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ЛАБОРАТОРИЯ ТЕОРЕТИЧЕСКОЙ ФИЗИКИ

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NONROTATIONAL STATES OF SOME TRANSCURIUM ELEMENTS

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NONROTATIONAL STATES OF SOME TRANSCURIUM ELEMENTS

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Неротационные состояния ряда транскюриевых элементов

В работе проведено исследование нижайших неротационных состояний ядер в области $250 \le A \le 261$ на основе полумикроскопического подхода. Приводятся энергии и структура основных и возбужденных состояний нечетных, четно-четных и нечетно-нечетных ядер, а также приведенные вероятности E2- и E3-переходов на вибрационные состояния четно-четных ядер.

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Ivanova S.P., Komov A.L., Malov L.A., Soloviev V.G. **E4 - 6663**

Nonrotational States of Some Transcurium Elements

The lowest nonrotational states of nuclei in the region $250 \le A \le 261$ are investigated on the basis of the semi-microscopic approach. The energies and the structure of the ground and excited states of odd-A, doubly even and doubly odd nuclei and the reduced probabilities of E2- and E3-transitions to the vibrational states of doubly even nuclei are presented.

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I. Introduction

In the present paper the lowest nonrotational states of deformed nuclei in the region $250 \leqslant A \leqslant 261$ are investigated on the basis of the semi-microscopic approach/1/. The collective vibrational states of doubly even nuclei are described in the one-phonon approximation, in the framework of the superfluid nuclear model with multipole-multipole residual interaction/1,2/. The ground and low-lying excited states of odd-A deformed nuclei are calculated by means of the method suggested in refs./3/, in which the interaction of quasiparticles with the phonons of an even-even core and the mixing of one-quasiparticle states due to this interaction, are considered. The average nuclear field is described by the Saxon-Woods anisotropic potential. The one-particle problem is solved by a semi-analytical method proposed in refs./4/. In a number of earlier papers/5-7/ the states of deformed nuclei were investigated in the region $234 \leqslant A \leqslant 250$. A satisfactory description of the properties of the low-lying states of doubly even and odd-A nuclei was obtained.

Contrary to the nuclei of the region $234 \leqslant A \leqslant 250$ for which there is much experimental information, the nuclei of the region under consideration $250 \leqslant A \leqslant 261$ are scantily explored. One has measured an extremely small number of the lowest vibrational states of doubly even nuclei. In most odd-A nuclei only the spin of the ground state is known. There are also no data on electromagnetic transition probabilities and quadrupole moments. The masses of some nuclei have not been measured. The absense of the information of the kind impedes the improvement of the parameters of the model in question, that is, the parameters of the single-particle problem (deformation parameters, spin-orbital interaction constant, etc.) as well as the pairing and multipole interaction constants.

One of the purposes of this paper is to give a description of the low-lying nonrotational states which may serves as a "reference point" in further experimental studies.

2. Parameters of the Model

Our choice of the parameters of the model is based on the results of similar investigations for nuclei of the region $234 \leq A \leq 250$/5-7/ as well as for nuclei of the rare-earth region $150 \leq A \leq 190$/8/.

The Saxon-Woods potential parameters do not strongly change with small changes of the mass number A/6/. The most sensitive are the diffuseness α and the spin-orbital interaction constant. We use the single-particle energies and the wave functions calculated for the nucleus A = 255 with the following parameters:

Neutron system:

$V_0 = 46.0$ MeV; $r_0 = 1.26$ fm; $\alpha = 1.30$ fm^{-1};
$\varkappa = 0.47$ fm^2.

Proton system:

$V_0 = 62.5$ MeV; $r_0 = 1.24$ fm; $\alpha = 1.55$ fm^{-1};
$\varkappa = 0.36$ fm^2.

The equilibrium deformation parameters are chosen on the basis of the calculations of ref./9/:

$$\beta_{20} = 0.26; \qquad \beta_{40} = 0.035.$$

Figures 1,2 show the behaviour of the single-particle energies of the neutron and proton levels as a function of the quadrupole deformation β_{20} at $\beta_{40} = 0.035$. In our calculations we have taken into account the single-particle levels starting with the five oscillator ($N \geqslant 4$) shell for neutrons and the fourth ($N \geqslant 3$) one for protons. The cutoff from above is performed at $E = +5$ MeV. This corresponds to 105 neutron and 75 proton levels located almost symmetrically with respect to the Fermi surface energy E_F. The number of the matrix elements of the matrix elements for certain multipolarities $\lambda\mu$ is as large as 1500. The value of the pairing interaction constant is chosen from the comparison of the calculated pairing energies with those obtained from the experimental nuclear masses utilizing the results of ref./10/ For neutron system $G_N \simeq 19/A$ MeV, for proton system $G_Z \simeq 27/A$ MeV.

For the multipole-multipole interaction constants one usually uses the following A-dependence:

$$\varkappa^{(\lambda)} = p^{(\lambda)} A^{-\frac{2\lambda+3}{3}}; \qquad p^{(\lambda)} = const$$

In ref./7/ it was indicated that this dependence for nuclei of the transuranium region is too strong, a better description of the experimental results is achieved with $\varkappa^{(\lambda)} = $ const. For the nuclei considered in the present paper it is assumed that $\varkappa^{(\lambda)} =$ const.

In doubly even nuclei of the transcurium region the $K^\pi = 2^+$ states in ^{250}Cf are measured to be 1032 keV and in ^{254}Fm – 693 keV/11/. These states are regarded as first excited quadrupole states, and in the model suggested here to them there correspond the first roots of secular equations/2/. The location of these levels is well described for a chosen value of the constant $\varkappa^{(2)} = 0.76$ keV.fm^{-4}. Using this value, the energy and the structure of the lowest $K^{\pi} = 0^{+}, 2^{+}$ states for the most stable doubly even isotopes of transcurium elements have been calculated. This constant is by 10% smaller than $\varkappa^{(2)}$ for nuclei in the region $232 \leq A \leq 254$ which corresponds to the same values of $\rho^{(2)}$ for both regions/5/.

The octupole states of the nuclei under consideration are presently known only in ^{250}Cf: the $K^{\pi} = 1^{-}$ state is 1175.45 keV/12/, and the $K^{\pi} = 2^{-}$ state is 871.4 keV/12,13/. The constant $\varkappa^{(3)}$ is 9.6×10^{-3} keV.fm^{-6}, it is by 20% smaller than for nuclei in the region $232 \leq A \leq 254$, the $\rho^{(3)}$ - values being the same for both regions.

3. Doubly Even Nuclei

The calculations are performed in the framework of the method suggested in refs./1,2/. Table 1 gives the energies of the first quadrupole excitations and the reduced probabilities for electric transitions (in single-particle units) from the ground state to the I = 2, $K^{\pi} = 0^{+}$ and 2^{+} levels $B(E2, g \to I = 2, K = 0, 2)$ with an effective charge $e_{eff}^{(2)} = 0.1$. As is seen from Table I the B(E2) values are of the order of a few units. This indicated that the first quadrupole states are of the collective nature. The second quadrupole excitations in the nuclei in question are collectivized far more weakly.

In Table 2 we present the energies of the first octupole excitations and the reduced probabilities $B(E3, 0_g \rightarrow I=3, K=0,1,2)$ in single-particle units. The effective charge $e^{(3)}_{eff}$ is 0.1.

In the nuclei considered, not only the first $K^\pi = 0^-$ states but also the first $K^\pi = 1^-$ states are found to be strongly collectivized. The first $K^\pi = 2^-$ are collectivized less strongly. This is seen from the comparison of the appropriate B(E3) values.

4. Odd-A Nuclei

The wave function of an odd-A nucleus which describes the state with a given K^π is/1,3/

$$\Psi_j(K^\pi) = \frac{1}{\sqrt{2}}\left\{\sum_\sigma\sum_n C^j_{\rho_n}\alpha^+_{\rho_n\sigma} + \sum_{\lambda\mu i}\sum_{s\sigma} D^{\lambda\mu i j}_{\rho_1\ldots\rho_n s\sigma}\alpha^+_{s\sigma} Q^+_i(\lambda\mu)\right\}\Psi . \quad (1)$$

Here $\alpha^+_{s\sigma}$ is the quasiparticle creation operator, $\sigma = \pm 1$, $Q_i(\lambda\mu)$ is the phonon operator of multipolarity ($\lambda\mu$), Ψ is the wave function of the ground state of a doubly even nucleus. By $\rho_n\sigma$ we mean the set of the quantum numbers characterizing an n number of the single-particle levels with a given K^π and by $s\sigma$ the remaining levels of the average field.

The normalization condition for the wave function (1) is

$$\sum \left(C^j_{\rho_n}\right)^2 + \frac{1}{2}\sum_{\lambda\mu i}\sum_{s\sigma}\left(D^{\lambda\mu i j}_{\rho_1\ldots\rho_n s\sigma}\right)^2 = 1 . \quad (2)$$

The quantity $(C^j_{\rho_n})^2$ defines the contribution of the one-quasiparticle component with a given ρ_n to the wave function of the state in question. The quantity $\frac{1}{2}\sum_\sigma (D^{\lambda\mu i j}_{\rho_1\ldots\rho_n s\sigma})^2$ defines the contribution of the component with quasiparticle in a state s plus phonon $\lambda\mu i$ to the wave function $\Psi_j(K^\pi)$.

In calculating the energies and the wave functions of the nonrotational states in odd-A nuclei one finds the average value of the Hamiltonian which describes the pairing and multipole-multipole interactions over the state (1). The condition of energy minimum is used to obtain the secular equation which defines the nonrotational state energies/1,3/. In our calculations of low-lying nonrotational states of odd-A nuclei we take into account the interaction of quasiparticles with quadrupole and octupole oscillations of a doubly even core. We take into account the contribution of only two first excitations of this type. That is, the summation in (I) is performed over $\lambda\mu$ = 20,22,30,31,32 and over i = 1,2. The octupole oscillations with $\lambda\mu$ = 33 little affect the states of odd-A nuclei up to 1.2 MeV excitation energy.

Tables 3-12 give the results of calculation of the nonrotational states for odd-N nuclei of ^{251}Cf, ^{253}Cf, ^{253}Fm, ^{257}Fm, ^{255}102, ^{257}102and for odd-Z nuclei: ^{251}Es, ^{257}Md, ^{257}103. In these tables we give the K^{π} values, the experimental energies taken from refs./13-15/, the calculated energies of all the nonrotational states up to 1.2 MeV, and the structure of these states, i.e. the quantities $(C^{j}_{\rho_n})^2$ (in percent), provided that $(C^{j}_{\rho_n})^2 \geqslant 0.01$ and the $(D^{\lambda\mu i j}_{\rho_1 \cdots \rho_n})^2$ values for two largest components quasiparticle plus phonon.

The mixing of the one-quasiparticle levels due to the interaction of quasiparticles with phonons results in that in the structure of a state with given K^{π} there appear several one-quasiparticle components $\rho_1 \dots \rho_n$. As is seen from the tables in the nuclei under consideration there are states to which the contribution comes from two or even three one-quasiparticle components. The energy shifts, taking into account this effect, are, as a rule, small, i.e. some dozens of keV. However, they turn out to be important if there are states close in energy and this may lead to a change in the order of the levels. For example, in nuclei ^{257}Fm and ^{261}Ku the $K^{\pi}=9/2^{+}$ state becomes ground only after the $615\downarrow$ and $604\uparrow$ level mixing has been taken into account. Their subsequent separation leads to that the energy of the first $K^{\pi}=9/2^{+}$ state becomes lower than the energy of the first $K^{\pi}=3/2^{+}$ state. The level $622\downarrow$ is mixed with the level $611\uparrow$ but this affects weakly the energy of the first $K^{\pi}=3/2^{+}$ state.

A similar effect is especially essential for nuclei with $A\sim 230$ due to the large level density.

5. Doubly Odd Nuclei

The properties of the lowest states of doubly-odd nuclei are not a subject of a special study in the present paper. However, some semiquantitative remarks can be made here concerning the location and the structure of certain levels of these nuclei.

For example, taking into consideration the results of our calculations and the experimental data for $^{257}_{101}\mathrm{Md}_{156}$, $^{253}_{98}\mathrm{Cf}_{155}$ and $^{257}102_{155}$ it may be expected that the most low-lying states of $^{256}_{101}\mathrm{Md}_{155}$ should be the 0^{-} and 7^{-} states with $n\,7/2^{-}\ 613\uparrow\, p\,7/2^{-}\,514\downarrow$, as in ^{166}Ho. At an energy 200-300 keV, this nucleus can have the 8^{-} and 8^{+} states the structure of which is: $n\,9/2^{+}\ 615\downarrow\, p\,7/2^{-}\ 514\downarrow$ and $n\,7/2^{+}\ 613\uparrow\, p\,9/2^{+}\ 624\uparrow$, respectively.

If we take into consideration the results of calculations for nuclei $^{257}_{100}\mathrm{Fm}_{157}$ and $^{261}_{104}\mathrm{Ku}_{157}$ then it may be asserted that in the nucleus $^{258}_{10}\text{Md}_{157}$ the 8^- level and the 1^- isomer with structure $n\,9/2^+\ 615\downarrow p7/2^-\ 514\downarrow$ lie very low (possibly the first one is the ground state).

An analogous analysis can be performed for all doubly-odd nuclei of the region under consideration. In nuclei $^{252}_{99}\text{Es}_{153}$ and $^{254}_{99}\text{Es}_{155}$ it may be expected that low-lying be either 7^+ or 0^+ state with structure $n\,7/2^+\ 613\uparrow\ p7/2^+\ 633\uparrow$ one of which is an isomer; to an energy 500-600 keV for ^{254}Es and 700-800 keV for ^{252}Es there will correspond the 8^- state with structure $n\,9/2^+\ 615\downarrow\ p7/2^-\ 514\downarrow$.

The doubly odd isotopes of element 103 have still been studied little experimentally. There is some information on obtaining isotopes with A = 256 and 258. However, we know nothing about the spins and parities of the ground states of these nuclei. On the basis of these calculations it may also be expected that the ground state of the nuclei $^{256}103$ and $^{258}103$ is the 5^+ state with $n\,1/2^+\ 620\uparrow\ p9/2^+\ 624\uparrow$ or 8^+ state with $n\ 7/2^+ 613\uparrow\ p9/2^+\ 624\uparrow$ and there is the isomeric 1^+ state. At low excitation energies (~400keV), we have the following levels 9^- $n\,9/2^-\ 734\uparrow p9/2^+\ 624\uparrow$, 10^- $n\,11/2^-\ 725\uparrow\ p9/2^+\ 624\uparrow$ and 5^- $n\,9/2^+\ 615\downarrow p1/2^-\ 521\downarrow$ for $^{256}103$. In the nucleus $^{258}103$ the first of these states (9^-) appears to lie higher (~600 keV), and two others (10^- and 5^-)-somewhat lower than in the nucleus $^{256}103$.

Thus, the experimental study of doubly-odd nuclei may give rich additional information on the levels of the average field of the region considered. The detection of the levels with high spins in these nuclei is important for performing further theoretical investigations. Insufficient amount of experimental data makes it impossible to carry out a more detailed comparison of the results of our calculations with experiment and restricts the possibility of choosing unambiguously the parameters of the model. We hope that this paper will, to a certain extent, stimulate further comprehensive study of the nuclei of the transcurium region and may serve as a certain guide in making investigations.

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Table I.

Energies of quadrupole states (in MeV) and reduced probabilities B(E2, $0_g \to I=2^+$, K =0,2) for electric transitions (in single-particle units $B_{s.p.u.}(E2) = 0.3 \cdot A^{4/3}$

Nuclei	$K^{\pi} = 0^+$		$K^{\pi} = 2^+$		
	Energy theor.	B(E2)	Energy exp.	Energy theor.	B(E2)
248 Cf	0.87	6.3		I.20	4.8
250	0.9I	5.3	I.032	0.93	5.2
252	I.05	6.I		0.7I	5.7
250 Fm	0.90	4.3		I.26	4.0
252	0.97	3.2		I.08	3.6
254	I.I0	3.I	0.693	0.78	4.6
256	0.93	5.0		0.65	5.9
252 I02	I.04	2.8		I.33	3.5
254	I.06	2.2		I.I2	3.3
256	I.20	3.0		0.92	3.3
256 Ku	0.9I	4.5		I.23	2.5
I58	I.08	4.5		0.95	3.0
260	0.90	6.5		0.83	3.2

Table 2.

Energies of the octupole states (in MeV) and reduced probabilities $B(E3, 0_g^+ \rightarrow I^\pi = 3^-, K = 0, 1, 2)$ for electric transitions (in single-particle units $B_{s.p.u.}(E3) = 0.42 A^2$)

Nuclei	$K^\pi = 0^-$		$K^\pi = I^-$			$K^\pi = 2^-$		
	Energy theor.	B(E3)	Energy exp.	Energy theor.	B(E3)	Energy exp.	Energy theor.	B(E3)
248 Cf	I.09	I2.8		0.92	9.8		I.07	5.3
250	I.I2	I3.4	I.I755	I.03	II.9	0.87I4	0.98	6.8
252	0.95	I5.8		I.0I	I8.2		0.98	5.5
250 Fm	I.I4	II.3		0.98	7.3		I.23	4.3
252	I.20	II.2		0.92	I5.I		I.25	4.6
254	I.09	I2.7		I.I4	I5.0		I.06	4.9
256	0.80	I7.2		I.08	I5.9		0.96	6.I
252 I02	I.26	I0.0		0.98	7.I		I.26	4.I
254	I.29	II.I		0.90	I5.5		I.30	4.3
256 Ku	I.30	I0.6		I.I7	I3.5		0.80	9.2
256	I.30	9.8		I.I0	9.I		I.I8	5.3
258	I.29	I0.6		I.I3	I4.9		0.99	5.9
260	I.00	I3.3		I.05	I6.5		0.88	7.3

T a b l e 3.

Energy and structure of the ground and excited states in ^{251}Cf

K^{π}	Energy (keV)		Structure							
	exp.	theor.								
$1/2^+$	0	0	620↑	86%			622↓+Q_1(22)	5%	620↑+Q_1(20)	2%
$7/2^+$	106	50	613↑	89%	624↓	5%	611↑+Q_1(22)	2%	725↑+Q_1(32)	2%
$3/2^+$	178	170	622↓	84%			620↑+Q_1(22)	9%	752↓+Q_1(30)	2%
$9/2^-$	434	320	734↑	91%			734↑+Q_1(20)	3%	622↑+Q_1(32)	2%
$9/2^+$	426	370	615↓	75%	604↑	3%	615↓+Q_1(20)	11%	613↑+Q_1(22)	3%
$11/2^-$	370	380	725↑	94%			613↑+Q_1(32)	2%	615↓+Q_1(31)	1%
$7/2^+$		390	624↓	89%	613↑	5%	734↑+Q_1(31)	2%	743↑+Q_1(30)	1%
$1/2^-$		630	761↓	61%			761↓+Q_1(20)	10%	620↑+Q_1(30)	9%
$5/2^+$	544	840	622↑	65%	633↓	2%	734↑+Q_1(32)	22%	622↑+Q_1(20)	5%
$1/2^+$		860	631↓	73%			631↓+Q_1(20)	19%	633↓+Q_1(22)	2%
$7/2^-$		940	743↑	65%			624↓+Q_1(30)	15%	743↑+Q_1(20)	14%
$3/2^+$		970	611↑	27%			613↑+Q_1(22)	63%	622↓+Q_1(20)	4%
$3/2^-$		1010	752↓	42%			620↑+Q_1(31)	19%	622↓+Q_1(30)	18%
$1/2^-$		1140	770↑	67%			770↑+Q_1(20)	12%	752↓+Q_1(22)	11%
$5/2^-$		1150	503↓	11%			734↑+Q_1(22)	84%	624↓+Q_1(31)	2%
$13/2^-$		1160	716↑	4%			734↑+Q_1(22)	96%		
$9/2^-$		1170	734↑	2%			734↑+Q_1(20)	94%	624↓+Q_1(31)	3%

Table 4.

Energy and structure of the ground and excited states in ^{253}Cf

K^{π}	Energy (keV)		Structure									
	exp.	theor.										
$7/2^+$	0	140	$613\uparrow$	92%	$624\downarrow$	2%			$611\uparrow+Q_1(22)$	2%	$503\uparrow+Q_1(30)$	1%
$1/2^+$		0	$620\uparrow$	87%					$622\downarrow+Q_1(22)$	4%	$752\downarrow+Q_1(31)$	1%
$3/2^+$		90	$622\downarrow$	86%					$620\uparrow+Q_1(22)$	6%	$752\downarrow+Q_1(30)$	2%
$9/2^+$	242	150	$615\downarrow$	76%	$604\uparrow$	4%			$615\downarrow+Q_1(20)$	9%	$613\uparrow+Q_1(22)$	3%
$11/2^-$		240	$725\uparrow$	95%					$615\downarrow+Q_1(31)$	1%	$613\uparrow+Q_1(32)$	1%
$1/2^-$		340	$761\downarrow$	64%					$761\downarrow+Q_1(20)$	9%	$620\uparrow+Q_1(30)$	7%
$9/2^-$		590	$734\uparrow$	88%					$734\uparrow\ +Q_1(20)$	4%	$624\downarrow+Q_1(31)$	3%
$7/2^+$		670	$624\downarrow$	87%	$613\uparrow$	3%			$734\uparrow+Q_1(31)$	3%	$743\uparrow+Q_1(30)$	2%
$3/2^+$		810	$611\uparrow$	28%					$613\uparrow+Q_1(22)$	66%	$600\uparrow+Q_1(22)$	2%
$3/2^-$		820	$752\downarrow$	49%					$622\downarrow+Q_1(30)$	28%	$620\uparrow+Q_1(31)$	8%
$5/2^+$		950	$622\uparrow$	20%	$613\downarrow$	8%	$633\downarrow$	1%	$620\uparrow+Q_1(22)$	56%	$615\downarrow+Q_1(22)$	7%
$5/2^+$		1040	$613\downarrow$	36%	$622\uparrow$	7%			$615\downarrow+Q_1(22)$	38%	$620\uparrow+Q_1(22)$	9%
$1/2^+$		1090	$611\downarrow$	64%	$600\uparrow$	2%			$611\downarrow+Q_1(20)$	11%	$761\downarrow+Q_1(30)$	8%
$1/2^+$		1150	$600\uparrow$	13%					$622\downarrow+Q_1(22)$	79%	$611\uparrow+Q_1(22)$	3%
$7/2^-$		1170	$743\uparrow$	28%					$725\uparrow+Q_1(22)$	50%	$624\downarrow+Q_1(30)$	10%

Table 5.

Energy and structure of the ground and excited states in ^{253}Fm

K^{π}	Energy (keV) exp.	theor.	Structure					
I/2$^+$	(0)	0	620↑ 90%		622↓ + Q_1(22)	3%	76I↓ + Q_1(30)	I%
7/2$^+$		40	6I3↑ 93%	624↓ 3%	6II↑ + Q_1(22)	I%	725↑ + Q_1(32)	I%
3/2$^+$		I80	622↓ 87%		620↑ + Q_1(22)	5%	76I↓ + Q_1(3I)	2%
9/2$^-$		250	734↑ 92%		624↓ + Q_1(3I)	3%	734↑ + Q_1(20)	2%
II/2$^-$		300	725↑ 95%		6I5↓ + Q_1(3I)	I%	6I3↑ + Q_1(32)	I%
7/2$^+$		340	624↓ 90%	6I3↑ 4%	734↑ + Q_1(3I)	3%	743↑ + Q_1(30)	I%
9/2$^+$		480	6I5↓ 79%	604↑ 2%	6I5↓ + Q_1(20)	8%	725↑ + Q_1(3I)	3%
I/2$^-$		670	76I↓ 57%		622↓ + Q_1(3I)	II%	620↑ + Q_1(3I)	II%
5/2$^+$		880	622↑ 77%	633↓ 2%	734↑ + Q_1(32)	9%	743↑ + Q_1(3I)	4%
7/2$^-$		940	743↑ 69%		624↓ + Q_1(30)	I4%	743↑ + Q_1(20)	9%
I/2$^+$		960	63I↓ 79%		63I↓ + Q_1(20)	I4%	633↓ + Q_1(22)	2%
3/2$^-$		I000	752↓ 34%		620↑ + Q_1(3I)	47%	622↓ + Q_1(30)	II%
3/2$^+$		II20	6II↑ 27%		6I3↑ + Q_1(22)	63%	622↓ + Q_1(20)	4%
5/2$^-$		II30	752↑ 5%	503↓ 2%	624↓ + Q_1(3I)	89%	734↑ + Q_1(22)	I%
7/2$^+$		II80	624↓ 3%		734↑ + Q_1(3I)	96%	624↓ + Q_1(20)	I%

Table 6.

Energy and structure of the ground and excited states in ^{257}Fm

K^{π}	Energy (keV)		Structure			
	exp.	theor.				
$9/2^+$	(0)	0	6I5↓77%	604↑ 4%	6I5↓+Q_1(20) 7%	6I3↓+Q_1(22) 4%
$3/2^+$		40	622↓88%	6II↑ I%	752↓+Q_1(30) 3%	76I↓+Q_1(3I) I%
$I/2^+$		II0	620↑9I%		76I↓+Q_1(30) 2%	622↓+Q_1(22) I%
$II/2^-$		I80	725↑96%		6I5↑+Q_1(30) I%	6I5↓+Q_1(3I) I%
$I/2^-$		200	76I↓68%		76I↓+Q_1(20) 9%	620↑+Q_1(30) 5%
$7/2^+$		260	6I3↑9I%	624↓ 2%	6II↑+Q_1(22) 2%	503↑+Q_1(30) I%
$3/2^-$		6I0	752↓52%		622↓+Q_1(30) 26%	752↓+Q_1(20) 4%
$5/2^+$		730	6I3↓42%		6I5↓+Q_1(22) 43%	600↑+Q_1(22) 4%
$3/2^+$		770	6II↑40%	622↓ I%	6I3↑+Q_1(22) 48%	600↑+Q_1(22) 4%
$7/2^+$		780	624↓60%	6I3↑ 3%	622↓+Q_1(22) 27%	6I3↑+Q_1(20) 3%
$9/2^-$		820	734↑85%		734↑+Q_1(20) 5%	6I3↑+Q_1(3I) 3%
$I/2^+$		840	6II↓64%	600↑ I%	76I↓+Q_1(30) I0%	6II↓+Q_1(20) I0%
$5/2^+$		870	622↑I2%	6I3↓2% 633↓I%	620↑+ | (22)46%	6I5↓+Q_1(22) 3%
$I3/2^-$		900	7I6↑84%		7I6↑+Q_1(20) 6%	6I5↓+Q_1(32) 5%
$I/2^+$		940	600↑20%	620↑ I%	63I↓I%	622↓+Q_1(22) 66%
$7/2^-$		I000	743↑ I%		725↑+Q_1(22) 98%	
$I5/2^-$		I0I0			725↑+Q_1(22)I00%	
$7/2^+$		II00	624↓I9%		622↓+Q_1(22) 7I%	6I3↑+Q_1(20) 4%
$9/2^+$		III0	604↑83%	6I5↓ 7%	604↑+Q_1(20) 4%	862↑+Q_1(22) 2%
$I/2^+$		II70	600↑32%	6II↓ I%	622↓+Q_1(22) 32%	6II↑+Q_1(22) I4%
$I/2^-$		II90	770↑5%	76I↓ I%	620↑+Q_1(30) 84%	620↑+Q_1(3I) 4%

Table 7.

Energy and structure of the ground and excited states in $^{255}102$

K^{π}	Energy (keV) exp.	theor.	Structure							
1/2$^+$	0	0	620↑	91%			622↓+Q_1(22)	3%	752↓+Q_1(31)	1%
7/2$^+$		30	613↑	93%	624↓	3%	611↑+Q_1(22)	1%	725↑+Q_1(32)	1%
3/2$^+$		180	622↓	88%			620↑+Q_1(22)	5%	761↓+Q_1(31)	2%
9/2$^-$		290	734↑	92%			624↓+Q_1(31)	3%	734↑+Q_1(20)	1%
11/2$^-$		330	725↑	95%			615↓+Q_1(31)	2%	613↑+Q_1(32)	1%
7/2$^+$		340	624↓	90%	613↑	3%	734↑+Q_1(31)	3%	743↑+Q_1(30)	1%
9/2$^+$		500	615↓	81%	604↑	2%	615↓+Q(20)	6%	725↑+Q_1(31)	4%
1/2$^-$		680	761↓	56%			620↑+Q(31)	13%	622↓+Q_1(31)	13%
5/2$^+$		880	622↑	79%	633↓	2%	734↑+Q_1(32)	8%	743↑+Q_1(31)	5%
1/2$^+$		990	631↓	82%			631↓+Q_1(20)	10%	633↓+Q_1(22)	2%
3/2$^-$		995	752↓	31%			620↑+Q_1(31)	54%	622↓+Q_1(30)	8%
7/2$^-$		1010	743↑	71%			624↓+Q_1(30)	12%	743↑+Q_1(20)	7%
5/2$^-$		1100	752↑	4%	503↓	2%	624↓+Q_1(31)	91%	613↑+Q_1(31)	1%
7/2$^+$		1140	624↓	3%			734↑+Q_1(31)	97%		
3/2$^+$		1150	611↑	28%			613↑+Q_1(22)	64%	624↓+Q_1(22)	3%
9/2$^-$		1160					613↑+Q_1(31)	98%	624↓+Q_1(31)	2%
5/2$^-$		1170					613↑+Q_1(31)	99%	624↓+Q_1(31)	1%

Table 8.

Energy and structure of the ground and excited states in $^{257}102$.

K^π	Energy (keV) exp.	Energy (keV) theor.	Structure			
$7/2^+$	0	I30	6I3↑94%	624↓ I%	725↑+Q_1(32) I%	6II↑+Q_1(22) I%
$I/2^+$		0	620↑9I%		622↓+Q_1(22) 2%	743↓+Q_1(32) I%
$3/2^+$		80	622↓90%	6II↑ I%	620↑+Q_1(22) 3%	752↓+Q_1(30) I%
$II/2^-$		2I0	725↑94%		6I3↑+Q_1(32) 2%	6I5↓+Q_1(3I) I%
$9/2^+$	~ 250	300	6I5↓8I%	604↑ 3%	6I5↓+Q_1(20) 5%	7I6↑+Q_1(32) 3%
$I/2^-$		560	76I↓66%		622↓+Q_1(3I) 6%	76I↓+Q_1(20) 6%
$9/2^-$		570	734↑89%		622↑+Q_1(32) 4%	624↓+Q_1(3I) 2%
$7/2^+$		670	624↓9I%	6I3↑ I%	734↑+Q_1(3I) 2%	725↑+Q_1(32) I%
$3/2^-$		930	752↓4I%		620↑+Q_1(32)28%	622↓+Q_1(30) I0%
$5/2^+$		980	622↑43%	633↓ 4%	734↑+Q_1(32)34%	620↑+Q_1(22) I4%
$3/2^+$		I0I0	6II↑32%		6I3↑+Q_1(22)6I%	622↓+Q_1(20) 2%
$II/2^-$		IIIO	725↑ 2%		6I3↑+Q_1(32)98%	

Table 9.

Energy and structure of the ground and excited states in ^{261}Ku

K^{π}	Energy (keV) exp.	Energy (keV) theor.	Structure				
9/2$^+$	0	0	6I5↓ 75%	604↑ 4%		6I5↓+Q_1(20) II%	725↓+Q_1(30) 2%
3/2$^+$		40	622↓ 90%	6II↑ I%		752↓+Q_1(30) 2%	76I↓+Q_1(3I) I%
I/2$^+$		II0	620↑ 93%			76I↓+Q_1(30) I%	622↓+Q_1(22) I%
I/2$^-$		I50	76I↓ 68%			76I↓+Q_1(20) I4%	622↓+Q_1(3I) 3%
II/2$^-$		I80	725↑ 96%			6I5↓+Q_1(3I) I%	844↑+Q_1(3I) I%
7/2$^+$		270	6I3↑ 93%	624↓ 2%		734↑+Q_1(3I) I%	624↓+Q_1(20) I%
3/2$^-$		630	752↓ 58%			622↓+Q_1(30) I5%	752↓+Q_1(20) II%
9/2$^-$		760	734↑ 82%			734↑+Q_1(20) 7%	624↓+Q_1(3I) 3%
I/2$^+$		8I0	6II↓ 63%	600↑ 2%		6II↓+Q_1(20) I5%	76I↓+Q_1(30) 7%
7/2$^+$		820	624↓ 73%	6I3↑ 3%		6I3↑+Q_1(20) 7%	622↓+Q_1(22) 7%
I3/2$^-$		870	7I6↑ 80%			7I6↑+Q_1(20) 9%	6I5↓+Q_1(32) 6%
3/2$^+$		930	6II↑ 54%	622↓ I%	602↓ I%	6I3↑+Q_1(22) 24%	622↓+Q_1(20) I2%
5/2$^+$		970	6I3↓ 50%	622↑ I%		6I5↓+Q_1(22) 33%	620↑+Q_1(22) 4%
5/2$^+$		I070	622↑ 20%	6I3↓ 2%	633↓ I%	620↑+Q_1(22) 66%	734↑+Q_1(32) 5%
3/2$^+$		IIIO	602↓ 6I%			602↓+Q_1(20) I4%	76I↓+Q_1(3I) 6%
9/2$^+$		II20	604↑ 8I%	6I5↓ 9%		604↑+Q_1(20) 5%	6I5↓+Q_1(20) I%
I/2$^+$		II50	600↑ I6%	63I↓ 5%	6II↓ I%	622↓+Q_1(22) 40%	620↑+Q_1(20) 30%

Table 10.

Energy and structure of the ground and excited states in ^{251}Es

K^π	Energy (keV)		Structure							
	exp.	theor.								
$3/2^-$	0	0	521↑	97%			402↓$+Q_1(30)$	1%	521↓$+Q_1(22)$	1%
$7/2^+$		50	633↑	98%						
$7/2^-$	(350)	380	514↓	98%			633↑$+Q_1(30)$	1%		
$5/2^+$		580	642↑	70%			642↑$+Q_1(20)$	20%	521↑$+Q_1(31)$	4%
$9/2^+$		670	624↑	95%			512↑$+Q_1(32)$	2%	624↑$+Q_1(20)$	1%
$1/2^-$		700	521↓	67%	530↑	5%	521↑$+Q_1(22)$	18%	521↓$+Q_1(20)$	6%
$1/2^-$		810	530↑	63%	521↓	9%	530↑$+Q_1(20)$	18%	642↑$+Q_1(32)$	2%
$1/2^+$		830	660↑	73%			651↑$+Q_1(22)$	10%	660↑$+Q_1(20)$	8%
$3/2^+$		900	402↓	30%	651↑	1%	633↑$+Q_1(22)$	40%	521↑$+Q_1(30)$	17%
$5/2^-$		980	523↓	78%	512↑	1%	523↓$+Q_1(20)$	10%	633↑$+Q_1(31)$	6%
$3/2^+$		990	651↑	68%			660↑$+Q_1(22)$	17%	651↑$+Q_1(20)$	8%
$3/2^-$		1000					521↑$+Q_1(20)$	100%		
$7/2^+$		1010					633↑$+Q_1(20)$	100%		
$11/2^+$		1020	615↑	1%			633↑$+Q_1(22)$	99%		
$1/2^+$		1060	400↑	3%	660↑	1%	521↑$+Q_1(32)$	90%	521↑$+Q_1(31)$	3%
$5/2^-$		1065	512↑	19%	523↓	6%	633↑$+Q_1(31)$	71%	624↑$+Q_1(32)$	2%
$3/2^-$		1070					633↑$+Q_1(32)$	99%		
$11/2^-$		1080					633↑$+Q(32)$	100%		
$1/2^-$		1090	521↓	12%	530↑	2%	521↑$+Q_1(22)$	81%	521↓$+Q_1(20)$	3%
$3/2^+$		1100	402↓	10%	651↑	2%	633↑$+Q_1(22)$	52%	521↑$+Q_1(30)$	30%
$1/2^+$		1110	400↑	6%	660↑	3%	521↑$+Q_1(31)$	78%	521↑$+Q_1(32)$	7%
$9/2^-$		1120					633↑$+Q_1(31)$	100%		
$5/2^+$		1130	642↑	2%	402↑	1%	521↑$+Q(31)$	95%	642↑$+Q_1(20)$	2%

Table 11.

Energy and structure of the ground and excited states in ^{257}Md

K^{π}	Energy (keV)		Structure			
	exp.	theor.				
7/2$^-$	(0)	0	5I4↓ 98%			
9/2$^+$		220	624↑ 95%		5I2↑+Q_1(32) 2%	624↑+Q_1(20) I%
3/2$^-$		280	52I↑ 86%		52I↑+Q_1(20) 6%	633↑+Q_1(32) 5%
I/2$^-$		330	52I↓ 89%		52I↑+Q_1(20) 7%	52I↑+Q_1(22) I%
7/2$^+$		370	633↑ 86%		633↑+Q_1(20) I0%	52I↑+Q_1(32) 2%
3/2$^-$		740	50I↑ I%		5I4↓+Q_1(22) 98%	
II/2$^-$		760			5I4↓+Q_1(22) I00%	
3/2$^+$		770	402↓ I0%		633↑+Q1(22) 64%	52I↑+Q_1(30) 23%
5/2$^-$		800	5I2↑ 8I%		624↑+Q_1(32) I4%	50I↓+Q_1(22) 2%
I/2$^-$		8I0	530↑ 4%	52I↓ I%	52I↑+Q_1(22) 94%	530↑+Q_1(20) I%
3/2$^+$		860			633↑+Q_1(22) I00%	
5/2$^+$		920	642↑ 53%		52I↑+Q_1(3I) 22%	642↑+Q_1(20) I4%
3/2$^+$		930	402↓ 3%	65I↑ I%	52I↑+Q_1(30) 62%	633↑+Q_1(22) 32%
7/2$^+$		970			5I4↓+Q_1(30) I00%	
5/3$^+$		I040	642↑ 2%		624↑+Q_1(22) 94%	521↑+Q_1(31) 2%
7/2$^-$		I060			633↑+Q_1(30) I00%	
7/2$^-$		II00			5I4↓+Q_1(20) I00%	
3/2$^+$		III0	65I↑ 3%		5I4↓+Q_1(32) 94%	660↑+Q_1(22) I%
II/2$^+$		II20			5I4↓+Q_1(32) I00%	
I/2$^+$		II30	660↑ 38%	400↑ I%	52I↑+Q_1(3I) 37%	65I↑+Q_1(22) I0%
I/2$^+$		II90	660↑ 4%		52I↑+Q_1(32) 89%	521↑+Q_1(31) 4%
5/2$^-$		I200	523↓ I%		52I↓+Q_1(22) 98%	624↑+Q_1(32) I%

T a b l e 12.

Energy and structure of the ground and excited states in $^{257}103$

	Energy (keV)		Structure				
	exp.	theor.					
$9/2^+$		0	624↑ 96%	5I2↑+Q_1(32)	2%		
$I/2^-$	(0)	I00	52I↓ 96%	52I↓+Q_1(20)	2%		
$7/2^-$		I80	5I4↓ 98%	Q			
$5/2^-$		440	5I2↑ 83%	624↑+Q_1(32)	I5%	50I↓+Q_1(22)	I%
$3/2^-$		640	52I↑ 82%	633↑+Q_1(32)	I0%	52I↑+Q_1(20)	4%
$7/2^+$		750	633↑ 84%	52I↑+Q_1(32)	8%	633↑+Q_1(20)	6%
$3/2^+$		890	65I↑ 2%	5I4↓+Q_1(32)	98%		
$II/2^+$		920	6I5↑ I%	5I4↓+Q_1(32)	99%		
$3/2^-$		I020	50I↑ I%	5I4↓+Q_1(22)	99%		
$II/2^-$		I040		5I4↓+Q_1(22)	I00%		
$5/2^-$		I070	5I2↑ I5%	624↑+Q_1(32)	84%		
$5/2^+$		I080		52I↓+Q_1(32)	93%	624↑+Q_1(22)	6%
$5/2^+$		I090	642↑ I%	624↑+Q_1(22)	92%	52I↓+Q_1(32)	6%
$I3/2^+$		II00		624↑+Q_1(22)	I00%		
$5/2^-$		I200	523↓ I%	52I↓+Q_1(22)	99%		

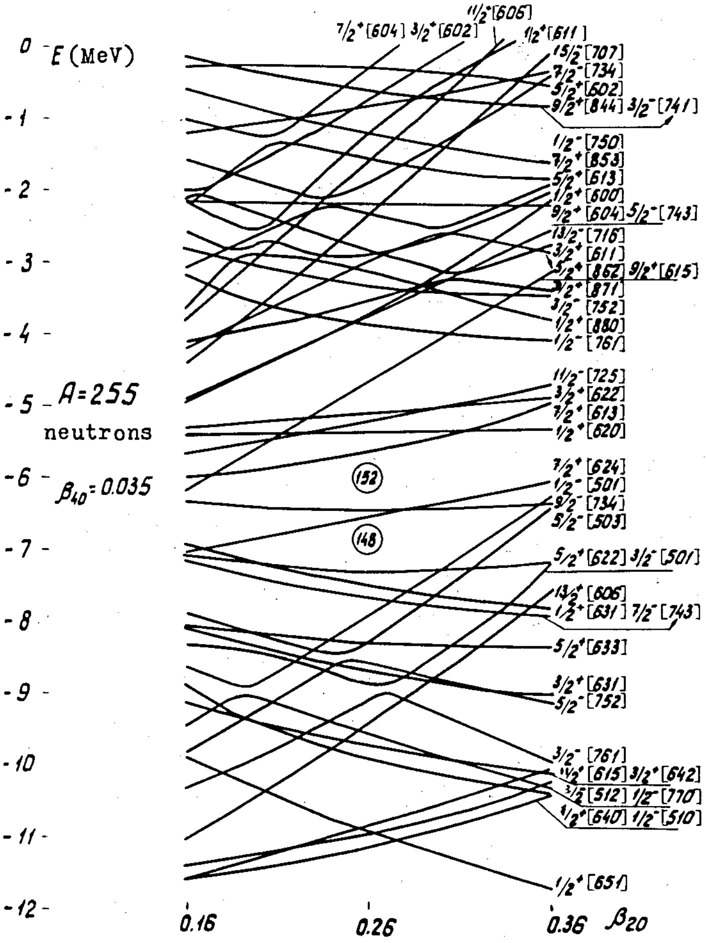

Fig. 1. Scheme of neutron single-particle states, A=255.

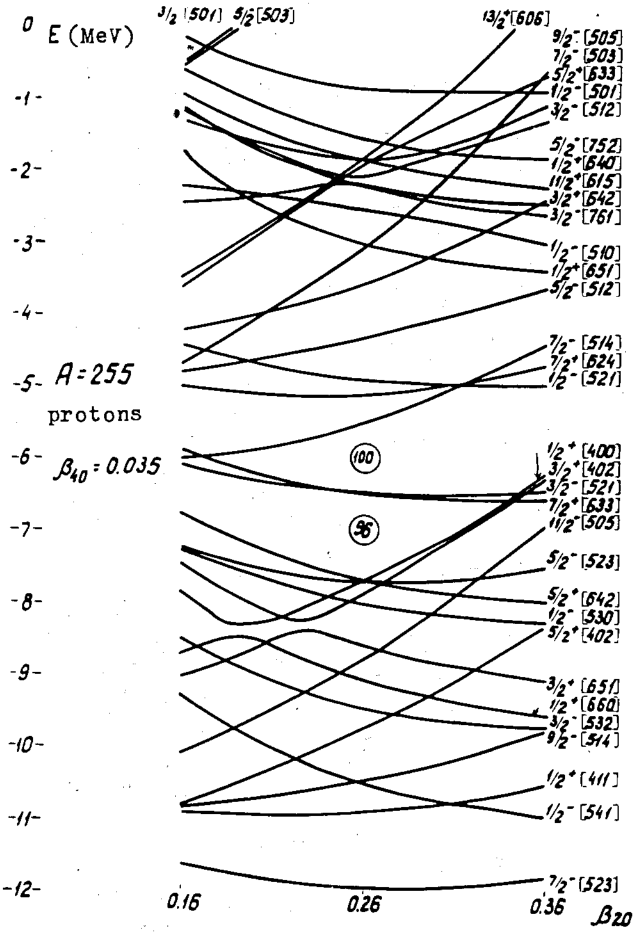

Fig. 2. Scheme of proton single-particle states, A=255.