Изв. АН СССР, сер. физ., 1969, т.33, №8, с.1244-1251

ОБЪЕДИНЕННЫЙ
ИНСТИТУТ
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ

Дубна

E4 - 4224

ЛАБОРАТОРИЯ ТЕОРЕТИЧЕСКОЙ ФИЗИКИ

L.A.Malov, V.G.Soloviev, U.M.Fainer

NONROTATIONAL STATES OF DEFORMED ODD-Z NUCLEI IN THE REGION $177 \leq A \leq 187$

1968

E4 - 4224

L.A.Malov, V.G.Soloviev, U.M.Fainer[x]

NONROTATIONAL STATES OF DEFORMED ODD-Z NUCLEI IN THE REGION $177 \leq A \leq 187$

Submitted to Известия АН СССР

x/ Institute of Physics of the Latvian Academy of Science, Riga

The effect of the interaction of quasiparticles with phonons on the structure of the states in odd-A deformed nuclei was considered in ref. [1]. In refs. [2-6] the energies of the excited states of odd-A deformed nuclei are calculated and their structure is studied. In ref. [7] the interaction of quasiparticles with gamma-vibrational phonons is considered, in those cases where these interactions are predominant, the results are close to those in ref [2].

The calculations in refs. [1-7] are carried out with the schemes of the levels and the wave functions of the Nilsson potential. In refs. [8,9] the characteristics of the one-phonon states of even-even deformed nuclei in the region $150 < A < 188$ are calculated with the use of the one-particle energies and the wave functions of the Woods-Saxon potential calculated in [10,11].

In the present paper we give the energies and the structure of the ground and excited states of odd-Z nuclei in the region $177 \leq A < 187$ calculated with one-particle energies and the wave functions of the Woods-Saxon potential for $A = 181$ (obtained in ref. [11]). In the calculations the quadrupole and octupole phonons given in [9] are used. The calculations are performed for β deformation equal to 0.20, 0.23 and 0.26. For each nucleus we give the characteristics of all the calculated states with an energy up to 1 MeV of the most states with energy up to 1.5 MeV.

As is know, in the scheme of the average field levels there are some states with given K^{π} 's. In/1/ a general case is considered where several states $\rho_1, \rho_2, \ldots \rho_n$ with a given K^{π} are taken into account. In calculating the excited state ehergies up to 1.5 MeV it is possible to restrict oneself to the case when two states ρ_1 and ρ_2 are taken into account. The wave function is written in the form

$$\Psi_j(K^{\pi}\rho_1,\rho_2) = \frac{N_j(\rho_1,\rho_2)}{\sqrt{2}} \sum_{\sigma} \{ C^j_{\rho_1} \alpha^+_{\rho_1\sigma} + C^j_{\rho_2} \alpha^+_{\rho_2\sigma} +$$

$$+ \sum_{\lambda\mu i\nu} D^{\lambda\mu i j}_{\rho_1\rho_2\nu\sigma} \alpha^+_{\nu\sigma} Q^+_i(\lambda\mu) \Psi , \qquad (1)$$

here $Q_i(\lambda\mu)$ in the phonon operator of multipolarity $(\lambda\mu)$ $\alpha_{\nu\sigma}$ is the quasi-particle absorption operator, Ψ is the wave function of the ground state of an even-even nucleus.

Using the variational principle we get the following secular equation

$$\begin{vmatrix} V_j(\rho_1,\rho_1) - (\epsilon(\rho_1) - \eta_j) & V_j(\rho_1,\rho_2) \\ V_j(\rho_1,\rho_2) & V_j(\rho_2,\rho_2) - (\epsilon(\rho_2) - \eta_j) \end{vmatrix} = 0, \qquad (2)$$

where

$$V_j(\rho_q,\rho_n) = 1/4 \sum_{\lambda\mu i\nu} \frac{v_{\rho_q\nu} v_{\rho_n\nu}}{Y^i(\lambda\mu)} \frac{f^{\lambda\mu}(\rho_q\nu) f^{\lambda\mu}(\rho_n\nu)}{\epsilon(\nu) + \omega_i^{\lambda\mu} - \eta_j}, \qquad (3)$$

where $\epsilon(\nu)$ are the quasi-particle energies. $f^{\lambda\mu}(\rho\nu)$ is the matrix element of multipole operator with momentum $\lambda\mu$ for the remaining notations see ref./2/. In (2) there are only poles of the first order. The roots (2) η_j are the energies of the states with a given K^π, in this case $j = 1,2,3,\ldots$ For the ground state of an odd-A nucleus $\eta_1(K^\pi_F)$ assumes the smallest value. The excited state energies are defined as

$$\eta_j(K^\pi) - \eta_1(K^\pi_F). \tag{4}$$

The quantities $C^j_{\rho_1}$ and $C^j_{\rho_2}$ are written in the form

$$C^j_{\rho_1} = 1 - \frac{V_j(\rho_1, \rho_2)}{V_j(\rho_1, \rho_1) - (\epsilon(\rho_1) - \eta_j)},$$

$$C^j_{\rho_2} = 1 - \frac{V_j(\rho_1, \rho_2)}{V_j(\rho_2, \rho_2) - (\epsilon(\rho_2) - \eta_j)}, \tag{5}$$

then we get

$$D^{\lambda\mu i j}_{\rho_1\rho_2\nu\sigma} = C^j_{\rho_1} D^{\lambda\mu i j}_{\rho_1\nu\sigma} + C^j_{\rho_2} D^{\lambda\mu i j}_{\rho_2\nu\sigma},$$

$$N_j(\rho_1, \rho_2)^{-2} = (C^j_{\rho_1})^2 + (C^j_{\rho_2})^2 + 1/2 \sum_{\lambda\mu i} \sum_{\nu\sigma} (D^{\lambda\mu i j}_{\rho_1\rho_2\nu\sigma})^2. \tag{6}$$

The contribution of the one-quasi-particle state ρ_1 to the wave function (1) is as $N_j(\rho_1, \rho_2)^2 (C^j_{\rho_1})^2$.

In considering some low-lying states we can restrict ourselves to the account of only one one-particle level ρ with given K^{π}_{ν}. This corresponds to the equation to zero of each diagonal element of (2). The contribution of the one-quasi-particle component ρ is defined by $(C^{j}_{\rho})^2$ and the contribution of the state quasiparticle in ν-state plus phonon $\lambda\mu i$ is defined by $(C^{j}_{\rho})^2 (D^{\lambda\mu i j}_{\rho\nu})^2$.

Some excited states have a noticeable admixture: quasiparticle plus gamma-vibrational phonon. Such states are characterized by an increase of the reduced probabilities B(E2) of electric E2-transitions. A part of them is given in Table 1. It is seen from the Table that there is a sufficiently good agreement between the experimental and calculated $B(E2)/B(E2)_{s.p.}$ in ^{187}Re and ^{185}Re. It should be noted that the use of the wave functions and the one-particle energies of the Woods-Saxon potential has lead to an essential improvement of the description of states with a large admixture of gamma-vibrational phonons as compared to ref./2/.

The results of calculations of the energies and the wave functions for some odd-A nuclei are given in Tables 2-7. In the fourth column of the Tables the contribution (in percent) of two-three largest components obtained from the normalization conditions of the wave function is given. For example, to the ground state of ^{187}Re with $K^{\pi} = 5/2^{+}$ the contibution is given by the 97% one-quasiparticle state 402 ↑ and the 2.4% component: quasiparticle in the 400 ↑ state plus phonon $Q_1(22)$.

Now we pass to a brief discussion of the results of Tables 2-7.

Re isotopes (Tables 2-5). In all the Re isotopes the ground state is the 402 ↑ state. According to the calculations the contributions of the one-particle component 402 ↑ to the ground state of the isotopes ^{187}Re, ^{185}Re, ^{183}Re, ^{181}Re and ^{179}Re is 96-98%. The spectrum of these nuclei studied in/12,13/ and in other works is very interesting. In the interaction of quasiparticles with phonons the main role is played by gamma-vibrational and octupole $Q_1(32)$ phonons. The role of the $Q_1(22)$ phonon essentially increases in heavy isotopes of ^{187}Re and ^{185}Re as compared to the light ones. This is due to the experimentally observed decrease of the energies of gamma-vibrational in even-even W isotopes. The calculations of gamma-vibrational phonons in even--even nuclei performed in/9/ with one-particle energies and the wave functions of the Woods-Saxon potential explain well this tendency. In ^{187}Re and ^{185}Re the low-lying $K^{\pi}=1/2^{+}$ and $9/2^{+}$ states containing the large contributions of a gamma-vibrational phonon are found experimentally. The calculated energies and the reduced B(E2) probabilities are in good agreement with experimental data. It is interesting to note that both theory and experiment point out that in each of these nuclei there must exist two close $K^{\pi}=1/2^{+}$states with strongly different properties. The lowest of them for ^{185}Re and ^{187}Re contains the component quasiparticle in the 402 ↑ state plus phonon $Q_{1}(22)$, while the second one is the qusi-particle 411 ↓ state with small admixture of different states quasiparticle plus phonon. For ^{181}Re and ^{183}Re the energies of the $K^{\pi}=1/2^{+}$ states are much higher than in ^{187}Re and ^{185}Re and the order is opposite (the collective state lies by 100-200 KeV higher than the one-quasiparticle one). The excitations for these $K^{\pi}=1/2^{+}$ states differ noticaeble, this is seen from Table 1.

It should be noted that in ^{185}Re and ^{187}Re there must exist other low-lying collective vibrational states. Each state is mainly gamma--vibrational phonon constructed on one of the lowest one-quasiparticle 514, 541 or 404 levels. It is very interesting to discover experimentally these states.

In ^{183}Re the three-quasiparticle $K^{\pi}=25/2^{+}$ state is observed in/14/. The culculations show that there can exist two three-quasiparticle $K^{\pi}=25/2^{+}$ states in which the energy for the multiplet centres is somewhat higher than the experimental one. The state (p514 ↑ n624 ↑ n514 ↓) with $K^{\pi}=25/2^{+}$ is the lowest in the multiplet while the second state (p402 ↑ n624 ↑ n615↑) with $K^{\pi}=25/2^{+}$ has an energy which is somewhat higher than that in the multiplet centre. In ^{183}Re, according to the independent quasiparticle model, there must be another three-quasiparticle state with $K^{\pi}=21/2^{-}$ (p402 ↑ n624 ↑ n514↓). It would be interesting to find three-quasiparticle states in ^{181}Re the energy of which is expected to be somewhat lower than in ^{183}Re. In ^{185}Re and

^{187}Re the energies of the three-quasiparticle states with $K^{\pi}=25/2^{+}$ and $21/2^{-}$ are higher than in ^{181}Re and ^{183}Re.

It is seen from Tables 2-5 that in all the isotopes of Re rather low are the energies of the states the structure of which is the following: qusiparticle plus octupole phonon $Q_1(32)$. However it should be taken into consideration that the main contribution to the phonon $Q_1(32)$ of the corresponding even-even W nuclei is given by the two-quasiparticle (p 402↑ p514↑) state. Therefore for the odd Re isotopes the low-lying states such as quasiparticle plus octupole phonon $Q_1(32)$ are close to the three-quasiparticle ones. The same may be said about the ^{181}Re states: quasiparticle plus octupole phonon $Q_1(31)$.

<u>^{181}Ta (Table 6).</u> According to the Woods-Saxon scheme, deformation $\beta = 0.26$ the one-particle 404↓ and 514↑ levels intersect with each other. Therefore the calculations give approximately the same energies for the states. It follows from the experimental data that the 514↑ level lies by 6 KeV higher than the ground 404↓ state. The accuracy of our calculation is restricted so that it is impossible to explain such a difference in the energies of these states. The calculations predict some low-lying vibrational states constructed on the basis of the one-particle 404↓, 514↑ and 541↓ states. Especially low are the states with a large admixture of gamma- and beta-vibrational phonons. These states have not been yet found experimentally. Some states are of complex structure, e.g. the $3/2^{+}$ state with an energy 1210KeV. The $1/2^{-}$-state of energy 170 KeV is mainly one-quasiparticle 541↓ state. It has been discovered experimentally in ^{183}Re the deformation of which is close to the deformation of ^{181}Ta. In heavier isotopes of Re this level lies possibility higher.

We have restricted to giving the table only for ^{181}Ta, the calculated excited states of ^{179}Ta and ^{177}Ta differ insignificantly from ^{181}Ta. The strongest differences are the following: in ^{177}Ta and ^{189}Ta the role of gamma-vibrational phonons decreases as compared to ^{181}Ta and the energies of the states containing a large admixture of gamma-vibrational phonons increse noticeably. The octupole $K^{\pi}=3/2^{-}$

and $11/2^-$ -states lying in ^{181}Ta at a height of about 1.8MeV are lowered up to 1.3-1.4 MeV in light isotopes of ^{181}Ta .

<u>^{177}Lu (Table 7).</u> This nucleus is experimentally studied in ref./15-18/ and in other papers. But vibrational states have not been yet discovered. The calculations show that in ^{177}Lu the collective nonrotational states have an energy higher than 1.3 MeV.

In ^{177}Lu five three-quasiparticle states with $K^{\pi}=23/2^-$, $11/2^+$, $7/2^+$, $15/2^+$ and $13/2^+$ are experimentally observed. The calculations give somewhat overestimated energies for the multiplet centres. It should be noted that the $514\uparrow + Q_1(31)$ state is essentially three-quasiparticle state with configuration ($p514\uparrow\ n514\downarrow\ n624\uparrow$).

In ^{179}Lu and ^{175}Lu the energies of the three-quasiparticle $K^{\pi}=11/2^+$ and $23/2^-$-states lie by 500-700 KeV higher than in ^{177}Lu. The $411\downarrow +$ $+\ Q(31)$ state in ^{175}Lu have three-quasiparticle structure and lies at about 2 MeV. The role of the quadrupole phonons in ^{179}Lu, ^{177}Lu, ^{175}Lu remains practically the same.

The performed calculations have shown that the use of the one-particle energies and the wave functions of the Woods-Saxon potential leads to a noticeable improvement in the description of the odd isotopes of Re, Ta and heavy Lu isotopes as compared to the calculations based on the Nilsson potential. The Coriolis forces which are in some cases important have not been taken into account. In describing a state which is close to a quasipotential state it is apparently necessary to take into account the change of its equilibrium deformation as compared to the deformation of nuclei in the ground states.

In conclusion we express our gratitute to A.A.Korneichuk. S.I.Fedotov and H.Schulz for their help and discussions.

References

1. V.G.Soloviev. Phys.Lett., <u>16</u>, 308 (1965).
2. V.G.Soloviev, P.Vogel. Nucl.Phys., <u>A92</u>, 449(1967).
3. В.Г.Соловьев, П.Фогель. Докл. АН СССР 171, 69(1966).
4. Л.А.Малов, В.Г.Соловьев. ЯФ 5., 566(1967).
5. М.К.Колпакчу, П.Фогель. Изв. АН СССР, сер.физ., 30, 2025(1966).

6. В.Г.Соловьев, П.Фогель, Г.Юнгклауссен, Изв. АН СССР, сер.физ., 31, 518 (1967).
7. D.R.Bes, Cho Yi Chung. Nucl. Phys., 86, 381 (1966).
8. А.А.Корнейчук, Л.А.Малов, В.Г.Соловьев, С.Н.Федотов. Г.Шульц. Препринт ОИЯИ Е4-4075, 1968.
9. Л.А.Малов, В.Г.Соловьев, У.М.Файнер. Докл. АН СССР. Препринт ОИЯИ Р4-4073 (1968).
10. Ф.А.Гареев, С.П.Иванова, Б.Н.Калинкин. Изв. АН СССР, сер.физ., 32, 1690(1968).
11. Ф.А.Гареев, С.П.Иванова, Б.Н.Калинкин, С.К.Слепнев, М.Г.Гинзбург. Препринт ОИЯИ Р4-3607 (1967).
12. K.M.Bisgard, E.Veje. Nucl.Phys., A103, 545 (1967);
13. J.O.Newton. Nucl.Phys., A108 353 (1968).
14. M.I.Emmott, J.R.Leigh, J.O.Newton and D.Ward, Phys.Lett., 20, 56 (1966); 22, 719(1966) (erratum).
15. L.Kristensen, M.Jorgensen, O.B.Nielsen, and G.Sidenius. Phys.Lett. 8, 57(1964); H.S.Johansen, M.Jergensen, O.B.Nielsen, and C.Sidenius. Phys.Lett., 8, 51(1964).
16. P.Alexander, F.Boehm and E.Kankeleit. Phys.Rev., 133, B284 (1964).
17. М.К.Балодис, Н.Д.Крамер, П.Т.Прокофьев, У.М.Файнер. ЯФ, 3,199 (1966).
18. R.K.Sheline. Proc. Int.Symp. on Nucl. Structure, Dubna, 1968.

Received by Publishing Department
on December 25, 1968.

Table 1

The reduced probabilities of E2-transitions

Nuclei	K^{π}	ρ	ν	Energy (KeV)		$B(E2)/B(E2)_{s.p.}$		C_{ρ}^{2} %	$C_{\rho}^{2}(D_{\rho\nu}^{\lambda\mu})^{2}$ %
				Exp.	Calcul.	Exp.	Calcul.		
^{187}Re	9/2–	532↑	514↑	686	920		2,0	0,6	99
^{187}Re	9/2+	404↑	402↑	840	840	2,5	1,9	0,3	99
^{187}Re	1/2+	411↓		625	970		0,1	88	2
^{187}Re	1/2+	400↑		511	710	3,8	3,2	14	85
^{185}Re	9/2+	404↑	402↑	966	860	2,6	2,7	0,7	99
^{185}Re	1/2+	411↓		879	950		0,2	89	5,8
^{185}Re	1/2+	400↑		645	660	3,6	4,1	18	80
^{183}Re	9/2+	404↑	402↑		1310		2,1	0,7	99
^{183}Re	1/2+	411↓		1102	970		≤0,01	93	0,3
^{183}Re	1/2+	400↑			1060		3,7	28	70

Table 2

^{187}Re ($\beta = 0.20$)

K^{π}	Energy, KeV Exp.	Calcul.	Structure
5/2+	0	0	402↑ 97% ; 400↑+Q(22) 2,4%
9/2−	206	440	514↑ 99%
1/2−		630	541↓ 91% ; 541↓+Q(20) 6%
1/2+	511	710	400↑ 14% ; 402↑+Q(22) 85%
9/2+	840	840	404↑ 0,3% ; 402↑+Q(22) 99%
7/2+		910	404↓ 95% ; 404↓+Q(20) 5%
5/2−	686	920	532↑ 0,6% ; 514↑+Q(22) 99%
13/2−		930	514↑+Q(22) ~ 100%
1/2+	625	970	411↓ 88% ; 411↑+Q(22) 5,6%; 402↑+Q(22) 2%
11/2−		1020	505↑ 94% ; 505↑+Q(20) 5,7%
3/2+	773	1210	402↓ 6,8% ; 404↓+Q(22) 84%
11/2+		1240	404↓+Q(22) ~100%
3/2+	865	1240	411↑ 5,6% ; 411↓+Q(22) 74%; 404↓+Q(22) 16%
5/2+		1320	642↑ 0,1% ; 514↑+Q(32) 99%
5/2+		1340	413↓ 2% ; 411↓+Q(22) 97%
3/2−		1460	532↓ 20% ; 541↓+Q(22) 70%
5/2+		1500	402↑+Q(20) ~100%
5/2−		1530	523↓ 2 % ; 541↓+Q(22) 98%
3/2+		1530	402↓ 72% ; 411↓+Q(22) 26%

Table 3

^{185}Re ($\beta = 0,20$)

K^{π}	Energy, KeV Exp.	Calcul.	Structure
5/2+	0	0	402↑ 96%; 400↑+Q_1(22) 3%
9/2−		460	514↑ 99%;
1/2−		620	541↓ 88%; 541↓+Q_1(20) 9,6%
1/2+	645	660	400↑ 18%; 402↑+Q_1(22) 80%; 402↓+Q_1(22) 2%
9/2+	966	860	404↑ 0,7%; 402↑+Q_1(22) 99%
7/2+		930	404↓ 92%; 404↓+Q_1(20) 6,7%
5/2−		940	532↑ 1%, 514↑+Q_1(22) 99%
1/2+	879	950	411↓ 89%; 402↑+Q_1(22) 5,8%; 411↑+Q_1(22) 4%
13/2−		960	514↑+Q_1(22) ~ 100%
11/2−		1030	505↑ 91%; 505↑ +Q_1(20) 8%
3/2+	(~840)	1210	402↓ 15%; 404↓+Q_1(22) 78%; 400↑+Q_1(22) 3%
3/2+		1210	411↑ 16%; 411↓+Q_1(22) 84%
11/2+		1260	404↓+Q_1(22) ~ 100%
5/2+		1340	413↓ 3%; 411↓+Q_1(22) 97%
9/2−		1410	402↑+Q_1(32) ~ 100%
5/2+		1410	402↑ 0,1%, 402↑+Q_1(20) 99%
1/2−		1410	402↑+Q_1(32) ~ 100%
3/2−		1440	532↓ 25%; 541↓+Q_1(22) 68%
3/2+		1480	402↓ 61%; 404↓+Q_1(22) 19%; 400↑+Q_1(22) 19%
5/2−		1540	523↓ 3%; 541↓+Q_1(22) 97%

Таблица 4

^{183}Re ($\beta = 0,20$)

K^{π}	Energy, KeV Exp.	Calcul.	Structure
5/2+	0	0	402↑ 98%; 400↑ +Q(22) 2%
9/2-	496	430	514↑ 99%
1/2-		600	541↓ 89%; 541↓+Q(20) 9%
7/2+	851	900	404↓ 93%; 404↓+Q(20) 6%
1/2+	1102	970	411↓ 93%; 411↑+Q(22) 4%
11/2-		1000	505↑ 92%; 505↑+Q(20) 7%
1/2+		1060	400↑ 28%; 402↑+Q(22) 70%
9/2+		1310	404↑ 0,7%, 402↑+Q(22) 99%
1/2-		1370	530↑ 0,4%; 402↑+Q(32) 99%
9/2-		1370	402↑+Q(32) ~100%
5/2-		1390	532↑ 1,3%; 514↑+Q(22) 98%
13/2-		1400	514↑+Q(22) ~100%
5/2+		1430	413↓ 0,2%; 514↑+Q(32) 99%
3/2+	(1035)	1500	402↓ 71%; 404↓+Q(22) 15%; 400↑+Q(22) 10%
3/2+		1590	411↑ 29%; 411↓+Q(22) 68%
3/2-		1670	532↓ 69%; 541↓+Q(22) 19%; 532↓+Q(20) 5%
21/2-		2000	p402↑ n624↑ n514↑ ~100%
25/2+		> 2200	p402↑ n624↑ n615↑ ~100%
25/2+	1907,5,	2300	p514↑ n624↑ n514↓ ~100%

Table 5

^{181}Re (β=0,23)

K^{π}	Energy, KeV Exp.	Calcul.	Structure
5/2+	0	0	402↑ 97%; 400↑+Q(22) 1,6%
1/2−		150	541↓ 92%; 541↓+Q(20) 6,7%
9/2−	356	360	514↑ 99%
7/2+		630	404↓ 95%; 404↓+Q(20) 4%
1/2+		1030	411↓95 %; 411↑+Q(22) 3%
1/2−		1040	530↑ 73%; 402↑+Q(32) 17%; 530↑+Q(20) 5%
11/2−		1130	505↑ 91%; 505↑+Q(20) 8%
5/2+		1170	642↑ 0,2%; 514↑+Q(32) 99%
13/2+		1180	514↑+Q(32) ~100%
9/2−		1190	402↑+Q(32) ~100%
1/2−		1210	530↑ 15%; 402↑+Q(32) 82%
3/2−		1240	532↓ 80%; 532↓+Q(20) 6%; 404↓ +Q(32) 6%
1/2+		1260	400↑ 38%; 402↑+Q(22) 58%; 402↓+Q(22) 3%
11/2−		1330	404↓+Q(32) ~100%
3/2−		1340	532↓ 3%; 404↓+Q(32) 93%
3/2+		1360	651↑ 7%; 541↓+Q(32) 92%
5/2+		1390	541↓ +Q(32) ~100%
1/2+		1420	660↑ 80%; 660↑+Q(20) 11%
3/2−		1490	402↑+Q(31) ~100%
21/2−		1490	p402↑ n624↑ n514↓ ~100%
7/2−		1500	402↑+Q(31) ~100%
9/2−		1510	514↑ 0,8%; 514↑+Q(20) 99%
5/2+		1530	402↑ 0,5%; 402↑+Q(20) 99%
25/2+		1800	p514↑ n624↑ n514↓ ~100%
25/2+		> 2700	p402↑ n624↑ n615↑ ~100%

Table 6

^{181}Ta (β=0.26)

K^{π}	Energy, KeV Exp.	Calcul.	Structure
7/2+	0	400	404↓ 99%
9/2−	6	0	514↑ 99%
1/2−		170	541↓ 91%; 541↓ +Q_1(20) 7,2%
5/2+	482	330	402↑ 93%; 402↑+Q_1(20) 3%; 400↑+Q_1(22) 3%
1/2+	612	530	411↓ 95%; ~~411↑ 95%~~ 411↑+Q_1(22) 3%
3/2+		1140	402↓ 4%; 404↓ +Q_1(22) 96%
5/2−		1190	532↑ 0,9%; 514↑+Q_1(22) 99%
11/2+		1200	404↓ +Q_1(22) ~100%
13/2−		1200	514↑+Q_1(22) ~100%
3/2+		1210	411↑ 40%; 411↓+Q_1(22) 54%; 404↓ +Q_1(22) 2%
3/2−		1220	532↓ 68%; 541↓+Q_1(22) 19%; 532↓ +Q_1(20) 5%
9/2−		1270	514↑ +Q_1(20) ~100%
7/2+		1270	404↓ +Q_1(20) ~100%
7/2−		1330	523↑ 94%; 523↑+Q_1(20) 3%; 411↑+Q_1(32) 3%
1/2+		1380	400↑ 19%; 402↑+Q_1(22) 76%; 402↓+Q_1(22) 2%
7/2+		1420	404↓ +Q_1(31) 80%; 402↑+Q_1(32) 20%
5/2−		1420	404↓+Q_1(31) ~ 100%
1/2+		1490	660↑ 78%; 660↑+Q_1(20) 10%; 651↑+Q_1(22) 3%

Table 7

^{177}Lu ($\beta = 0{,}26$)

K^{π}	Energy, KeV Exp.	Calcul.	Structure
7/2+	0	0	404↓ 97% ; 404↓+Q_1(20) 2,5%
9/2−	150	20	514↑ 98%
1/2+	570	150	411↓ 96% ; 411↑ +Q_1(22) 2%
1/2+		480	541↓ 86% ; 541↓ +Q_1(20) 10%
5/3+	458	670	402↑ 87% ; 514↑ +Q_1(32) 5%; 402↑ +Q_1(20) 3%
7/2−		870	523↑ 93% ; 411↑ +Q_1(32) 4%; 523↑ +Q_1(20) 1%
3/2+		890	411↑ 69% ; 411↓ +Q_1(22) 22%;523↑ +Q_1(32) 6%
1/2+		1300	411↓ +Q_1(20) ~100%
5/2+		1280	413↓ 7% ; 411↓ +Q_1(22) 90%
23/2−	970	1350	p404↓ n514↓ n624↑
3/2+		1340	402↓ 6% ; 404↓ +Q_1(22) 84%
11/2+		1360	404↓ +Q(22) ~100%
3/2+		1360	411↑ 16% ; 411↓ +Q_1(22) 77%;523↑ +Q_1(32) 5%
1/2−		1400	411↓ +Q(31) ~100%
3/2−		1400	411↓ +Q(31) ~100%
9/2−		1410	514↑ 0,5%; 514↑ +Q_1(20) 80;402↑ +Q_1(32) 19%
5/2−		1490	523↓ 0,4%; 411↓ +Q_1(32) 99%
3/2−		1500	411↓ +Q_1(32) ~100%
11/2+	1230	1510	514↑ +Q_1(31) ~100%
7/2+	1240	1510	514↑ +Q_1(31) ~100%
25/2+		1510	p514↑ n514↓ n624↑
15/2+	1357	2000	p 404↓ n514↓ n510↑
13/2+	1503	2000	p404↓ n514↓ n510↑