Letters to the Editor

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Identification of the Seven-Hour Mo^{93} Isomer

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THE seven-hour isomer of molybdenum is known[1,2] to decay by a 0.3-Mev lifetime determining transition followed by two cascade gamma-rays of 0.7 and 1.5 Mev. From the $K/(L+M)$ ratio of 2.8±0.3 and the energy 256 kev measured[3] by the group at Brookhaven, the isomeric transition was shown[4] by Goldhaber and Sunyar to be an $E4$ type. Ruby and Richardson later obtained[5] an energy of 262 kev and a $K/(L+M)$ ratio of 2.9±0.2 for the 7-hour transition and the values 692±11 kev and 1.51 ±0.035 Mev for the cascade gamma-rays.

Although a mass number 93 has been tentatively assigned[1] to this isomer, it is difficult to understand why the activity cannot be formed by the (d,p) or (n,γ) reactions on Mo^{92} or the (γ,n) reaction on Mo^{94}. Also, this mass number is not consistent with the predictions of shell theory, as pointed out[2] by Goldhaber and Hill. Recently, more evidence in favor of the mass 93 assignment was obtained[6] by Boyd and Charpie who studied the excitation functions for the production of 7-hour Mo and 10-day Nb^{92} formed by proton bombardment of Nb. Their data indicated that the first of these is due to the (p,n) reaction and the second due to the (p,pn) reaction on Nb^{93}. They concluded that the 7-hour isomer probably belongs to Mo^{93}.

We have made a direct mass assignment of this activity in the isotope separator at the Nobel Institute using sources obtained by bombarding Nb metal powder with deuterons. The cyclotron targets were prepared by forcing the powder under very high pressure into the surface of a copper block from which it could be scraped after the bombardment. Irradiations of 80 microampere-hours were made at a beam energy of 25 Mev, after which the active powder was introduced into a perforated lava tube and inserted in the separator ion source. This was arranged so that chlorine gas could pass through the powder and extract the activity in a manner somewhat similar to the technique used[7] by Keim at Oak Ridge. The lava tube was heated indirectly to a few hundred degrees by the ion source filament. It had been shown beforehand that the chlorine method gave strong lines from the stable isotopes of molybdenum when Mo metal powder was used in the ion source. With the bombarded niobium powder samples, stable Nb^{93} was also extracted by the chlorine and could be identified at once on the separator viewing screen by comparing the position of its line with those of the stable krypton isotopes and with three lines resulting from doubly-ionized $W^{182,183,184}$.

Separation of the Mo activity was carried out for 2 hours at a current of 1–3 microamperes on a 2.5 mg/cm² Al collector foil. A blackening of the foil at mass number 93 as a result of stable Nb^{93} was observed. By counting areas of the collector covering 10 successive mass units beginning with 88 and also from a radioautograph of the foil, it was established that the only activity present was at mass number 93.

A 6-mm wide strip at mass number 93 was then cut from the collector foil (adjacent masses in this region are about 9 mm apart) and examined in the double-focusing spectrometer. Figure 1 shows the internal conversion spectrum from this sample measured at a resolution of 0.8 percent. The energy of the transition is

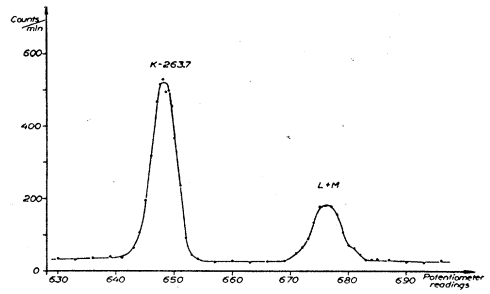

FIG. 1. Internal conversion spectrum of the Mo^{93} separated sample.

263.7±1.0 kev, and the $K/(L+M)$ ratio 2.79±0.15 is in favorable agreement with earlier results. The M line is not quite resolved but from the appearance of the curve probably accounts for 20–30 percent of the $L+M$ component. The half-life of 7 hours used to correct for decay was later checked by measuring the activity on the foil.

The gamma-rays from an unseparated portion of the active Mo were examined in the double-focusing spectrometer by observing the external conversion electrons from a 9-mg/cm² gold foil. Figure 2 shows the photolines and Compton electrons corresponding to the isomeric transition and two gamma-rays of 0.685±0.003 and 1.479±0.005 Mev. The total decay energy based on these measurements is 2.428±0.006 Mev.

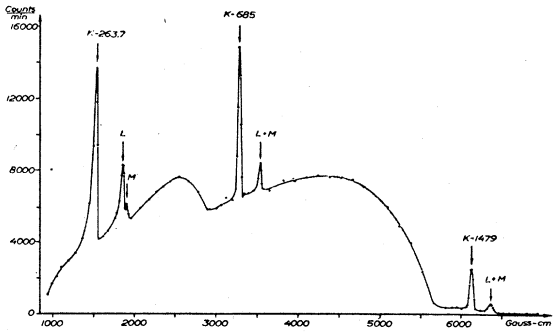

FIG. 2. External conversion of Mo^{93} gamma-rays in a 9-mg/cm² gold foil (unseparated sample).

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"Core Isomerism"—Remarks on Mo^{93m}†

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IT has been pointed out[1] that the 7-hr Mo isomer behaves in some respects as if it were an even-even nucleus. Now that this activity has been definitely assigned to an odd mass number, both by the study of the $Nb^{93}(p,n)$ excitation function[2] and by a direct mass spectrographic determination,[3] it seems appropriate to discuss the probable mode of excitation of Mo^{93m} further. This isomer lies outside the usual odd A "islands of isomerism," and it appears that we are dealing here with a case of "core isomerism" where the isomerism can be ascribed to an excitation of the