Radiation Laboratory, University of California, Berkeley, by one of the authors, has been continued by making chiefly neutron bombardments on these elements from the cyclotron in the Institute of Physical and Chemical Research, Tokyo. Both lithium and beryllium targets were bombarded by 20 to 100 μa of 5.5 to 7.6 Mev deuteron beam at Berkeley and 20 to 40 μa of about 3 Mev in Tokyo to produce fast and slow neutrons. The results obtained on yttrium are given in Table I.

A further careful chemical test and a study of β-rays must be done for the assignment of the shorter periods. The 2.3 hr. period is expected to be due to Dy contamination. The results obtained on zirconium are given in Table II.

The 34 d period might be due to Hf contamination. The 70 hr. period assigned to be Y^{92} here seems likely to

TABLE I. *Radioactivity induced in yttrium by neutron bombardment.*

BOMBARDMENTS	OBSERVED PERIODS			
Slow neutrons	—	2.3 hr.	66 hr.	—
Fast neutrons	60 min.	—	66 hr.	55 days
Sign	e^-	e^-	e^-	e^-
Chemical test	—	—	Y	Sr
Assignment	?	Dy^{165}?	Y^{90}	Sr^{89}
Upper limit derived from K–U plot	—	—	2.1±0.1 Mev	—

TABLE II. *Radioactivity induced in zirconium by neutron and deuteron bombardment.*

BOMBARDMENTS	OBSERVED PERIODS						
Slow neutrons	—	—	17 hr.	—	—	—	63 d
Fast neutrons	—	3 weak hr.	—	70 hr.	70 hr.	—	63 d
Deuterons (8 Mev)	90 min.	2.5 hr.	—	—	3 d	weak 34 d	63 d
Sign	e^-	e^-	e^-	e^+	e^-	e^-	e^-
Chemical test	—	—	Zr	Zr	Y	Cb	Zr
Assignment	—	Y^{94}?	Zr^{95}	Zr^{89}	Y^{92}	Cb^{95}?	Zr^{93}
Upper limit derived from K–U plot	—	—	1.25 ±0.1 Mev	1.03 ±0.1 Mev	1.3 ±0.1 Mev	—	0.25 ±0.3 Mev