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CONVERSION SPECTRUM OF Ho^{160}

In the present work the conversion spectrum arising in the radioactive transformation $Er^{160} \to Ho^{160} \to Dy^{160}$ was studied. The spectral investigations were carried out with a double-focusing spectrometer ([1]), adjusted, for the most part, to operate with an instrumental line half-width of 0.5%. A considerable part of the measurements was made with a relative line half-width of 0.3%, for which purpose, at the suggestion of the author of paper ([1]), the source and the receiving slit in the spectrometer were made somewhat narrower than usual.

The conversion spectrum, as was already indicated in ([2]), proves to be the same in both fractions: Er^{160} gives no conversion electrons; all the electrons belong to Ho^{160}. The results of investigations of the conversion spectrum accompanying the decay of both fractions are given in Table 1.

The experimental data on the transitions 215, 310, 364, 394 keV and the hard ones, beginning with 1048 keV, were obtained only in two series of measurements with one erbium source and with a line half-width of 0.5%, and with a line half-width of 0.3%. The investigation of the remaining lines was carried out with several erbium and holmium sources. The intensity of all the observed lines decreased with a period corresponding to the half-life of the fraction under study: 29 h for the erbium fraction and 5 h for the holmium fraction. The energy difference $K - L$ for all measured transitions is equal to the difference of the binding energies on the corresponding shells of Dy.

The error in determining the line energies is 0.1-0.3%, depending on their intensity. The statistical error in determining the relative intensities is also determined by the counting rate on the lines and amounts to several percent for the strongest of them.

The general form of the conversion spectrum, in the main, coincides with that given in ([2]); however, it was possible to clarify a number of new facts that made it possible to construct the decay scheme of Ho^{160}.

1. The $L_{\rm I} + L_{\rm II}, L_{\rm III}, M$ and N lines of the 60-keV transition, which occurs in Ho^{160} ([2,3]), were observed. They are shown in Fig. 1. Decomposition into components makes it possible to determine the relative line intensities

$$L_{\mathrm{I}} : L_{\mathrm{II}} : L_{\mathrm{III}} : M : N = 0.1 : 1.0 : 1.0 : 0.47 : 0.1.$$

In Table 2 are given the theoretical values of this ratio for various multipoles (Rose' s values of α_L were used, interpolated by Granichnaya ([4]); for $\alpha_{L_{\mathrm{III}}}, E3$ the correction of Anderson and Bergström ([5]) was taken into account).

The experimental data are closest to $E2$ or $E3$. If the levels of Ho^{160} under consideration are the isomeric levels predicted by Peker ([6]), with spins 5+ and 2+, then the transition type should be $E4 + M3$; however, no admixture of these multipoles can explain the experimental value $L_{\mathrm{II}} : L_{\mathrm{III}}$.

2. The ratio determined by us $L_{\mathrm{I}} : L_{\mathrm{II}} : L_{\mathrm{III}} = 0.2 : 1.1 : 1.0$ for the 86.4-keV transition confirms that its multipolarity is $E2$ (the theoretical ratio for $E2$ is $L_{\mathrm{I}} : L_{\mathrm{II}} : L_{\mathrm{III}} = 0.19 : 1.1 : 1.0$).
3. The line $E_e = 99.3$ keV, observed in work ([2]), has been identified by us as the L-line of the 107-keV transition; the K-conversion line of this transition has been found.
4. The conversion line of the 298-keV transition on the K-shell is a close doublet with $\Delta E \simeq 1$ keV.
5. K-conversion lines of transitions of 310, 364, and 394 keV were detected; K- and L-lines of the 407-keV transition were detected; the L-line of the 514.5-keV transition was found.

Table 1

Internal-conversion lines of Ho^{160}

No.	E_e, keV	Identification	$h\nu$, keV	I/I_0	No.	E_e, keV	Identification	$h\nu$, keV	I/I_0
1	51.2	$L_I + L_{\mathrm{II}}$	60.1	1150	31	638.4	L	647.1	0.85
2	52.05	L_{III}	60.1	1050	32	647.0	M	648.3	0.26
3	57.9	M	60	480	33	675.9	K	729.7	6.9
4	59.2	N	59.6	110	34	720.5	L	729.6	1.1
5	33.0	K	86.8	814	35	729.4	$M+N$	730.7	0.32
6	76.3	$L_I + L_{\mathrm{II}}$	86.2	790	36	700.9	K	754.7	0.6
7	78.4	L_{III}	86.2	610	37	713	K	766.7	0.8
8	84.5	M	86.3	400	38	819.4	K	873.2	0.92
9	86.1	N	86.5	100	39	863.8	L	872.9	0.1
10	53.9	K	107.7	10	40	826.0	K	879.8	2.6
11	99.3	L	107.2	28	41	871.0	L	880.0	0.4
12	142.2	K	196.2	100	42	879.6	M	880.3	0.15
13	189.7	L	197	37	43	909.6	K	963.4	2.1
14	195.6	M	197	8.4	44	912.9	K	966.6	1.8

No.	E_e, keV	Identification	$h\nu$, keV	I/I_0	No.	E_e, keV	Identification	$h\nu$, keV	I/I_0
15	161.0	K	214.8	0.3	45	960.1	L	968.0	0.72
16	243.4	K	297.2	3.0	46	994	K	1048	0.11
17	244.6	K	298.4	3.0	47	1040	L	1048	0.03
18	290.7	L	298.5	0.9	48	1015	K	1069	0.24
19	297.0	M	298.3	0.26	49	1061	L	1069	0.048
20	256	K	310	0.16	50	1079	K	1133	0.085
21	301	K	365	0.22	51	1126	K	1180	0.066
22	339	K	393	0.09	52	1147	K	1201	0.07
23	353	K	407	0.4	53	1210	K	1264	0.077
24	399	L	407	0.06	54	1219	K	1273	0.082
25	460.6	K	514.4	0.75	55	1231	K	1285	0.035
26	506.1	L	514.8	0.08	56	1323	K	1377	0.070
27	485	K	538.9	2.25	57	1381	K	1435	0.045
28	531.1	L	540.0	0.42	58	1427	L	1435	0.034
29	539.4	M	540.6	0.15	59	1665	K	1719	0.023
30	593.8	K	647.6	5.25					—

6. In the interval between the strong K- and L-conversion lines of the 730-keV transition, K-lines of transitions of 755 and 767 keV were detected.

Table 2

Theoretical values of the ratios $L_I : L_{\mathrm{II}} : L_{\mathrm{III}}$

	$L_I : L_{\mathrm{II}} : L_{\mathrm{III}}$		$L_I : L_{\mathrm{II}} : L_{\mathrm{III}}$
$E1$	$2.3 : 0.86 : 1$	$M1$	$107 : 7.1 : 1$
$E2$	$0.09 : 1.2 : 1$	$M2$	$3.0 : 0.30 : 1$
$E3$	$0.01 : 1.2 : 1$	$M3$	$0.58 : 0.08 : 1$
$E4$	$0.17 : 0.68 : 1$	$M4$	$0.8 : 0.12 : 1$
$E5$	$0.008 : 0.45 : 1$	$M5$	$0.04 : 0.007 : 1$
Experimental value	$1.0 : 1.0 : 1.0$	Experimental value	$1.0 : 1.0 : 1.0$

7. The conversion lines corresponding to transitions of 880 and 967 keV proved to be doublets with an energy difference ΔE equal to 7 and 3 keV (Fig. 2).

8. In the hard region of the conversion spectrum, 14 lines of 11 different transitions were found. The data presented in this work, as well as the data on the decay of Tb^{160} (7-12), can serve as a basis for constructing a decay scheme of Tb^{160} and Ho^{160}.

Such a scheme is shown in Fig. 3. In the sequence of levels of Dy^{160}, two rotational bands are outlined: $K = 0$, $E^* = 0$ keV (0+), 86.4 keV (2+), 283

Figure 1

Figure 1: Figure 1

Figure 2

Figure 2: Figure 2

keV (4+), 580 keV (6+); $k = 2$, $E^* = 966$ keV (2+), 1050 keV (3+), 1157 keV (4+). A strongly populated level at 1697 keV appears, with transitions from it going to levels of the 2nd rotational band*.

* The development of this scheme was carried out with the participation of L. K. Peker.

Fig. 1. Conversion on the L-, M- and N-shells of the 60-keV transition. The dashed line shows the resolution of the L-line into components. The conversion of the 86.4-keV transition has a similar form.

Fig. 2. K-conversion lines: doublets 873–880 and 963–967 keV. Line half-width 0.3%.

Fig. 3. Scheme of the excited levels of Dy^{160}. In region I lines were observed only in Tb^{160}; in region II, in Tb^{160} and Ho^{160}; and in III, only in Ho^{160}.

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Figure 3: Fig. 3. Scheme of the excited levels of Dy^{160}. In region I lines were observed only in Tb^{160}; in region II, in Tb^{160} and Ho^{160}; and in III, only in Ho^{160}.

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Note: Figure translations are in progress. See original paper for figures.