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# NON-ROTATIONAL STATES OF ODD DEFORMED NUCLEI IN THE REGION $179 \leqslant A \leqslant 185$

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# NON-ROTATIONAL STATES OF ODD DEFORMED NUCLEI IN THE REGION $179 \leqslant A \leqslant 185$

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The interaction of quasiparticles with phonons noticeably affects the energies and wave functions of the non-rotational states of odd-N deformed nuclei. This effect is taken into account in the calculations which are performed in the framework of the superfluid nuclear model with both interactions leading to superconducting pairing correlations and multipole-multipole interactions. The mathematical formalism for calculating the energies and wave functions of the non-rotational states of odd-N deformed nuclei taking into account the interaction of quasiparticles with phonons is presented in detail in ref. /1/.

Firstly the calculation of the non-rotational states was performed on the basis of the Nilsson single-particle energies and wave functions, ref. /2/. Further in order to improve the accuracy and reliability of calculations one used as the average field the anisotropic potential. In ref. /3/ an approximate method of solving the Schroedinger equations with the Saxon-Woods potential for deformed nuclei was developed. This method was found to be efficient and in ref. /4/ was used to calculate the single particle energies and wave functions for nuclei in the region 150< A 190.

The recalculation of the spectra of deformed nuclei on the new basis with the single-particle energies and wave functions of the anisotropic Saxon-Woods potential takes some years. In ref. /5/ the energies and wave functions of the one-phonon states of even-even nuclei in the region $150 < A < 190$ are calculated. They are used in calculating the non-rotational states of even nuclei. In ref. /6/ the energies and wave functions of the non-rotational states of a number of deformed nuclei with an odd number of protons are calculated. In ref. /7/ some data for nuclei with an odd number of neutrinos are given. The energies and wave functions of the non-rotational states of nuclei with an odd number of protons in the region $153 \leq A \leq 175$ are calculated in ref. /8/. At present there are calculations for the low-lying non-rotational states of almost all odd-A deformed nuclei in the region $150 < A < 190$.

The present paper gives the results of calculations of the non-rotational states of odd-A deformed nuclei in the region $179 \leq A \leq 185$.

As is known, the behaviour of the Saxon-Woods single-particle energies and wave functions depends on the mass number A. Therefore the region of nuclei with $150 < A < 190$ is divided into four zones: A = 155, 165, 173 and 181. In calculations one, thus, takes the single-particle energies and wave functions for the appropriate zone. Here we employ the Saxon-Woods energies and wave functions for zone A = 181, calculated in ref. /9/. There the term with hexadecapole deformation in the formula for the expansion of the nuclear shape over multipoles is taken into account. In our paper we have made some improvement of the Saxon-Woods parameters. The values of these parameters are given in ref. /8/.

The present calculations are performed with the same scheme as the calculations published in refs. /6,7/. For each nucleus we have calculated the non-rotational states up to an energy of (2-3) MeV. The calculations are performed for the values of the equilibrium quadrupole $\beta_{20}$ and hexadecapole $\beta_{40}$ deformation parameters which are close to the measured and calculated values for the corresponding even-even nuclei.

The calculated energy and the structure of some states close to the one-quasiparticle states can be affected noticeably by the deflection of their equilibrium deformations from the equilibrium deformations of nuclei in the ground states. According to ref. /10/, such a deflection may occur for the single-particle states the energies of which strongly change with increasing deformation parameter $\beta_{20}$ . In the region of nuclei under consideration the change of $\beta_{20}$ in the excited states compared to the ground states may be essential for the following states close to the one-quasiparticle states: in the proton system -541 , 532 , 404, 402, , 505 ; in the neutron system -503 , 505 . The account of this effect will be made later on.

In these calculations the Coriolis forces have not been taken into account, since as a rule they change a little the energy and structure of non-rotational states. It is not difficult to calculate approximately the Coriolis interaction effect if use is made of the matrix elements given in ref. /11/. For each nucleus it is possible to calculate the Coriolis forces in our scheme as it was done, e.g. in ref. /12/.

The results of calculations of the energies and wave functions for a number of odd-A nuclei are given in Tables 1-8. There we give nuclei, for the exception of $^{181}Ta$ the spectra of which were not calculated earlier. The fourth column of these tables contains the contribution (in parcent) of a few largest components. These values are obtained from the normalization condition of the wave function. For example, by $514\downarrow$ 98% we denote the contribution of the one-quasiparticle $514\downarrow$ component and by $512\downarrow + Q_1(22)$ 1% the contribution of the component quasiparticle $512\downarrow$ plus the first root ($i = 1$) of the phonon with $\lambda = 2$, $\mu = 2$, i.e. the phonon is written in the form $Q_i(\lambda\mu)$. The tables give all the non-rotational levels up to an energy of 1.1 MeV in $^{183}Os$, $^{185}Os$, up to 1.3 MeV in $^{179}W$, $^{185}W$ and to 1.5 MeV in $^{181}W$, $^{183}W$ $^{179}Ta$, $^{181}Ta$ and a number of higher levels. A number of three-quasiparticle states with large spin is also given. The experimental data are taken from ref. /11/ and refs. /13/. The systematics of these experimental data is also given in ref. /14/.

A number of remarks is made concerning the results given in Tables 1-8. The position of the neutron $521\downarrow$ state in the single-particle scheme is such that it allows to describe the behaviour of states close to the one-quasiparticle $521\downarrow$ one in zones $A = 155$ and 165, however, in zone $A = 181$ one has not succeeded in explaining the structure of $1/2^-$ states with an energy of 936 keV in $^{183}W$ and 1013 keV in $^{185}W$. It is impossible to understand the very low location of the $5/2^-$ state with energy 888 keV in $^{185}W$ by itself and compared to the location of $^{183}W$. There are some other cases when the calculated relative position of two levels considerably differs from the experimental one. These discrepancies cannot be removed by a small change of the Saxon-Woods parameters for zone $A = 181$.

The non-rotational states of $^{181}Ta$ are given for the second time. From comparison of table 3 with table 6 in ref. /6/ it is seen that a slight change of the Saxon-Woods parameters and the equilibrium deformations $\beta_{20}$ and $\beta_{40}$ leads to a noticeable displacement of the energies of a number of states.

It should be noted that a certain disagreement between the results of calculations and the experimental data may be due to the fact that the equilibrium deformation of the nucleus differs from that for which the calculation has been carried out.

A number of low-lying states contains a large admixture of gamma-vibrational phonons which leads to an increase of $E2$ transition probabilities. Table 9 gives the reduced $B(E2)$ probabilities (in single-particle units) calculated with effective charge $l_{eff}$ = 0.2.

The energy and structure of the states in $^{177}Yb$ , $^{177}Hf$ , $^{179}Hf$ and $^{181}Hf$ calculated by us differ not strongly from those calculated with the Nilsson single-particle energies and wave functions and given in ref. /2/. Therefore we do not include these tables and restrict ourselves to introducting in table 10 the energies of a series of three-quasiparticle states with large spins. The effect of spin splitting of fourplets which can significantly change the level energy is not taken into account. It should be noted that, according to ref. /15/ the energy of the state with largest spin must remain unaffected.

The calculation performed have shown that the calculations of the non-rotational states of odd-N deformed nuclei on the basis of the superfluid nuclear model with pairing and multipole-multipole forces using the Saxon-Woods single-particle energies and wave functions are in satisfactory agreement with the corresponding experimental data. Besides, the obtained wave functions of non-rotational states can be used for calculating various characteristics of deformed nuclei.

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Table 1

Nucleus $^{179}W$ ( $\beta_{20}$ = 0,24, $\beta_{40}$ = − 0,03)

| $K^{\pi}$ | Energy, KeV Exp. | Theory | Structure | | |
|---|---|---|---|---|---|
| 7/2⁻ | 0 | 0 | 514↓ 98% | 512↓ +$Q_1$(22) 1% | |
| 9/2⁺ | 309 | 50 | 624↑ 99% | | |
| 5/2⁻ | 430 | 150 | 512↑ 98% | | |
| 7/2⁺ | 477 | 290 | 633↑ 96% | 521↑ +$Q_1$(32) 2% | 651↑ +$Q_1$(22) 2% |
| 1/2⁻ | 222 | 310 | 521↓ 91% | 521↑ +$Q_1$(22) 4% | 523↓ +$Q_1$(22) 3% |
| 1/2⁻ | 627 | 500 | 510↑ 84% | 512↓ +$Q_1$(22) 10% | 512↑ +$Q_1$(22) 5% |
| 5/2⁺ | | 770 | 642↑ 93% | 660↑ +$Q_1$(22) 4% | |
| 3/2⁻ | | 810 | 512↓ 80% | 510↑ +$Q_1$(22) 10% | 514↓ +$Q_1$(22) 8% |
| 3/2⁺ | | 980 | 651↑ 75% | 514↓ +$Q_1$(32) 8% | 633↑ +$Q_1$(22) 8% |
| 11/2⁺ | | 1030 | 615↑ 1% | 514↓ +$Q_1$(32) 98% | |
| 3/2⁺ | | 1030 | 651↑ 7% | 514↓ +$Q_1$(32) 92% | |
| 7/2⁻ | | 1040 | 503↑ 21% | 514↓ +$Q_1$(20) 77% | 501↑ +$Q_1$(22) 1% |
| 1/2⁺ | | 1100 | 660↑ 11% | 512↑ +$Q_1$(32) 87% | |
| 3/2⁻ | | 1110 | 521↑ 13% | 633↑ +$Q_1$(32) 83% | 521↓ +$Q_1$(22) 4% |
| 9/2⁺ | | 1110 | | 512↑ +$Q_1$(32) 100% | |
| 5/2⁻ | | 1120 | | 624↑ +$Q_1$(32) 99% | |
| 5/2⁻ | | 1150 | 523↓ 2% | 512↑ +$Q_1$(20) 97% | |
| 1/2⁺ | | 1150 | 660↑ 74% | 512↑ +$Q_1$(32) 13% | 642↑ +$Q_1$(22) 7% |
| 11/2⁻ | | 1190 | | 633↑ +$Q_1$(32) 100% | |
| 7/2⁻ | | 1190 | 503↑ 68% | 514↓ +$Q_1$(20) 23% | 501↑ +$Q_1$(22) 5% |
| 11/2⁺ | | 1230 | 615↑ 89% | 503↑ +$Q_1$(32) 6% | 633↑ +$Q_1$(22) 2% |
| 5/2⁺ | | 1330 | 642↑ 1% | 521↓ +$Q_1$(32) 99% | |
| 3/2⁺ | | 1330 | 651↑ 1% | 521↓ +$Q_1$(32) 98% | |
| 7/2⁺ | 1680 | 1500 | npp 514↓ 514↑ 402↑ | | |
| 23/2⁻ | | 1600 | npp 624↑ 514↑ 402↑ | | |
| 19/2⁺ | | 1700 | npp 512↑ 514↑ 402↑ | | |

Table 2

Nucleus $^{181}W$ ( $\beta_{20} = 0{,}24$, $\beta_{40} = -0{,}03$)

| $K^{\pi}$ | Energy, KeV Exp. | Theory | Structure | | | |
|---|---|---|---|---|---|---|
| $9/2^+$ | 0 | 0 | 624↑98% | | | |
| $1/2^-$ | 458 | 250 | 510↑83% | | 512↑+$Q_1$(22) 16% | |
| $7/2^-$ | 662 | 380 | 503↑58% | 514↓24% | 501↑+$Q_1$(22) 10% | 514↓+$Q_1$(20) 5% |
| $7/2^-$ | 409 | 480 | 514↓74% | 503↑20% | 501↑+$Q_1$(22) 5% | |
| $3/2^-$ | 726 | 530 | 512↓79% | | 510↑+$Q_1$(22) 16% | 514↓+$Q_1$(22) 3% |
| $5/2^-$ | 366 | 650 | 512↑94% | | 624↑+$Q_1$(32) 3% | |
| $1/2^-$ | 385 | 830 | 521↓88% | | 521↑+$Q_1$(22) 5% | 523↓+$Q_1$(23) 3% |
| $7/2^+$ | 954 | 850 | 633↑94% | | 651↑+$Q_1$(22) 4% | 521↑+$Q_1$(32) 1% |
| $9/2^+$ | | 900 | | | 624↑+$Q_1$(20)100% | |
| $11/2^+$ | | 1010 | 615↑94% | | 503↑+$Q_1$(32) 4% | 624↑+$Q_1$(22) 1% |
| $5/2^+$ | | 1100 | 642↑13% | | 624↑+$Q_1$(22) 85% | |
| $13/2^+$ | | 1150 | | | 624↑+$Q_1$(22)100% | |
| $5/2^-$ | | 1170 | 512↑ 3% | | 624↑+$Q_1$(32) 97% | |
| $7/2^-$ | | 1210 | 503↑ 2% | | 514↓+$Q_1$(20) 98% | |
| $11/2^-$ | | 1290 | | | 514↓+$Q_1$(22)100% | |
| $3/2^+$ | | 1300 | 651↑ 1% | | 514↓+$Q_1$(32) 98% | |
| $11/2^+$ | | 1300 | | | 514↓+$Q_1$(32)100% | |
| $3/2^-$ | | 1310 | 512↓ 1% | | 514↓+$Q_1$(22) 96% | |
| $5/2^-$ | | 1380 | 523↓ 2% | | 512↑+$Q_1$(20) 97% | 521↓+$Q_1$(22) 1% |
| $3/2^+$ | | 1380 | 651↑44% | | 633↑+$Q_1$(22) 46% | 660↑+$Q_1$(22) 7% |
| $5/2^+$ | | 1390 | 642↑74% | | 624↑+$Q_1$(22) 15% | 660↑+$Q_1$(22) 9% |
| $11/2^-$ | | 1420 | | | 624↑+$Q_1$(31)100% | |
| $7/2^-$ | | 1420 | | | 624↑+$Q_1$(31)100% | |
| $9/2^-$ | | 1490 | | | 512↑+$Q_1$(22)100% | |
| $23/2^-$ | | 1500 | npp 624↑514↑402↑ | | | |
| $3/2^-$ | | 1570 | 501↑30% | | 503↑+$Q_1$(22) 32% | 512↓+$Q_1$(20) 31% |

Table 3

Nucleus $^{183}W$ ( $\beta_{20} = 0.24$, $\beta_{40} = -0.03$)

| K | Energy, KeV Exp. | Energy, KeV Theory | Structure | | | |
|---|---|---|---|---|---|---|
| 1/2⁻ | 0 | 0 | 510↑95% | | 512↓+$Q_1$(22) 4% | |
| 3/2⁻ | 209 | 190 | 512↓92% | 501↑ 0.2% | 510↑+$Q_1$(22) 7% | |
| 11/2⁺ | 310 | 500 | 615↑98% | | 503↑+$Q_1$(32) 1% | |
| 7/2⁻ | 453 | 580 | 503↑95% | | 501↑+$Q_1$(22) 3% | |
| 9/2⁺ | 623 | 600 | 624↑98% | | 512↑+$Q_1$(32) 1% | |
| 7/2⁻ | 1072 | 1110 | 514↓99% | | | |
| 5/2⁻ | 905 | 1160 | 512↑67% | | 624↑+$Q_1$(32) 19% | 510↑+$Q_1$(22) 12% |
| 1/2⁻ | | 1390 | 521↓ 2% | | 510↑+$Q_1$(20) 97% | |
| 5/2⁺ | | 1420 | 642↑ 2% | | 624↑+$Q_1$(22) 98% | |
| 13/2⁺ | | 1430 | | | 624↑+$Q_1$(22)100% | |
| 5/2⁻ | | 1450 | 512↑ 2% | | 510↑+$Q_1$(22) 80% | 624↑+$Q_1$(32) 18% |
| 9/2⁻ | | 1490 | 505↓98% | | 503↑+$Q_1$(22) 2% | |
| 3/2⁻ | | 1490 | 512↓ 4% | | 510↑+$Q_1$(22) 93% | |
| 3/2⁺ | | 1500 | | | 510↑+$Q_1$(32)100% | |
| 5/2⁺ | | 1500 | | | 510↑+$Q_1$(32)100% | |
| 15/2⁺ | | 1500 | npp 510↑514↑402↑ | | | |
| 3/2⁻ | | 1520 | 501↑10% | | 512↓+$Q_1$(20) 80% | 503↑+$Q_1$(22) 8% |
| 7/2⁺ | | 1530 | 633↑97% | | 651↑+$Q_1$(22) 2% | |
| 5/2⁻ | | 1580 | 512↑28% | | 624↑+$Q_1$(32) 63% | 510↑+$Q_1$(22) 8% |
| 1/2⁻ | | 1670 | 521↓90% | | 510↑+$Q_1$(20) 3% | 521↑+$Q_1$(22) 2% |
| 1/2⁻ | | 1700 | 510↑ 4% | | 512↓+$Q_1$(22) 96% | |
| 17/2⁺ | | 1700 | npp 512↓514↑402↑ | | | |
| 3/2⁻ | | 1760 | 501↑19% | | 503↑+$Q_1$(22) 62% | 512↓+$Q_1$(20) 18% |

Table 4

Nucleus $^{185}W$ ( $\beta_{20}$ = 0.22, $\beta_{40}$ =-0.03)

| K | Energy, KeV Exp. | Theory | Structure | | |
|---|---|---|---|---|---|
| $3/2^-$ | 0 | 0 | 512↓ 99% | | |
| $1/2^-$ | 24 | 20 | 510↑ 99% | | |
| $7/2^-$ | 244 | 110 | 503↑ 99% | | |
| $11/2^+$ | 198 | 130 | 615↑ 99% | | |
| $9/2^+$ | 716 | 720 | 624↑ 98% | 512↑+$Q_1$(32) 1% | |
| $9/2^-$ | 789 | 730 | 505↓100% | | |
| $1/2^-$ | | 1010 | 521↓ 3% | 510↑+$Q_1$(20) 97% | |
| $5/2^-$ | | 1030 | | 510↑+$Q_1$(22)100% | |
| $3/2^-$ | | 1030 | | 510↑+$Q_1$(22)100% | |
| $3/2^-$ | | 1040 | 501↑ 6% | 512↓+$Q_1$(20) 92% | 503↑+$Q_1$(22) 1% |
| $7/2^-$ | | 1080 | 514↓ 1% | 512↓+$Q_1$(22) 99% | |
| $1/2^-$ | | 1080 | | 512↓+$Q_1$(22)100% | |
| $7/2^-$ | | 1180 | 514↓ 9% | 503↑+$Q_1$(20) 91% | |
| $3/2^-$ | | 1190 | 501↑ 1% | 503↑+$Q_1$(22) 98% | 512↓+$Q_1$(20) 1% |
| $7/2^+$ | | 1190 | | 615↑+$Q_1$(22)100% | |
| $5/2^+$ | | 1300 | | 510↑+$Q_1$(32)100% | |
| [illegible]$/2^+$ | | 1310 | | 510↑+$Q_1$(32)100% | |
| $7/2^-$ | 1058 | 1330 | 514↓ 90% | 503↑+$Q_1$(20) 9% | |
| [illegible]$/2^+$ | | 1360 | | 512↓+$Q_1$(32)100% | |
| $7/2^+$ | | 1370 | | 512↓+$Q_1$(32)100% | |
| $5/2^-$ | 888 | 1490 | 512↓ 75% | 624↑+$Q_1$(32) 23% | |
| $17/2^+$ | | 1500 | npp 512↓514↑402↓ | | |
| $15/2^+$ | | 1500 | npp 510↑514↑402↑ | | |
| $1/2^-$ | | 1510 | 521↓ 1% | 510↑+$Q_2$(20) 99% | |
| $7/2^+$ | | 1580 | 633↑ 99% | | |
| $25/2^-$ | | 1600 | npp 615↑514↑402↑ | | |
| $1/2^-$ | | 1740 | 521↓ 93% | 510↑+$Q_1$(20) 3% | 541↓+Q(20) 2% |

Table 5

Nucleus $^{183}Os$ ( $\beta_{20} = 0.21$, $\beta_{40} = -0.03$)

| K | Energy, KeV Exp. | Energy, KeV Theory | Structure | | | | | |
|---|---|---|---|---|---|---|---|---|
| $9/2^+$ | 0 | 0 | 624↑ | 98% | | | | |
| $1/2^-$ | 171 | 140 | 510↑ | 85% | 512↓+$Q_1$(22) | 15% | | |
| $3/2^-$ | | 380 | 512↓ | 82% | 510↑+$Q_1$(22) | 15% | | |
| $7/2^-$ | | 410 | 503↑ | 89% | 501↑+$Q_1$(22) | 8% | 615↑+$Q_1$(32) | 2% |
| $7/2^-$ | | 470 | 514↓ | 99% | | | | |
| $7/2^+$ | | 580 | 633↑ | 94% | 651↑+$Q_1$(22) | 4% | | |
| $1/2^-$ | | 590 | 521↓ | 90% | 521↑+$Q_1$(22) | 4% | 523↓+$Q_1$(22) | 3% |
| $5/2^-$ | | 630 | 512↑ | 95% | 521↓+$Q_1$(22) | 2% | 624↑+$Q_1$(32) | 1% |
| $11/2^+$ | | 740 | 615↑ | 97% | 503↑+$Q_1$(32) | 1% | 624↑+$Q_1$(22) | 1% |
| $5/2^+$ | | 890 | 642↑ | 50% | 624↑+$Q_1$(22) | 44% | 660↑+$Q_1$(22) | 5% |
| $13/2^+$ | | 990 | | | 624↑+$Q_1$(22) | 100% | | |
| $7/2^-$ | | 1000 | | | 514↓+$Q_1$(20) | 100% | | |
| $3/2^+$ | | 1020 | 651↑ | 60% | 633↑+$Q_1$(22) | 29% | 660↑+$Q_1$(22) | 10% |
| $5/2^+$ | | 1100 | 642↑ | 38% | 624↑+$Q_1$(22) | 56% | 660↑+$Q_1$(22) | 6% |
| $3/2^-$ | | 1160 | 501↑ | 28% | 503↑+$Q_1$(22) | 41% | 512↑+$Q_1$(20) | 25% |
| $5/2^-$ | | 1170 | 523↓ | 2% | 512↑+$Q_1$(20) | 97% | | |
| $1/2^+$ | | 1170 | 660↑ | 71% | 642↑+$Q_1$(22) | 18% | 651↑+$Q_1$(22) | 10% |
| $15/2^-$ | | 1600 | npp 624↑ 402↑ 541↓ | | | | | |

Table 6

Nucleus $^{185}Os$ ( $\beta_{20} = 0.21$, $\beta_{40} = -0.03$)

| K | Energy, KeV Exp. | Theory | Structure | | | |
|---|---|---|---|---|---|---|
| 1/2⁻ | 0 | 0 | 510↑92% | | $512\downarrow + Q_1(22)$ 7% | |
| 3/2⁻ | 128 | 130 | 512↓87% | | $510\uparrow + Q_1(22)$ 12% | |
| 7/2⁻ | | 210 | 503↑93% | | $501\uparrow + Q_1(22)$ 5% | |
| 9/2⁺ | | 390 | 624↑99% | | | |
| 11/2⁺ | | 420 | 615↑99% | | | |
| 3/2⁻ | | 870 | 501↑27% | 512↓ 1% | $503\uparrow + Q_1(22)$ 64% | $512\downarrow + Q(20)$ 5% |
| 9/2⁻ | | 960 | 505↓97% | | $503\downarrow + Q_1(22)$ 3% | |
| 7/2⁻ | | 970 | 514↓99% | | $512\downarrow + Q_1(22)$ 1% | |
| 5/2⁻ | | 1060 | 512↑48% | | $510\uparrow + Q_1(22)$ 50% | |
| 5/2⁺ | | 1100 | 642↑ 6% | | $624\uparrow + Q_1(22)$ 94% | |
| 7/2⁺ | | 1110 | 633↑96% | | $651\uparrow + Q_1(22)$ 4% | |
| 13/2⁺ | | 1130 | | | $624\uparrow + Q_1(22)$ 100% | |
| 1/2⁻ | | 1160 | 521↓85% | | $510\uparrow + Q_1(20)$ 8% | $521\uparrow + Q_1(22)$ 3% |
| 3/2⁻ | | 1229 | 512↓ 6% | | $510\uparrow + Q_1(22)$ 88% | $503\uparrow + Q_1(22)$ 2% |

Table 7

Nucleus $^{179}$Ta ( $\beta_{20} = 0.27$ $\beta_{40} = -0.03$)

| K | Energy, KeV Exp. | Energy, KeV Theory | Structure | | |
|---|---|---|---|---|---|
| 7/2$^+$ | 0 | 0 | 404↓ 100% | | |
| 9/2$^-$ | 31 | 20 | 514↑ 100% | | |
| 5/2$^+$ | 238 | 530 | 402↑ 96% | 660↑+$Q_1$(22) 2% | 514↑+$Q_1$(32) 1% |
| 1/2$^+$ | 520 | 740 | 411↓ 96% | 411↑+$Q_1$(22) 3% | |
| 1/2$^-$ | 750 | 750 | 541↓ 98% | 532↓+$Q_1$(22) 1% | |
| 3/2$^+$ | | 1110 | 651↑ 1% | 404↓+$Q_1$(22) 99% | |
| 11/2$^+$ | | 1120 | | 404↓+$Q_1$(22) 100% | |
| 5/2$^-$ | | 1120 | | 514↑+$Q_1$(22) 99% | |
| 13/2$^-$ | | 1130 | | 514↑+$Q_1$(22) 100% | |
| 7/2$^+$ | | 1130 | | 514↑+$Q_1$(31) 100% | |
| 5/2$^-$ | | 1130 | | 404↓+$Q_1$(31) 100% | |
| 3/2$^-$ | | 1180 | 532↑ 88% | 404↓+$Q_1$(32) 9% | 541↓+$Q_1$(22) 2% |
| 7/2$^+$ | | 1180 | | 404↓+$Q_1$(20) 100% | |
| 7/2$^+$ | | 1220 | | 514↑+$Q_2$(31) 100% | |
| 9/2$^-$ | | 1220 | | 514↑+$Q_1$(20) 100% | |
| 11/2$^-$ | | 1230 | | 404↓+$Q_1$(32) 100% | |
| 3/2$^-$ | | 1230 | 532↓ 8% | 404↓+Q(32) 91% | |
| 5/2$^+$ | | 1230 | 402↑ 1% | 514↑+$Q_1$(32) 99% | |
| 13/2$^+$ | | 1240 | | 514↑+$Q_1$(32) 100% | |
| 23/2$^-$ | | 1300 | pnn 404↓ 514↑ 624↑ | | |
| 25/2$^+$ | | 1300 | pnn 514↑ 514↑ 624↑ | | |
| 3/2$^+$ | | 1470 | 411↑ 16% | 411↓+$Q_1$(22) 84% | |
| 5/2$^+$ | | 1550 | 413↓ 1% | 411↓+$Q_1$(22) 99% | |
| 1/2$^-$ | | 1590 | | 411↓+$Q_1$(31) 100% | |
| 3/2$^-$ | | 1590 | | 411↓+$Q_1$(31) 100% | |
| 21/2$^-$ | | 1600 | pnn 404↓ 512↑ 624↑ | | |

Nucleus $^{181}Ta$ ( $\beta_{20}$ = 0,27, $\beta_{40}$ = - 0,03)

| $K^{\pi}$ | Energy, KeV Exp. | Energy, KeV Theory | Structure | |
|---|---|---|---|---|
| 7/2+ | 0 | 0 | 404↓ 100% | |
| 9/2− | 6 | 10 | 514↑ 100% | |
| 5/2+ | 482 | 560 | 402↑ 98% | 660↑ + $Q_1$(22) 1% |
| 1/2− | | 750 | 541↓ 99% | 532↓ + $Q_1$(22) 1% |
| 1/2+ | 615 | 810 | 411↓ 97% | 411↑ + $Q_1$(22) 2% |
| 3/2+ | | 1120 | | 404↓ + $Q_1$(22) 100% |
| 11/2+ | | 1130 | | 404↓ + $Q_1$(22) 100% |
| 7/2+ | | 1130 | | 514↑ + $Q_1$(31) 100% |
| 5/2− | | 1130 | | 404↓ + $Q_1$(31) 100% |
| 9/2− | | 1130 | | 404↓ + $Q_1$(31) 100% |
| 5/2− | | 1140 | | 514↑ + $Q_1$(22) 100% |
| 13/2− | | 1140 | | 514↑ + $Q_1$(22) 100% |
| 3/2− | | 1200 | 532↓ 98% | 541↓ + $Q_1$(22) 1% |
| 17/2− | | 1300 | pnn 404↓ 624↑ 510↑ | |
| 19/2+ | | 1300 | pnn 514↑ 624↑ 510↑ | |
| 7/2+ | | 1400 | | 404↓ + $Q_1$(20) 100% |
| 9/2− | | 1400 | | 514↑ + $Q_1$(20) 100% |
| 3/2+ | | 1520 | 411↑ 12% | 411↓ + $Q_1$(22) 88% |
| 5/2+ | | 1580 | 413↓ 1% | 411↓ + $Q_1$(22) 99% |
| 1/2− | | 1580 | | 411↓ + $Q_1$(31) 100% |
| 3/2− | | 1580 | | 411↓ + $Q_1$(31) 100% |
| 19/2− | | 1600 | pnn 404↓ 624↑ 512↓ | |
| 7/2− | | 1690 | 523↑ 98% | 411↑ + $Q_1$(32) 1% |
| 1/2− | | 1740 | 530↑ 96% | 532↓ + $Q_1$(22) 2% |

Table 9

**Reduoed probabilities for E2 transitions from ground states**

| Nucleus | K | E(Kev) Exp. | E(KeV) Theor. | B(E2) theor. | Contribution single-quasi-part. | Components quasipart.+ phonon |
|---|---|---|---|---|---|---|
| $^{179}W$ | $3/2^-$ | | 810 | 0.1 | 512↑ 80% | 514↓ + $Q_1(22)$ 8% |
| | $3/2^-$ | | 1420 | 0.8 | 512↓ 6% | 514↓ + $Q_1(22)$ 9% |
| | $11/2^-$ | | 1370 | 0.9 | | 514↓ + $Q_1(22)$ 100% |
| $^{181}W$ | $5/2^+$ | | 1100 | 0.8 | 642↑ 13% | 624↑ + $Q_1(22)$ 85% |
| | $5/2^+$ | | 1390 | 0.1 | 642↑ 74% | 624↑ + $Q_1(22)$ 15% |
| | $13/2^+$ | | 1150 | 0.9 | | 624↑ + $Q_1(22)$ 100% |
| $^{183}W$ | $3/2^-$ | 209 | 190 | 0.1 | 512↓ 92% | 510↑ + $Q_1(22)$ 7% |
| | $3/2^-$ | | 1490 | 0.8 | 512↓ 4% | 510↑ + $Q_1(22)$ 93% |
| | $5/2^-$ | 905 | 1160 | 0.1 | 512↑ 67% | 510↑ + $Q_1(22)$ 12% |
| | $5/2^-$ | | 1450 | 0.7 | 512↑ 2% | 510↑ + $Q_1(22)$ 80% |
| | $5/2^-$ | | 1580 | 0.1 | 512↑ 28% | 510↑ + $Q_1(22)$ 8% |
| $^{185}W$ | $7/2^-$ | | 1080 | 1.3 | 514↓ 1% | 512↑ + $Q_1(22)$ 99% |
| | $1/2^-$ | | 1080 | 1.3 | | 512↑ + $Q_1(22)$ 100% |
| $^{183}Os$ | $5/2^+$ | | 890 | 0.4 | 642↑ 50% | 624↑ + $Q_1(22)$ 44% |
| | $5/2^+$ | | 1100 | 0.6 | 642↑ 38% | 624↑ + $Q_1(22)$ 56% |
| | $13/2^+$ | | 990 | 1.3 | | 624↑ + $Q_1(22)$ 100% |
| $^{185}Os$ | $5/2^-$ | | 1060 | 0.6 | 512↑ 48% | 510↑ + $Q_1(22)$ 50% |
| | $3/2^-$ | 128 | 130 | 0.1 | 512↓ 87% | 510↑ + $Q_1(22)$ 12% |
| | $3/2^-$ | | 1229 | 1.2 | 512↓ 6% | 510↑ + $Q_1(22)$ 88% |
| $^{179}Ta$ | $3/2^+$ | | 1110 | 0.9 | 651↑ 1% | 404↓ + $Q_1(22)$ 99% |
| | $11/2^+$ | | 1120 | 0.9 | | 404↓ + $Q_1(22)$ 100% |
| $^{18}$ Ta | $3/2^+$ | | 1120 | 0.9 | | 404↑ + $Q_1(22)$ 100% |
| | $11/2^+$ | | 1130 | 0.9 | | 404↓ + $Q_1(22)$ 100% |

Table 10

Energies of three-quasiparticle states without the account of spin splitting of multiplets

| Nucleus | K | Structure | Energy, KeV Exp. | Energy, KeV Theory |
|---|---|---|---|---|
| $^{177}Yb$ | $17/2^+$ | n 624↑ p 411↓ p 404↓ | | 1400 |
| | $19/2^-$ | n 624↑ p 411↓ p 514↑ | | 1600 |
| | $15/2^-$ | n 514↓ p 411↓ p 404↓ | | 1800 |
| | $25/2^-$ | n 624↑ p 404↓ p 514↑ | | 2100 |
| $^{177}Hf$ | $23/2^+$ | n 514↓ p 404↓ p 514↑ | 1315 | 1200 |
| | $25/2^-$ | n 624↑ p 404↓ p 514↑ | | 1300 |
| | $21/2^+$ | n 512↑ p 404↓ p 514↑ | | 1400 |
| $^{179}Hf$ | $25/2^-$ | n 624↑ p 404↓ p 514↑ | 1106 | 1200 |
| | $23/2^+$ | n 514↓ p 404↓ p 514↑ | | 1600 |
| | $17/2^+$ | n 510↑ p 404↓ p 514↑ | | 1700 |
| $^{181}Hf$ | $17/2^+$ | n 510↑ p 404↓ p 514↑ | | 1200 |
| | $19/2^+$ | n 512↓ p 404↓ p 514↑ | | 1400 |
| | $27/2^-$ | n 615↑ p 404↓ p 514↑ | | 1600 |
| | $25/2^-$ | n 624↑ p 404↓ p 514↑ | | 1800 |