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\(0^+ \to 0^+\) TRANSITION IN Ce\(^{140}\)

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Abstract

Full Text

PHYSICS

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$0^+ \to 0^+$ TRANSITION IN Ce^{140}

In papers ([1,2]) the existence was reported of a conversion line corresponding to a transition in Ce^{140} with an energy of 1909 keV (the average according to these two papers). According to ([1,2]), the intensity of this conversion line is comparatively large and amounts to approximately 1/3 of the intensity of the conversion line K-1596 keV. Quanta with an energy of 1695 keV are emitted practically in every decay of La^{140}.

The γ-spectrum of La^{140} was studied by us in papers ([3,4]). In paper ([3]) it was reported that if, in the decay of La^{140}, γ-rays with an energy of $\sim$ 1900 keV are emitted, then their intensity is less than 0.0015 quantum per decay.

This raised the question whether the conversion electrons K-1909 correspond to a transition between the excited state of Ce^{140} at 1909 keV, with quantum characteristics 0^+, and the ground state (also 0^+).

Fig. 1. Section of the γ-spectrum of La^{140} in the region of 1900 keV. The dashed line shows the "tails" of the γ-lines 1596 and $2343 + 2515$ keV.

To resolve this question, we carried out a careful study of the γ-spectrum of La^{140} in the energy region of 1900 keV. The measurements were made with a ritron-type γ-spectrometer ([5]). Lanthanum oxide irradiated with thermal neutrons was used as the source. The initial activity of the preparation was 2.8 Cu.

The results of the measurements (after subtraction of the background, which in this region amounted to $\sim$ 0.8 pulses/min) are presented in Fig. 1. On the scale of the figure, the peak of the 1596-keV γ-line corresponds to an ordinate of $\sim$ 1000. The experimental points lie on a smooth curve. No γ-line is observed in the energy region 1800–2000 keV; the height of the maximum corresponding to a γ-line with an intensity of 10^{-3} quantum per decay would be equal to unity in Fig. 1. A certain excess of recoil electrons over the background is due to the right-hand tail from the strong 1596-keV γ-line and the left-hand tail from the

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Fig. 2. Hard part of the spectrum ($10200 > H\rho > 6400$) of conversion electrons of La^{140}. Below—the spectrum obtained on the Leningrad State University Ketrón; above—obtained on the Ketrón of the Radium Institute of the Academy of Sciences of the USSR.

Figure 2: Fig. 2. Hard part of the spectrum ($10200 > H\rho > 6400$) of conversion electrons of La^{140}. Below—the spectrum obtained on the Leningrad State University Ketrón; above—obtained on the Ketrón of the Radium Institute of the Academy of Sciences of the USSR.

Fig. 3. Spectrum of conversion electrons of La^{140} in the region $11500 > H\rho > 10900$, obtained on the Leningrad State University Ketrón.

Figure 3: Fig. 3. Spectrum of conversion electrons of La^{140} in the region $11500 > H\rho > 10900$, obtained on the Leningrad State University Ketrón.

weak γ-lines 2343 and 2515 keV.

To estimate the contribution from these lines in the energy region of interest to us, we carried out a careful study of the shape of the left-hand tail of the 2760-keV γ-line of Na^{24} and the shape of the right-hand tail of the 1331-keV γ-line of Co^{60}. The tails of the 1596- and $2343 + 2515$-keV lines, estimated from these data, are shown in Fig. 1 (dashed line). Their sum corresponds to the experimental curve.

Thus, the intensity of γ-rays of $\sim$ 1900 keV, if they exist at all, is less than $4 \cdot 10^{-4}$ quantum per decay. These data, together with the data of papers ([1,2]) on the intensity of the 1909-keV conversion line, are sufficient to conclude that here we are dealing with a $0^+ \to 0^+$ transi-

···course. However, in the cited works the entire complex spectrum of conversion electrons of La^{140} was studied, and the line of interest to us was not given special attention. Therefore, to confirm the existence of the K-1909 line and to determine its intensity more accurately, we carried out an investigation of the hard part of the spectrum of conversion electrons of La^{140} on two β-spectrometers of the type "Ketrón," kindly placed at our disposal for this purpose by A. A. Bashilov (Leningrad University) and K. Ya. Gromov (Radium Institute of the Academy of Sciences of the USSR). In both cases the source used was La^{140}, separated from a solution containing Ba^{140}. The results of the experiments are shown in Fig. 2; the existence of the K- and L-1909 lines is beyond doubt. The averaged transition energy is 1902 keV. The intensity ratio is $K_{1902}/K_{1596} = 0.220$ (average over all experimental series).

Fig. 2. Hard part of the spectrum ($10200 > H\rho > 6400$) of conversion electrons of La^{140}. Below—the spectrum obtained on the Leningrad State University Ketrón; above—obtained on the Ketrón of the Radium Institute of the Academy of Sciences of the USSR.

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Fig. 3. Spectrum of conversion electrons of La^{140} in the region $11500 > H\rho > 10900$, obtained on the Leningrad State University Ketrón.

Taking into account the upper limit of the intensity of 1902-keV γ-rays obtained in our experiments ($4 \cdot 10^{-4}$) and the conversion coefficient known for the 1596-keV transition ([6]), $\alpha_K = 6.9 \cdot 10^{-4}$ (an E2-type transition), one can determine the lower limit of the conversion coefficient of the 1902-keV transition. It turns out that $\alpha_{K\text{-}1902} > 0.38$. Such a large conversion coefficient might be explained by a high order of multipolarity (> 10). But in that case we would have an isomeric level with a lifetime $> 10^{10}$ years. Meanwhile, the count rate on the K-1902 line decreases with a period $T \approx 38$ h, close to the half-life of La^{140} ($T = 40.2$ h). It remains to conclude that the transition with energy 1902 keV in Ce^{140} is a new $0^+ \to 0^+$ transition. The ratio α_K/α_L for this transition is 6.33.

At the same time we searched for and found the K- and L-conversion lines corresponding to the γ-lines 2343 and 2390 keV and to the γ-line 2515 keV found by us in work ([3]) (Figs. 2 and 3). The intensities of the K-lines are $4.5 \cdot 10^{-3}$, $0.22 \cdot 10^{-3}$, and $21 \cdot 10^{-3}$, respectively, relative to the intensity of K-1596, and $(\alpha_K/\alpha_L)_{2343} = 6.56$ and $(\alpha_K/\alpha_L)_{2515} = 6.28$. Table 1 gives the experimental and theoretical ([6]) conversion coefficients on the K-shell for

of the indicated transitions. We estimate the accuracy of the experimental values at 20%.

Table 1

Multipolarity of transitions with energies 2350, 2525, and 2910 keV in Ce^{140}

Transition energy (mean from papers ([3]) and present), $h\nu$, keV	α_K exp. $\cdot 10^4$	α_K theor. $\cdot 10^4$ ([6]) E1	α_K theor. $\cdot 10^4$ ([6]) E2	α_K theor. $\cdot 10^4$ ([6]) E3	α_K theor. $\cdot 10^4$ ([6]) E4	α_K theor. $\cdot 10^4$ ([6]) M1	α_K theor. $\cdot 10^4$ ([6]) M2	Conclusion on multipolarity
2350	3.94	1.66	3.39	5.82	9.12	4.03	8.32	M1, E2
2525	3.91	1.45	2.95	5.01	7.76	3.46	7.08	M1
2910	1.87	1.07	2.24	3.63	5.50	2.45	4.79	E2, M1, E2 + M1

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It should be noted that the transitions considered in the present article directly indicate the existence of excited states of Ce^{140} with energies 1902, 2350, 2525, and 2910 keV. Using a γ-spectrometer, the decay period of the intensity of γ-rays with energies 868 and 2350 keV, discovered in work ([3]), was determined; it was found to be $\simeq 40$ h. This circumstance supports the assignment of the indicated lines to La^{140}.

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REFERENCES

[1] J. Cork, J. Le Blanc et al., Phys. Rev., **83**, 856 (1951).
[2] N. M. Anton' eva, A. A. Bashilov, B. S. Dzhelepov, L. S. Chervinskaya, Izv. AN SSSR, ser. fiz., **22**, 179 (1958).
[3] V. P. Prikhodtseva, Yu. V. Khol' nov, Izv. AN SSSR, ser. fiz., **22**, 176 (1958).
[4] L. V. Arkhangel' skii, B. S. Dzhelepov et al., Izv. AN SSSR, ser. fiz., **19**, 251 (1955).
[5] B. S. Dzhelepov, N. N. Zhukovskii, Yu. V. Khol' nov, Izv. AN SSSR, ser. fiz., **18**, 599 (1954); B. S. Dzhelepov, V. P. Prikhodtseva, A. I. Feoktistov, Yu. V. Khol' nov, Izv. AN SSSR, ser. fiz., **20**, 1361 (1956).
[6] L. A. Sliv, I. M. Band, Tables of internal-conversion coefficients of gamma radiation, 1, Shell, Publishing House of the Academy of Sciences of the USSR, 1956.

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