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ON THE DECAY OF ^{182}Ta

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The gamma-ray spectrum from the decay of ^{182}Ta was measured with the aid of a Ge (Li)-spectrometer. Both the relative and absolute intensities of 32 gamma-transitions were determined and the existence of the new transition with the energy of 1180.9 keW was confirmed. The new level at the energy of 1510.21 keV was introduced. The absolute intensities of the beta-transitions together with the respective experimental values of the log ft were determined on the basis of the intensity balance.

I. INTRODUCTION

The decay of the isotope of ^{182}Ta ($T_{1/2} = 115$ d) to the excited levels of an even-even deformed nucleus ^{182}W has been studied by many authors. Several factors had caused the great interest in the decay of ^{182}Ta. Predominant among them was the fact that the nucleus of ^{182}W lies at the end of the region of the so-called deformed nuclei with the mass numbers $A = 150-185$ and this was why the experimental data concerning its excited level structure were of great importance as test values for the predictions of the various theoretical models of atomic nucleus. Besides both the relatively easy method of the ^{182}Ta production in the reaction ^{181}Ta (n, gamma) and the very convenient value of its half-life have played a decisive role in the study of nuclear radiation spectra accompanying the decay of ^{182}Ta $\rightarrow$ ^{182}W.

The most complete review of papers dealing with the decay of ^{182}Ta and also the survey and analysis of the experimental data have been given in monograph [1]. In the past three years there were published other papers giving more precise data about the energies and intensities of conversion electrons and gamma-rays arising during the decay of ^{182}Ta [2–4].

The aim of the present work was to obtain new and more precise data about the gamma-ray spectrum of ^{182}Ta, especially about its high-energy region ($E_\gamma > 850$ keV), using a high-resolution Ge(Li)-spectrometer, and to apply the obtained information about the decay of ^{182}Ta $\rightarrow$ ^{182}W in the study of the decay of both ^{182}Re isomers to the levels of ^{182}W [5, 6].

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II. EXPERIMENTAL RESULTS

The radioisotope of ^{182}Ta was obtained from the reaction ^{181}Ta (n, gamma) ^{182}Ta while the metallic tantalum was irradiated by a thermal neutron flux of 2×10^{13} n sec^{-1} cm^{-2}. The measurements were begun more than two months after irradiation in order to allow to decay the isotope of ^{183}Ta ($T_{1/2} = 5.1$ d), which resulted from the reaction of ^{181}Ta (2 n, gamma) ^{183}Ta with a large cross section.

The spectrum of gamma-rays accompanying the decay of ^{182}Ta was measured with the coaxial Ge (Li)-detector having the sensitive volume of about 6.5 cm^3. The resolution of the spectrometer was 2.0 keV in the energy region of $E_\gamma < 300$ keV and 2.5 keV at the energy of 660 keV.

A marked division into two parts is characteristic for the gamma-ray spectrum of ^{182}Ta: gamma-rays with energies of $E_\gamma < 300$ keV and those exceeding the energy of 850 keV. Therefore our experiments consisted of two parts, in which the low-energy and the high-energy region were measured separately under different conditions. The gamma-ray spectrum in the region of $E_\gamma > 850$ keV was measured with an absorber consisting of 5 mm Pb, 1 mm Cd and 1 mm Cu which absorbed to a great extent the low-energy part of the spectrum. In the region of energies of $E_\gamma < 300$ keV the measurements were carried out both with and without the absorber consisting of 0.5 mm Cd and 0.5 mm Cu. In the energy region of 300–850 keV the measurements were also performed using a 1.5 mm Pb + 0.5 mm Cd + 0.5 mm Cu absorber but no spectral lines were found. The best of the series of measurements performed in both investigated regions are given in Figs. 1 and 2.

The energies and relative intensities of ^{182}Ta gamma-transitions are given in Tables 1 and 2 and they can be compared with the results of other authors. Several authors have measured the gamma-rays of ^{182}Ta with a precision better than 0.002 % [2, 7, 8] in the energy region of $E_\gamma < 300$ keV, and 0.02 % for $E_\gamma > 850$ keV [3, 9, 10]. In our table the weighed average values of gamma-ray energies calculated from those given in the references are presented.

The relative intensities of gamma-rays from the decay of ^{182}Ta were determined using the plots of the Ge(Li)-detector efficiency obtained from the experimental calibration data which had been taken with 5–15 % relative errors. The weighed average values of the gamma-ray relative intensities were calculated using both ours and other authors' results, which were on the whole in good agreement within the quoted experimental errors. These values are given in the last but one column of the table and they were applied in the $^{182}Ta \rightarrow {}^{182}W$ decay scheme analysis.

In the low-energy part of the spectrum we were looking for the gamma-rays with the energy of 351.06 keV representing the E2-transition between the 6^+ — and 4^+ — levels of the ground state rotational band of ^{182}W. This transition has been known from the decay of ^{182}Re [11], but in the decay of

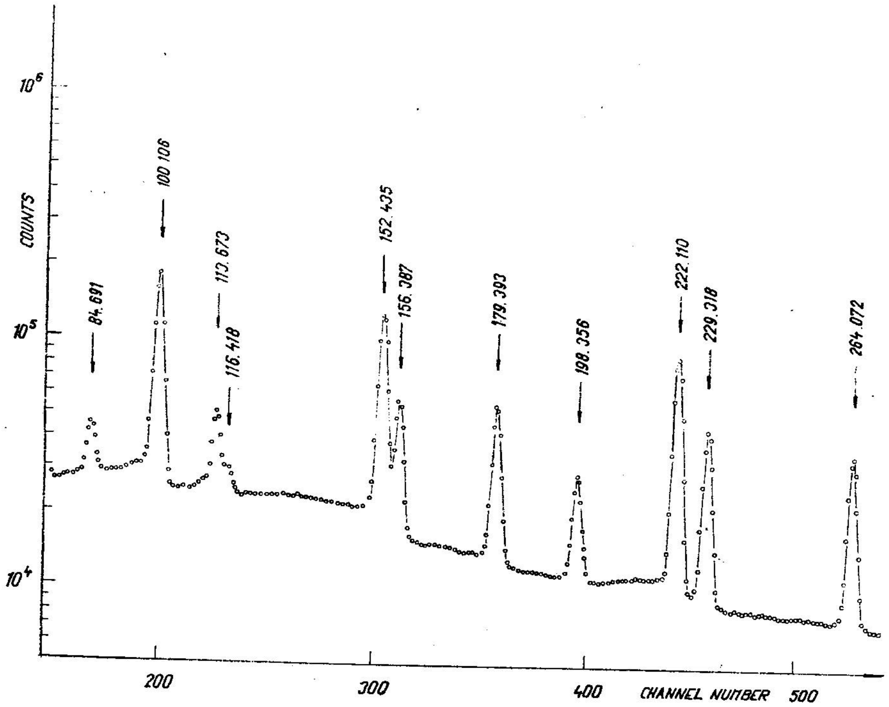

Fig. 1.

^{182}Ta it was reported only in one paper [1]. In our measurements the gamma-rays with the energy of 351.06 keV were not observed; it was therefore possible only to estimate the upper limit of the intensity of this transition up to 0.01 % per decay of ^{182}Ta.

Our measurements carried out in the high-energy part of the spectrum have confirmed the existence of the new gamma-transition with the energy of 1180.9 keV observed also in the decay of ^{182}Re [6]. As to the gamma-transition with the energy of 1437.8 keV observed so far only in the conversion

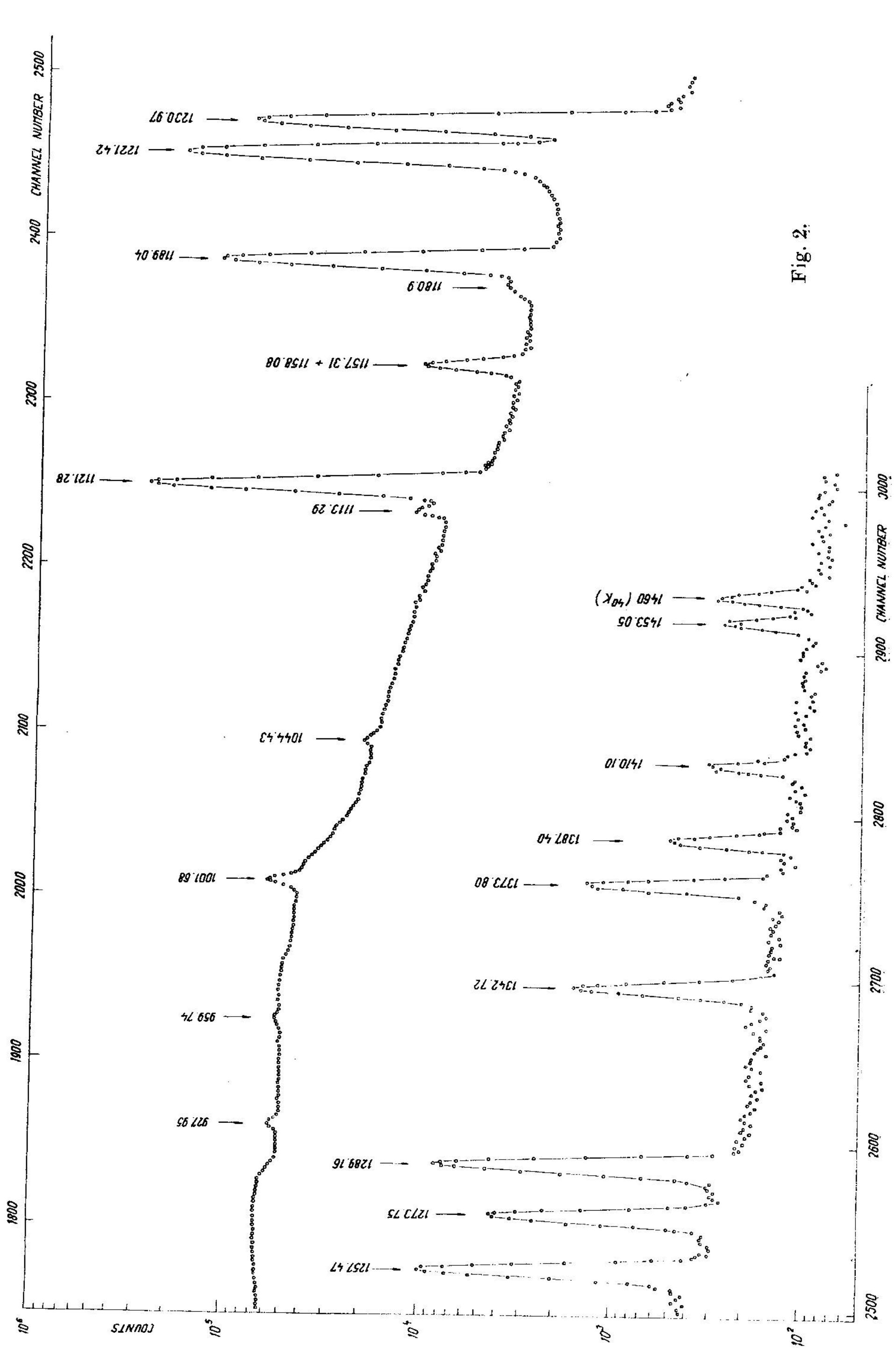

Fig. 2.

Table 1

Energies and relative intensities of gamma-rays and absolute intensities of transition in the decay of ^{182}Ta

Transition energy (keV)	Relative intensities of gamma-rays								Absolute total intensities
	Daniel [18]	Gruber [7]	Edwards [8]	Voinova [1]	White [3]	Sapyta [4]	Present paper	Weighed average	
42.714	—	—	0.665±0.035	—	—	—	—	0.665±0.035	0.403±0.023
65.722	8.1 ±0.5	8.06 ±0.49	7.69 ±0.38	—	—	—	—	7.88 ±0.16	11.5 ±0.5
67.750	120 ±7	120 ±9	113 ±6	—	—	—	—	116.4 ±2.8	50.1 ±1.1
84.691	8.4 ±0.6	8.34 ±0.46	7.23 ±0.35	7.1 ±0.7	—	7.0 ±0.5	7.6 ±0.8	7.57 ±0.28	22.8 ±0.9
100.106	40.4 ±2.0	40.3 ±2.0	38.5 ±1.9	40.0 ±4.0	—	40.7 ±2.8	40.3 ±4.0	39.9 ±0.4	69.1 ±0.7
113.673	5.21 ±0.32	5.22 ±0.27	5.23 ±0.27	5.1 ±0.9	—	5.20 ±0.36	5.28 ±0.40	5.22 ±0.02	7.77 ±0.03
116.418	1.32 ±0.12	1.32 ±0.11	1.21 ±0.07	1.12 ±0.20	—	1.20 ±0.20	1.27 ±0.13	1.25 ±0.04	0.550±0.018
152.435	18.2 ±0.9	18.1 ±0.9	19.6 ±0.8	20.0 ±2.0	21.0 ±0.8	19.5 ±1.4	19.3 ±1.4	19.4 ±0.5	7.64 ±0.18
156.387	6.82 ±0.41	6.77 ±0.40	7.69 ±0.35	7.7 ±0.9	8.10 ±0.40	7.5 ±0.5	7.13 ±0.48	7.37 ±0.24	2.89 ±0.09
179.393	9.4 ±0.6	9.3 ±0.5	8.80 ±0.38	8.9 ±1.0	9.44 ±0.40	8.7 ±0.6	8.7 ±0.6	9.07 ±0.19	5.50 ±0.11
198.356	4.20 ±0.31	4.19 ±0.27	4.11 ±0.23	4.13 ±0.40	4.37 ±0.25	4.30 ±0.30	4.15 ±0.28	4.21 ±0.05	1.948±0.021
222.110	21.9 ±0.9	21.8 ±0.9	21.6 ±0.8	21.3 ±2.1	22.7 ±0.9	21.2 ±1.5	21.5 ±1.5	21.9 ±0.3	8.06 ±0.11
229.318	9.6 ±0.6	10.0 ±0.5	10.46 ±0.46	10.4 ±1.2	11.1 ±0.5	10.5 ±0.7	10.3 ±0.7	10.33 ±0.19	4.32 ±0.06
264.072	9.9 ±0.7	9.9 ±0.7	10.34 ±0.46	10.0 ±1.2	10.7 ±0.4	10.3 ±0.7	10.4 ±0.7	10.36 ±0.13	4.07 ±0.04

Table 2

Energies and relative intensities of gamma-rays and absolute intensities of transition in the decay of ^{182}Ta

Transition energy (keV)	Relative intensities of gamma-rays							Absolute transition intensities
	Vitman [19]	Voinova [1]	Korkman [9]	White [3]	Sapyta [4]	Present paper	Weighed average	
891.92	≈0.3	<0.4	—	0.15 ±0.02	0.20 ±0.07	<0.3	0.16 ±0.04	0.056±0.014
927.95	1.74 ±0.26	1.8 ±0.4	—	1.79 ±0.09	1.6 ±0.2	1.75 ±0.20	1.76 ±0.07	0.620±0.025
959.74	0.95 ±0.24	0.8 ±0.5	—	1.02 ±0.06	1.3 ±0.2	0.95 ±0.11	1.02 ±0.05	0.361±0.018
1001.68	5.4 ±0.3	4.9 ±0.7	7.7 ±2.5	5.98 ±0.30	5.6 ±0.6	5.66 ±0.40	5.64 ±0.17	1.99 ±0.06
1044.43	1.2 ±0.2	0.7 ±0.5	<1	0.69 ±0.08	0.8 ±0.1	0.69 ±0.10	0.75 ±0.05	0.263±0.018
1113.29	—	—	—	1.13 ±0.10	1.2 ±0.2	1.44 ±0.20	1.19 ±0.08	0.420±0.028
1121.28	100	100	100	100	100	100	100	35.04±0.35
1157.58	4.1 ±1.2	2.0 ±0.4	2.67 ±0.15	2.83 ±0.07	2.76 ±0.30	2.90 ±0.20	2.81 ±0.13	0.99 ±0.06
1180.9	—	—	—	—	0.25 ±0.04	0.28 ±0.04	0.26 ±0.04	0.091±0.014
1189.04	44.3 ±1.5	46 ±5	48.0 ±2.0	47.4 ±0.7	46.3 ±3.2	46.7 ±2.3	46.9 ±0.6	16.50±0.27
1221.42	77 ±6	76 ±8	85.0 ±3.0	79.3 ±1.2	77 ±5	80.3 ±4.1	79.8 ±1.5	28.0 ±0.6
1223.2	—	—	—	—	0.6 ±0.1	—	0.6 ±0.1	0.21 ±0.04
1230.97	26 ±5	33 ±4	28.5 ±1.0	33.4 ±0.5	32.7 ±2.3	34.5 ±2.5	32.5 ±1.6	11.4 ±0.6
1257.47	3.8 ±0.3	4.1 ±0.6	3.90 ±0.16	4.33 ±0.07	4.3 ±0.3	4.46 ±0.45	4.24 ±0.12	1.49 ±0.05
1273.75	1.5 ±0.3	2.0 ±0.3	1.64 ±0.15	1.90 ±0.04	1.80 ±0.13	1.96 ±0.19	1.88 ±0.10	0.662±0.036
1289.16	3.7 ±0.2	4.4 ±0.6	3.67 ±0.15	4.05 ±0.07	3.80 ±0.27	4.10 ±0.40	3.96 ±0.13	1.40 ±0.05
1342.72	0.60 ±0.09	0.70 ±0.10	0.78 ±0.05	0.75 ±0.02	0.7 ±0.1	0.80 ±0.09	0.747±0.035	0.263±0.013
1373.80	0.52 ±0.09	0.72 ±0.10	0.70 ±0.14	0.66 ±0.02	0.6 ±0.1	0.70 ±0.08	0.655±0.034	0.230±0.013
1387.40	0.25 ±0.06	0.28 ±0.04	0.18 ±0.04	0.217±0.010	0.18 ±0.02	0.225±0.023	0.214±0.018	0.075±0.016
1410.10	0.12 ±0.02	0.11 ±0.02	0.13 ±0.06	0.117±0.008	0.11 ±0.02	0.130±0.025	0.118±0.004	0.041±0.002
1437.8	<0.02	<0.02	<0.05	<0.005	—	<0.01	<0.005	<0.002
1453.05	0.09 ±0.01	0.19 ±0.05	0.14 ±0.06	0.123±0.010	0.12 ±0.02	0.10 ±0.02	0.109±0.017	0.038±0.006

electron spectra of ^{182}Ta also only the upper limit of intensity can be estimated up to 0.01 % per decay. The gamma-rays with the energy of 1223.2 keV, observed for the first time in the gamma-gamma coincidences spectrum [4], could not be observed because the corresponding spectral line was overlapped by a very intensive photopeak of the transition with energy of 1221.42 keV.

III. TRANSITION MULTIPOLARITIES

The multipolarities of the gamma-transitions following the decay of ^{182}Ta were determined with the help of experimental data of two types:

1. The intensity ratios of the L_I, L_{II} and L_{III} subshell conversion electrons and in some cases also those of M_I, M_{II} and M_{III} subshells were considered. The experimental data were taken from papers [1, 2] and they are given in Tab. 3, together with theoretical values of the internal conversion coefficient (ICC) ratios interpolated from the data given in [12]. Conclusions concerning the transition multipolarities have been made on the basis of comparison of the available experimental data with the related theoretical ones. The multipolarity mixture were calculated from the following relation:

$$\delta^2 = \frac{\alpha_i}{\beta_i} \frac{1 - a_{ik}\, \alpha_k/\alpha_i}{1 - a_{ik}\, \beta_k/\beta_i},$$

where

$$\delta^2 = \frac{I_\gamma(E2)}{I_\gamma(M1)}, \quad \text{or} \quad \delta^2 = \frac{I_\gamma(M2)}{I_\gamma(E1)};$$

$$a_{ik} = \frac{I(L_i)}{I(L_k)}, \quad i, k = \text{I, II, III};$$

$$\alpha_{i,k} = \alpha_{L_{i,k}}(E1), \quad \text{or} \quad \alpha_{i,k} = \alpha_{L_{i,k}}(M1)$$

$$\beta_{i,k} = \beta_{L_{i,k}}(M2), \quad \text{or} \quad \beta_{i,k} = \beta_{L_{i,k}}(E2).$$

2. *The internal conversion coefficients.* The intensities of both the conversion electrons and the gamma-rays were measured for most of the gamma-transitions occurring in the decay of ^{182}Ta which enabled the experimental values of ICC to be calculated and the conclusions concerning the transition multipolarities (Tab. 4 and 5) to be made on the basis of comparison of the former with theoretical values of ICC [12]. The normalization factor for the ICC determination was calculated under the assumption that the transitions with energies of 100.106, 198.356, 229.318, 264.072, 1221.42 and 1257.47 keV were pure $E2$, and 1289.16 keV pure $M2$ types.

Table 3

Intensity ratios of ^{182}W subshell conversion electrons

Measured ratios	Exper. values	$E1$	$E2$	$M1$	$M2$	Multipolarity
			31.734 keV			
$L_{II} : L_I$	0.78 ± 0.08	0.792	70.1	0.097	0.069	$E1$
$L_{III} : L_I$	1.01 ± 0.11	1.065	82.1	0.012	0.487	
$M_I : L_{II}$	0.24 ± 0.04	0.282	0.039	2.34	3.69	
$M_{II} : L_I$	0.076 ± 0.020	0.154	16.9	0.023	0.020	
$M_{III} : L_I$	0.19 ± 0.04	0.215	20.5	0.003	0.129	
			42.714 keV			
$L_{III} : L_{II}$	1.25 ± 0.20	1.28	1.11	0.124	5.09	$E1$
$M_I : L_{II}$	0.31 ± 0.09	0.361	0.0037	2.34	3.05	
$M_{II} : L_{III}$	0.18 ± 0.05	0.160	0.219	1.98	0.054	
			65.722 keV			
$L_{II} : L_I$	0.121 ± 0.006	0.426	37.6	0.094	0.101	$M1$ +
$L_{III} : L_I$	0.048 ± 0.003	0.504	38.0	0.011	0.314	+ (0.7 ± 0.2) % $E2$
$M_I : L_{II}$	1.93 ± 0.20	0.510	0.007	2.37	2.44	
$M_{II} : L_I$	0.035 ± 0.007	0.092	9.23	0.023	0.027	
$M_{III} : L_I$	0.012 ± 0.004	0.114	9.59	0.0028	0.083	
			67.750 keV			
$L_{II} : L_I$	0.397 ± 0.016	0.415	34.8	0.095	0.102	$E1$
$L_{III} : L_I$	0.491 ± 0.019	0.490	34.9	0.011	0.309	
$M_I : L_{II}$	0.63 ± 0.13	0.524	0.0078	2.37	2.39	
$M_{III} : L_I$	0.127 ± 0.025	0.111	8.84	0.0028	0.081	
			84.691 keV			
$L_{II} : L_I$	0.394 ± 0.014	0.350	18.7	0.094	0.111	$M1$ +
$L_{III} : L_I$	0.308 ± 0.012	0.398	17.6	0.011	0.259	+ (10.7 ± 0.9) % $E2$
$M_I : L_{II}$	0.61 ± 0.08	0.620	0.013	2.39	2.17	
$M_{II} : L_I$	0.107 ± 0.012	0.078	4.62	0.023	0.029	
$M_{III} : L_I$	0.089 ± 0.010	0.092	4.48	0.0027	0.068	
			100.106 keV			
$L_I : L_{III}$	0.094 ± 0.004	2.94	0.093	91.8	4.45	$E2$
$L_{II} : L_{III}$	1.085 ± 0.016	0.91	1.125	8.62	0.522	
$M_I : L_{III}$	0.029 ± 0.001	0.637	0.0219	20.6	1.07	
$M_{II} : L_{III}$	0.261 ± 0.025	0.205	0.277	2.14	0.135	
$M_{III} : L_I$	2.54 ± 0.24	0.080	2.72	0.0027	0.059	
			113.673 keV			
$L_{II} : L_I$	0.262 ± 0.026	0.281	8.81	0.094	0.121	$M1$ +
$L_{III} : L_I$	0.131 ± 0.025	0.302	7.54	0.011	0.200	+ (9 ± 2) % $E2$
$M_I : L_{II}$	0.94 ± 0.14	0.770	0.026	2.40	1.98	

Table 3 (continued)

Measured ratios	Exper. values	$E1$	$E2$	$M1$	$M2$	Multipolarity
$M_{II} : L_I$	0.084 ± 0.015	0.064	2.18	0.024	0.031	
$M_{III} : L_I$	0.053 ± 0.012	0.072	1.92	0.0028	0.053	
			116 . 418 keV			
$\frac{L_{II} + L_{III}}{L_I}$	0.62 ± 0.05	0.478	15.4	0.104	0.319	$E1 + < 0.04\ \%\ M2$
			152 . 435 keV			
$L_{II} : L_I$	0.19 ± 0.04	0.229	4.59	0.093	0.128	$E1 + < 0.5\ \%\ M2$
$L_{III} : L_I$	0.22 ± 0.05	0.234	3.53	0.010	0.150	
			179 . 393 keV			
$L_{II} : L_I$	0.48 ± 0.05	0.205	3.28	0.091	0.130	$M1 +$
$L_{III} : L_I$	0.35 ± 0.04	0.205	2.37	0.010	0.126	$+ (40 \pm 4)\ \%\ E2$
			198 . 356 keV			
$L_{II} : L_I$	2.63 ± 0.40	0.192	2.72	0.091	0.131	$E2 + < 4\ \%\ M1$
$L_{III} : L_I$	1.86 ± 0.28	0.187	1.88	0.0099	0.113	
			222 . 110 keV			
$L_{II} : L_I$	0.182 ± 0.036	0.177	2.20	0.090	0.132	$E1 + < 0.7\ \%\ M2$
$L_{III} : L_I$	0.182 ± 0.036	0.170	1.45	0.0097	0.099	
			229 . 318 keV			
$L_{II} : L_I$	2.18 ± 0.26	0.173	2.09	0.089	0.132	$E2 + < 2\ \%\ M1$
$L_{III} : L_I$	1.50 ± 0.27	0.165	1.35	0.0097	0.095	
			264 . 072 keV			
$L_{II} : L_I$	1.52 ± 0.18	0.157	1.61	0.088	0.132	$E2 + < 3\ \%\ M1$
$L_{III} : L_I$	0.80 ± 0.20	0.147	0.983	0.0095	0.080	

Both the results of gamma-gamma angular correlations and the pair conversion coefficients in the decay of ^{182}Ta [1] and thus the conclusions concerning the quantum numbers of the levels in ^{182}W were taken into account for the determination of the transition multipolarities.

The analysis of all mentioned experimental data enabled the final conclusions about the transition multipolarities to be made and the double multipole mixtures to be determined. The gamma-transitions with the energies of 1044.43, 1158.08 and 1189.04 keV can be interpreted as triple multipolarity mixtures $E1 + M2 + E3$ [1]. The high experimental values of ICC for the transitions with energies of 1157.31 and 1437.8 keV indicate that the monopole transition $E0$ is involved in these transitions to a great extent.

Table 4

Internal conversion coefficients and multipolarities of gamma-transitions in ^{182}W

Transition energy	Conversion electrons	Values of ICC × 10³: Experiment	E 1	E 2	E 3	M 1	M 2	Multipolarities
42.714	L_{II}	159 ± 36	144	64900	4280000	674	22600	$E1 + < 0.2\ \%\ M2$
	L_{III}	173 ± 40	184	72000	4490000	83.5	115000	
65.722	L_I	2038 ± 160	88.9	221	7310	1990	43000	$M1 + < 1\ \%\ E2$
	M_I	492 ± 63	19.3	60.7	2200	445	10600	
67.750	L_I	90 ± 5	82.8	207	6210	1820	37900	$E1 + < 0.04\ \%\ M2$
	L_{III}	44.0 ± 2.2	40.6	7220	283000	20.6	11700	
84.691	K	5900 ± 550	471	1110	1620	6560	55800	$M1 + (10-15)\ \%\ E2$
	L_I	823 ± 50	48.8	135	1980	947	15000	
	L_{II}	318 ± 25	17.1	2530	88600	89.4	1670	
100.106	K	810 ± 80	308	894	1940	4050	30600	$E2$
	L_{II}	1110 ± 50	10.1	1170	35100	54.8	887	
	L_{III}	1030 ± 30	11.1	1040	27600	6.36	1700	
113.673	K	2370 ± 170	223	699	1770	2810	19400	$M1 + (12 \pm 4)\ \%\ E2$
	L_I	359 ± 31	24.0	73.9	553	404	4550	
	L_{II}	94 ± 10	6.75	651	17400	37.8	551	
116.418	K	≈ 220	210	664	1710	2620	17900	$E1$
	L_I	≈ 30	22.7	70.1	505	378	4140	
152.435	K	112 ± 8	105	348	1020	1220	6890	$E1 + < 0.3\ \%\ M2$
	L_I	13.9 ± 2.8	11.7	37.7	198	175	1450	
156.387	K	94 ± 19	98.3	326	959	1140	6300	$E1 + < 0.3\ \%\ M2$
	L_I	10 ± 3	11.0	35.5	182	163	1320	
179.393	K	560 ± 50	68.9	228	683	771	3910	$M1 + (39 \pm 9)\ \%\ E2$
	L_I	79 ± 4	7.87	25.5	118	111	786	

Table 4 (continued)

Transition energy	Conversion electrons	Values of ICC $\times 10^3$						Multipolarities
		Experiment	*E* 1	*E* 2	*E* 3	*M* 1	*M* 2	
198.356	K	182 ± 8	53.4	174	522	583	2780	$E2 + < 0.4\ \%\ M1$
	L_{III}	39.1 ± 1.8	1.15	37.2	494	0.83	60.8	
222.110	K	39.0 ± 2.0	40.1	129	382	426	1890	$E1 + < 0.05\ \%\ M2$
	L_I	5.5 ± 0.8	4.69	15.0	61.5	61.1	357	
229.318	K	117 ± 6	37.1	118	349	390	1700	$E2 + < 1\ \%\ M1$
	L_{II}	27.3 ± 1.8	0.75	28.8	413	5.0	42.0	
264.072	K	77 ± 7	26.1	80.5	234	286	1060	$E2 + < 1\ \%\ M1$
	L_I	10.2 ± 1.3	3.11	9.75	36.9	37.9	193	

Table 5

Internal conversion coefficients and multipolarities of gamma-transitions in ^{182}W

Transition energy	Values of ICC $\times 10^3$						Multipolarities	
	Experiment	*E* 1	*E* 2	*E* 3	*M* 1	*M* 2		
891.92	4.5 ± 1.8	1.86	4.65	10.2	11.1	27.5	$E2 + < 25\ \%\ M1$;	$E1 + (10 \pm 7)\ \%\ M2$
927.95	4.37 ± 0.32	1.73	4.31	9.32	10.1	24.8	$E2 + < 7\ \%\ M1$;	$E1 + (11 \pm 2)\ \%\ M2$
959.74	9.8 ± 0.9	1.63	4.03	8.65	9.27	22.6	$E3 + (8 \pm 6)\ \%\ M2$;	$E1 + (39 \pm 4)\ \%\ M2$
1001.68	3.97 ± 0.19	1.50	3.70	7.88	8.34	20.2	$E2 + (6 \pm 4)\ \%\ M1$;	$E1 + (13 \pm 1)\ \%\ M2$
1044.43	4.1 ± 0.6	1.39	3.42	7.19	7.52	18.1	$E1 + (16 \pm 4)\ \%\ M2$;	$E1 + M2 + E3$ [1]
1113.29	4.0 ± 0.8	1.24	3.02	6.27	6.42	15.3	$E2 + (29 \pm 23)\ \%\ M1$;	$E1 + (27 \pm 9)\ \%\ M2$
1121.28	3.15 ± 0.19	1.23	2.98	6.17	6.31	15.0	$E2 + < 11\ \%\ M1$;	$E1 + (14 \pm 1)\ \%\ M2$
1157.31	6.8 ± 0.7	1.16	2.80	5.77	5.84	13.8	$E2 + (0.40 \pm 0.06)\ \%\ E0$	
1158.08	2.1 ± 0.7	1.12	2.70	5.51	5.56	13.5	$E1 + (7 \pm 6)\ \%\ M2$;	$E1 + M2 + E3$
1189.04	4.10 ± 0.21	1.11	2.66	5.45	5.46	12.8	$E1 + (26 \pm 1)\ \%\ M2$;	$E1 + M2 + E3$ [1]
1221.42	2.57 ± 0.13	1.05	2.53	5.15	5.11	12.0	$E2 + < 7\ \%\ M1$;	$E1 + (14 \pm 1)\ \%\ M2$
1230.97	2.54 ± 0.16	1.04	2.49	5.07	5.02	11.7	$E2 + < 8\ \%\ M1$;	$E1 + (14 \pm 2)\ \%\ M2$
1257.47	2.45 ± 0.32	1.00	2.40	4.85	4.76	11.1	$E2 + < 15\ \%\ M1$;	$E1 + (14 \pm 3)\ \%\ M2$
1273.75	2.35 ± 0.23	0.98	2.34	4.72	4.61	10.7	$E1 + (13 \pm 2)\ \%\ M2$;	$E2 + < 10\ \%\ M1$
1289.16	9.8 ± 0.7	0.86	2.29	4.60	4.48	10.4	$M2 + < 22\ \%\ E3$;	$M2 + < 14\ \%\ E1$
1342.72	2.5 ± 0.5	0.89	2.12	4.23	4.06	9.39	$E2 + < 45\ \%\ M1$;	$E1 + (19 \pm 6)\ \%\ M2$
1373.80	3.94 ± 0.42	0.86	2.03	4.03	3.84	8.80	$E3 + < 7\ \%\ M2$;	$M1 + < 18\ \%\ E2$
1387.40	4.1 ± 0.8	0.84	1.99	3.95	3.74	8.64	$E3 + < 20\ \%\ M2$;	$M1 + < 25\ \%\ E2$
1410.10	2.7 ± 1.6	0.82	1.93	3.82	3.60	8.30	$E2 + M1$;	$E1 + (4 - 46)\ \%\ M2$
1437.8	> 40	0.80	1.86	3.67	3.43	7.90	$E2 + > 4\ \%\ E0$	
1453.05	3.5 ± 1.0	0.78	1.83	3.59	3.35	7.69	$E3 + < 22\ \%\ M2$	

The total absolute intensities of gamma-transitions occurring in the decay of $^{182}Ta \rightarrow {}^{182}W$ were calculated (Tab. 1) with the help of the ICC values and the experimentally approved fact [1] that the intensity of beta-transition leading to the ground state of ^{182}W is less than 0.001 % per decay.

IV. THE DECAY SCHEME

The decay scheme $^{182}Ta \rightarrow {}^{182}W$ was set up on the basis of our experimental results and the other data available in the preceding papers were also used.

The difference of the presented decay scheme from the ones published previously consists in the more precise energies of levels, due to the already mentioned high precision of the gamma transition energies determinantion.

In the previous papers dealing with the decay of ^{182}Ta ten excited states have been found in the ^{182}W nucleus and their quantum characteristics have been determined unambigously. They are levels at energies of 100.106 ($I^\pi = 2^+$), 329.424 ($I^\pi = 4^+$), 1221.415 ($I^\pi = 2^+$), 1257.430 ($I^\pi = 2^+$), 1289.164 ($I^\pi = 2^-$), 1331.131 ($I^\pi = 3^+$), 1373.853 ($I^\pi = 3^-$), 1442.825 ($I^\pi = 4^+$), 1487.520 ($I^\pi = 4^-$) and 1553.240 ($I^\pi = 4^-$) keV. Our experimental results and conclusions about the transition multipolarities confirm these data and therefore there is no need to analyze these levels and their quantum characteristics. In the following only the new experimental facts and conclusions which can be derived from them about the decay scheme of ^{182}Ta will be discussed.

The existence of a new level at the energy of 1510.21 keV has been already assumed in the paper about the decay of ^{182m}Re [5]. In a recent paper [4] and in our investigation of the decay of ^{182}Re [6] the existence of this level has been confirmed by the gamma-gamma coincidence experiments. These results disprove the assumption [1] concerning the level at the energy of 1410.1 keV, which had to be deexcited by the 1410.1 and 1310 keV transitions leading to the ground and first excited states of ^{182}W, respectively. The 1310 keV transition has been observed only in the pair-conversion positron spectrum [13] but it has not yet been found either in the gamma-ray spectrum or in that of the internal conversion electron in the decay of ^{182}Ta. The observation of a new transition with the energy of 1180.9 keV enabled the level at 1510.21 keV to be determined, which is deexcited by 1410.10 and 1180.9 keV transitions. As the conversion electrons from the 1180.9 keV transition had not been observed neither the ICC of this transition nor its multipolarity could be determined. The $E2 + (M1)$ multipolarity can be most likely assigned to the 1410.10 keV transition, whence there follow a positive parity of the level at 1510.21 keV and possible spin values $I = 2$, 3 or 4.

The 1437.8 keV transition observed in the ^{182}Ta conversion electron spectra [1, 9] deserves special attention. This transition has not been observed so far in the gamma-ray spectrum and the lower limit of its ICC has been estimated in paper [1] as $\alpha_K \geqslant 4.8 \times 10^{-3}$. This value has led to the conclusion about the multipolarity of 1437.8 keV transition being of the type $E3$, $M2$ or higher. On this basis an assumption of the existence of the 3^--level at 1437.8 keV has been made [1]. Our experiments as well as the results of White et al. [3] set up the upper limit of the intensity $I_\gamma(1437.8) \leqslant 0.005$ (Tab. 1) and in consequence the ICC of this transition has to be $\alpha_K \geqslant 40 \times 10^{-3}$. Such an ICC value is higher than the theoretical one for the M4 transition and thus leads to the conclusion that a great admixture of $E0$ multipolarity is involved in the 1437.8 keV transition. In the case of a pure $E0$ transition a level with the same energy and with $I^\pi = 0^+$ would have to exist in the nucleus of ^{182}W. Such a possibility is very unlikely because of two reasons:

1. A supposed 0^+-level would have to be excited directly in the decay of the ^{182}Ta ground state possesing $I^\pi = 3^-$, which means by the third-forbidden beta transition ($\Delta I = 3$, $\pi_i \pi_f = -1$), for which the log ft value has to exceed 18.
2. The $E2$-transition with the energy of 1337.7 keV and an intensity approximately by two orders higher than $I_K(1437.8)$ leading to the ^{182}W ground state from the supposed 1437.8 keV level would have to be found. Such a transition was not observed either in the gamma-ray spectrum of ^{182}Ta or in that of ^{182m}Re [5].

Therefore we expressed an assumption in our paper [5] about the $^{182m}Re \rightarrow {}^{182}W$ decay suggesting that the transition in question possesses $E0 + (M1) + E2$ multipolarity and that it leads to the 2^+-level of ^{182}W ground state rotational band. It means that it is possible to establish a new 2^+-level at the energy of 1537.9 keV in ^{182}W. The existence of such a level has been confirmed also by the gamma-rays with the energy of 1537 ± 2 keV observed in the decay of ^{182m}Re [5].

On the basis of the proposed decay scheme of ^{182}Ta and of the absolute transition intensities, the intensity balance was made and as a result the beta branchings in percents per decay for each level of ^{182}W were determined (see Fig. 3). Using these data and the Q-value of the ^{182}Ta beta-decay ($E_{\beta^-} = 1812 \pm 3$ keV [1]) the corresponding $\log ft$ values were determined. From the character of ^{182}Ta decay to the individual levels of the daughter nucleus it is possible to make conclusions about the probable values of the ^{182}Ta ground state quantum characteristics. From the decay scheme one can see that the most intensive beta components lead to the ^{182}W levels with $I^\pi = 2^-$ (1289.164 keV), 3^- (1373.853 keV) and 4^- (1553.240 keV). In consequence, these beta transitions appear to be:

1. either allowed, in which case the ground state of ^{182}Ta has $I^\pi = 3^-$;
2. or once forbidden (resp. unique, once forbidden) while to the ground state

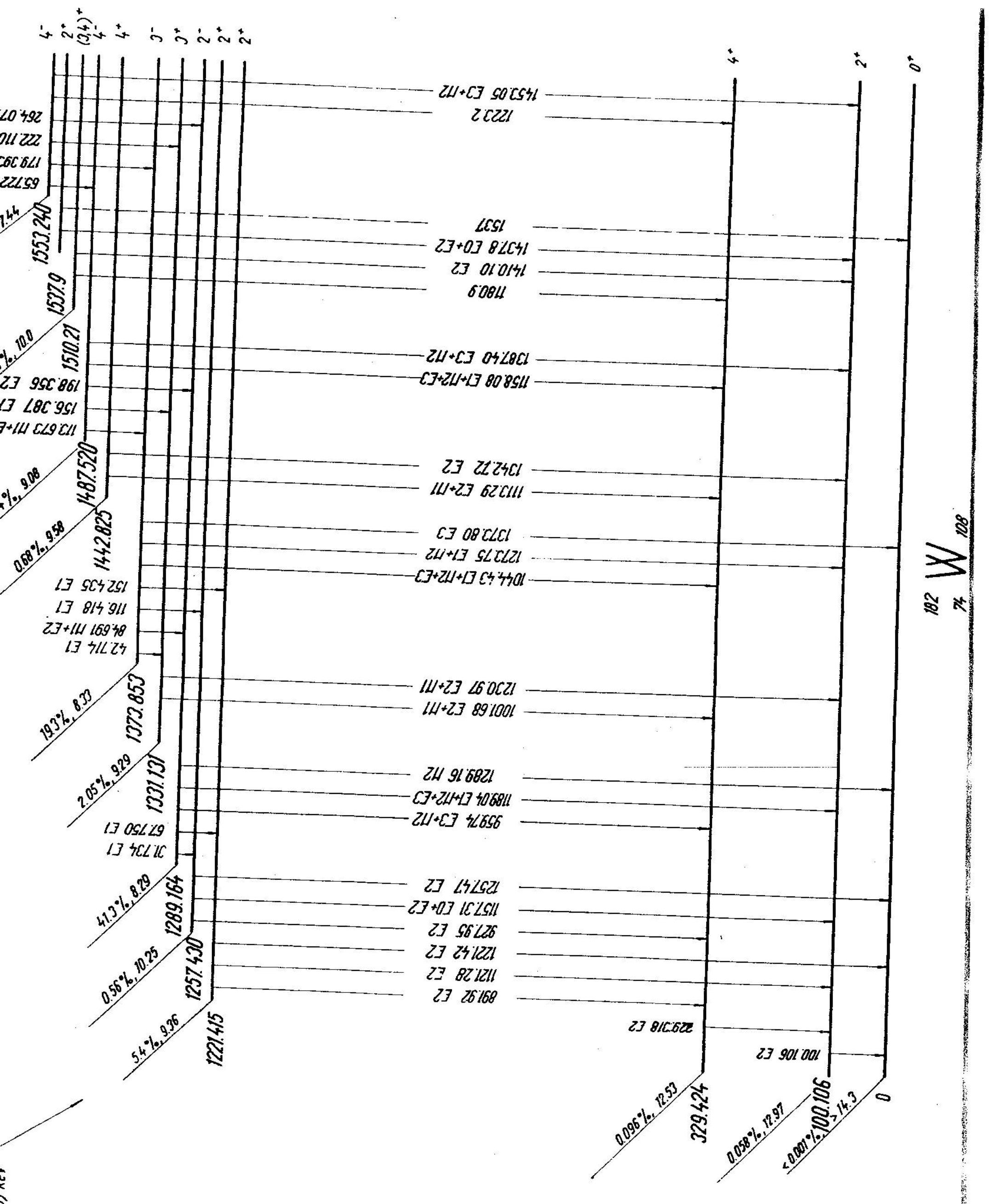

Fig. 3.

of ^{182}Ta $I^{\pi} = 2^{+}, 3^{+}$ or 4^{+} can be assigned. The second case is much less probable because of very high $\log ft$ values ($\log ft \geqslant 9.3$) for the beta transitions leading to the positive parity states of ^{182}W.

The relatively high values of $\log ft$ of the beta transitions leading to the levels at 1289.164 and 1373.853 keV ($\log ft > 8$) indicate that some kind of additional forbiddeness is imposed upon these transitions diminishing their probability. The level at 1289.164 keV is interpreted within the frame of the superfluid nuclear model [14] as a two-quasiparticle state p402↑—p514↑ and the level at 1373.853 keV as a first excited state in the rotational band appropriate to this state. If the ground state of ^{182}Ta is interpreted on the basis of the Nilsson model [15] as a p404↓—n510↑ proton-neutron configuration, one can see that the beta transition between this level and the p402↑—p514↑ state in ^{182}W is a two-particle transition, which is strongly forbidden in the frame of nuclear superfluidity model (the so-called F-forbidden transition). On the basis of this interpretation it is possible to explain the relatively high $\log ft$ values of the beta transitions leading to both levels of the rotational band with $K^{\pi} = 2^{-}$.

The beta-decay of ^{182}Ta to the 1553.240 keV level interpreted as a two-quasiparticle n624↑ — n510↑ state proceeds with the $\log ft = 7.44$, which value is in accordance with the experimental values of $\log ft = 6.5—8.4$ [16] for the beta transitions of the n624↑ ⇄ p404↓ type in the neighbouring odd-mass nuclei. These transitions belong to the class of so-called N-forbidden transitions the existence of which gives evidence of the mixing of wave functions of Nilsson states differing in asymptotic quantum numbers by $\Delta N = \Delta n_z = 2, \Delta \Lambda = 0$ [17]. In the present case the mixing of wave functions of Nilsson states n404↑ and p624↓ with n624↑ and p404↓ respectively, occurred, which in consequence leads to the allowed unhindered beta transitions n404↑ ⇄ p404↓ and n624↑ ⇄ p624↓, increasing to a great extent the transition probability between the states n624↑ and p404↓.

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