A NEW ISOTOPE Er^{159}

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Submitted to JETP editor June 20, 1961

J. Exptl. Theoret. Phys. (U.S.S.R.) 41, 1729-1732 (December, 1961)

The conversion-electron spectrum from the decay of neutron-deficient erbium isotopes was measured with a constant magnetic field β spectrograph. A new erbium isotope of mass number 159 ($T_{1/2}$ ~ 1 hr) has been discovered. Some new γ transitions which arise in the decay chain $Er^{159} \rightarrow Ho^{159} \rightarrow Dy^{159}$ have been detected. A decay scheme for this chain is proposed.

THE spectrum of the conversion electrons produced in the decay of the neutron-deficient erbium isotopes was measured with a constant magnetic field β spectrograph.[1] The neutron-deficient erbium isotopes were obtained by the bombardment of tantalum with 660-Mev protons from the synchrocyclotron of the Joint Institute for Nuclear Research.

In a previous article[2] we discussed the data on the conversion electrons produced in the decay of erbium isotopes with a half-life greater than two hours. In the present experiment we studied the conversion-electron lines whose intensity decayed, according to our estimates, with a half-life $T_{1/2}$ < 2 hr. We estimated the half-life from the decay in intensity (darkening) of the conversion lines on photographic film from successive exposures in the β spectrograph.

The target was bombarded for two hours. The exposure of the first film was usually begun 3 — 4 hr after the end of the bombardment and 30 — 40 min after separation of the erbium. The table lists the conversion-electron lines which we ascribe to isotopes with $T_{1/2}$ < 2 hr.

Gromov and Dneprovskiĭ[3] observed conversion-electron lines of energy 118.9, 123.5, 255.8, 301.0 and 307.4. kev during the study of the conversion-electron spectrum of an erbium fraction. The half-life of these lines, according to [3], is 50 ± 10 min. These lines are, of course, identical to lines No. 6, 7, 15, and 16 observed by us. We suggest that all the lines listed in the table are produced in a decay chain which starts with a previously unknown erbium isotope with a half-life of about one hour. The mass number of the new isotope can be determined on the basis of the following known experimental facts.

1. The mass numbers 165, 161, 160, and 158

Conversion-electron Lines of the Chain

$$_{68}Er^{159} \xrightarrow[K]{\sim 1\text{ hr}} {}_{67}Ho^{159} \xrightarrow[K]{33\text{ min.}} {}_{66}Dy^{159}$$

No.	H_ρ	E_e, kev	Identification of lines	$h\nu$, kev	Z*	Basis of identification
1	753.6	47,7	L_1—56,8	56.8±0,1	(66)	Decay scheme
2	928,2	70,8	L_1—79.9	79,9±0.1	(66)	Decay scheme
3	1185	111,3	—	—	—	—
4	1189	112,1	—	—	—	—
5	1196	113,1	—	—	—	—
6	1231	119.3	K—173,2	173,2±0,2	(66)	Decay scheme
7	1256	123,7	K—177.5	177,5±0,2	(66)	[7]
8	1400	150,3	K—205,9	205.9±0,3	67	(K, L_{11},L_{111})
9	1630	196.0	K—249.8	249.8±0,3	66	(K, L)
10	1635	197,0	L_1+L_{11}—205,9			
11	1639	197,9	L_{111}—206,0			
12	1646	199,4	K—253.2	253,2±0.3	66	(K, L)
13	1838	240,5	L_1—249,6			
14	1855	244,2	L_1—253,3			
15	1907	255,6	K—309,4	309.4±0,4	66	(K, L)
16	2103	300,4	L_1—309,5			

*Charge of nucleus in which transition occurs.

are apparently excluded, since the half-lives of these erbium isotopes are considerably greater than two hours.

2. Dalkhsuren et al[4] studied the Er^{163} spectrum and observed γ rays of energy ~300, 430 and 1100 kev. According to their data, the intensity of these γ rays is no greater than 0.2% per decay. No γ rays with energy less than 300 kev were observed. On the other hand, we observed a number of conversion lines (lines Nos. 1 — 12) which, no doubt, are associated with γ transitions from energies below 300 kev. It is also obvious that we cannot observe conversion lines of γ transitions with energy 300 kev and greater and a γ-ray intensity less than 0.2% per decay. These arguments enable us to exclude the mass number 163.

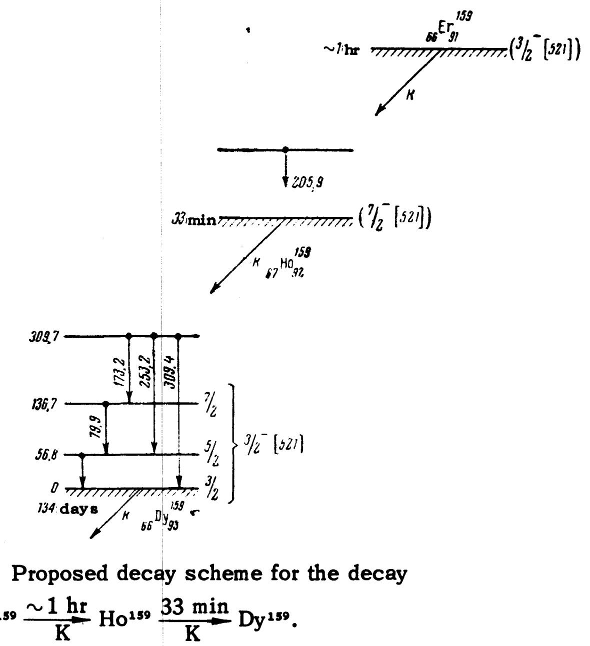
3. We can definitely eliminate the mass numbers 157, 156, and 155, since in the decay of erbium isotopes with such mass numbers we should have observed the well-known intense γ transitions of the daughter isotopes 326.6-kev Dy^{157},[5] 138.0-kev Ho^{159},[6] and 227.0-kev Dy^{155}.[5] Despite a careful search, the conversion lines associated with these transitions were not observed.

4. Toth[7] observed the radioactive Ho^{159} isotope with a half-life of 33 min. He studied the Ho^{159} γ spectrum with a scintillation γ spectrometer and observed γ rays of energy 125, 180, 250, and 305 kev. Conversion lines Nos. 9, 12, 13, 14, 15, and 16 can be identified as K and L lines of the 249.8, 253.2, 309.4 kev γ transitions. The difference in energy of the K and L lines was determined with sufficient accuracy to establish that these transitions take place in the dysprosium nucleus. It is obvious that the energies of these three transitions coincide, within the limits of experimental accuracy, with the 250- and 305-kev γ-ray peaks observed by Toth. The conversion-electron lines Nos. 2 — 7 must include lines (K or L) associated with the 125- and 180-kev γ lines, but we do not have any reliable arguments for the identification of these lines. Hence the comparison of the data of Toth with our results leads to the conclusion that the lines listed in the table arise in the decay chain

$$Er^{159} \xrightarrow[K]{\sim 1\ hr} Ho^{159} \xrightarrow[K]{33\ min} Dy^{159}.$$

According to the data in the table, we can also identify the 205.9-kev transition. The difference in energy between the K, L_{11}, and L_{111} lines shows that this transition occurs in the holmium nucleus, i.e., it arises in the decay $Er^{159} \rightarrow Ho^{159}$.

On the basis of the data we can make some comments on the decay scheme $Er^{159} \rightarrow Ho^{159} \rightarrow Dy^{159}$. The quantum characteristics of ${}_{66}Dy^{159}_{93}$ should be determined by the 93rd neutron. Consideration of the Nilsson diagram indicates that the 93rd neutron should be in the $3/2^-$ [521] state. The data in the literature on the Dy^{159} decay does not contradict the assumption that the ground state has a spin $3/2^-$. In this connection, to construct the Ho^{159} decay scheme we should, first of all, seek the rotational band level of the Dy^{159} ground state. The energy of the first rotational band level of the $3/2^-$ [521] state is 55 kev in ${}_{64}Gd^{157}_{93}$ and 60 kev in ${}_{64}Gd^{155}_{91}$. We can expect that the energy of the first rotational level of Dy^{159} is close to this value. Among the lines in the table is one at 47.7 kev, which can be identified as the L_1 line of the 56.8-kev γ transition. We assume that this transition determines the energy of the Dy^{159} first rotational state $5/2$ $3/2^-$ [521]. The energy of the second rotational level in the first approximation can then be estimated from the formula $E = A[I(I+1) - I_0(I_0+1)]$. The parameter A is calculated from the value of the energy level with spin $5/2$. It turns out that the energy of the level with spin $7/2$ should be about 136 kev. If it is assumed that the 70.8-kev line is the L_1 line of the 79.9-kev transition and that this transition takes place between Dy^{159} rotational band levels with spins $7/2$ and $5/2$, then the energy of the level with spin $7/2$ turns out to be 136.7 kev. Energy considerations also permit us to introduce a 309.7-kev level. Three transitions with energies 309.4, 253.2, and (if we identify the 119.3-kev line as a K line) 173.1 kev go from this level. The proposed scheme is shown in the figure.



Proposed decay scheme for the decay $Er^{159} \xrightarrow[K]{\sim 1\ hr} Ho^{159} \xrightarrow[K]{33\ min} Dy^{159}$.

The authors express their sincere gratitude to B. S. Dzhelepov for his interest in this work and to V. A. Khalkin and Wang Fu-Chün for preparing the erbium samples.

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Translated by E. Marquit
292