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The present paper is devoted to the study of the low-lying excitations in Hg heavy even isotopes. The calculations have been performed within the model which is known as the "pairing + multipole-multipole forces" model. We use the quadrupole-quadrupole and octupole-octupole forces and take into account the interaction of two-quasiparticle and vibrational excitations. In ref. [2] the structure of states in Hg even isotopes was calculated within the phenomenological model of the interaction of two proton holes with the core vibrations. This model was further developed in refs. [3,4]. In our approach the strength of the interaction between quasiparticles and vibrations is not an additional parameter. It is calculated on the basis of the single-particle energies, single-particle matrix elements of multipole operators and the constants of residual forces. A detailed discussion of these problems can be found in ref. [5], and some calculations for nuclei with $110 < A < 150$ are given in ref. [6].

The mercury isotopes, even heavy, are not good objects for our calculations. The 2_1^+ level energy in them is not large (400 *keV*) and these states are very collective. This fact results in a large value of anharmonic corrections. However, a small energy gap allows one to believe that at least for the states in the range of the two-phonon triplet we take into account the main components of the wave function (two-quasiparticle, one-phonon and two-phonon).

The main attention was paid to the positive parity states as there is more experimental information concerning them. As the potential describing the average field we have chosen the Saxon-Woods one with the following parameters [7]:
for protons

$$A = 195 \qquad Z = 77$$
$$r_0 = 1.24\ fm \qquad V_0 = 59.4\ MeV \qquad (1)$$
$$\kappa = 0.374\ fm^2 \qquad a = 1.587\ fm^{-1}$$

for neutrons

$$A = 195 \quad r_0 = 1.26\ fm \quad V_0 = 45.0\ MeV \quad \kappa = 0.379\ fm^2$$
$$a = 1.587\ fm^{-1}.$$

The level energies of the last unfilled shell obtained with these parameter values are given in *Table 1* (the proton scheme and neutron $E_I(n\ell j)$). The pairing constants were chosen according to the pairing energies [8], and we have obtained the following their values: $G_N = 0.130$ *MeV*, $G_Z = 0.194$ *MeV*.

The results of the calculations for the levels with $I^\pi = 2^+, 4^+$ are given in *Table 2*. The energies are in good agreement with experimental ones (the deviation does not exceed 100 *keV*). However, the relative location of the 2_2^+ and 4_1^+ levels is reproduced only in ^{200}Hg . Though in the calculations of electromagnetic characteristics we have used rather a large effective charge ($e_{eff} = 0.6$) $B(E2, 0^+_{g.s.} \to 2^+)_{theor}$ is less by a factor of 2-3 than the experimental value. One should note that earlier [9] when calculating this value in the framework of the random phase approximation using a large number of levels of the single-particle spectrum (up to the energies ~ 10 *MeV* in its quasidiscrete part), we obtained $B(E2)_{theor.}$ too low. Even larger deviation from experiment was received by the authors of ref. [10] who studied the properties of the 2^+ levels of Hg isotopes taking account of the interaction of vibration excitations only. The calculation results by the phenomenological model [3,4] agree with experiment better than ours but they are too low. The 2_1^+-states have mainly the one-phonon structure. The impurity of the two-phonon component in its structure grows with increasing isotope atomic number A (4% in ^{196}Hg and 17% in ^{202}Hg). This fact indicates a gradual strengthening of the quasiparticle-phonon interaction. Unfortunately, there are no experimental data on quadrupole moments of the 2_1^+ -levels, which are directly connected with the strength of anharmonic effects. Our results agree with the calculations of ref. [3] both in the sign and value, but they are less than the theoretical ones [10] by a factor of 3-4. Note, that the latter have an extremely large value $Q_2(2_1^+)$ and too low probability $B(E2, 0^+_{g.s.} \to 2_1^+)$.

Table 1.

Single-particle level schemes used in calculations

Proton Scheme		Neutron scheme			
$n\ell_j$	MeV E MeV	$n\ell_j$	E_I MeV	E_{II} MeV	E_{III} MeV
I $h_{9/2}$	-2.07	2 $g_{9/2}$	-2.29	-2.29	-2.29
3 $s_{1/2}$	-6.43	3 $p_{1/2}$	-5.91	-5.91	-5.91
2 $d_{3/2}$	-6.78	2 $f_{5/2}$	-6.54	-6.10	-6.40
1 $h_{11/2}$	-8.37	3 $p_{3/2}$	-6.96	-6.30	-6.72
2 $d_{5/2}$	-9.03	I $i_{13/2}$	-7.55	-7.90	-7.54
I $g_{7/2}$	-10.52	2 $f_{7/2}$	-9.29	-8.60	-8.25
I $g_{9/2}$	-14.87	I $h_{9/2}$	-9.52	-9.52	-9.31
		3 $s_{1/2}$	-14.37	-14.37	-14.37

Table 2.

Experimental/13/ and theoretical characteristics of low-lying states $I^{\pi}=2^+, 4^+$ in $^{196-202}Hg$.

Nucleus	$E(2_i^+)$ MeV		$B(E2, 0^+ \to 2_i^+)\ e^2b^2$		$Q_2(2_i^+)$ eb	$B(E2, 2_1^+ \to 2_i^+)\ e^2b^2$		$E(4_i^+)$ MeV		$B(E2, 4_1^+ \to 2_1^+)\ e^2b^2$
	Exp.	Theor.	Exp.	Theor.	Theor.	Exp.	Theor.	Exp.	Theor.	Theor.
	0.426	0.429	1.42±0.21	0.57	0.34	-	-	-	-	-
^{196}Hg	1.039	0.944	-	0.05	-0.23	-	0.14	1.061	1.102	0.13
	-	1.250	-	0.002	-0.26	-	0.02	-	1.342	0.03
	0.412	0.408	1.03±0.10	0.50	0.56	-	-	-	-	-
^{196}Hg	1.088	1.036	-	0.08	-0.28	-	0.065	1.048	1.107	0.07
	-	1.525	-	0.0009	-0.11	-	0.002	-	1.169	0.082
	0.368	0.388	0.92±0.15	0.40	0.63	-	-	-	-	-
^{200}Hg	1.254	1.107	0.06	0.03	0.03	0.12±0.02	0.005	0.947	1.052	0.016
	1.574	1.253	0.002	0.004	-0.24	0.007	0.02	-	1.184	0
	0.439	0.440	0.66±0.10	0.27	0.56	-	-	-	-	-
^{202}Hg	0.960	1.056	-	0.0004	0.19	-	0	-	1.028	0.014
	-	1.262	-	0.0022	-0.16	-	0.05	-	1.188	0.011

In accordance with the strengthening of the quasiparticle-phonon interaction there changes the structures of the 2_2^+ states. The data from *Table 2* show that if on the whole we reproduce correctly the value of one-phonon components in the 2_2^+ state wave functions, the value of the two-phonon component is too low. Its decrease with increasing A leads to the fact that in $^{200,202}Hg$ the 2_2^+ levels cannot be called the "two-phonon" ones, they are noncollective in their structure. In ^{200}Hg the 2_3^+ states should be called the "two-phonon" ones. That the "two-phonon" admixture is small is seen from two facts: small values of $B(E2, 2_1^+ \to 2_2^+)$ and $Q_2(2_2^+)$. The latter is not experimentally studied, but our result disagrees with the calculations of ref./2/, where $|Q_2(2_1^+)| \approx |Q_2(2_2^+)|$.

In the structure of 4_1^+ levels the value of the two-phonon component is more considerable than for 2_2^+. The energies of the $3_1^+, 6_1^+$ levels coincide satisfactorily with the experimental ones, but we do not present the data on them. We have found that these states have a two-quasiparticle structure, that is very doubtful as we did not take into account the admixture of the three-phonon component, which must be very important at the excitation energies ~1,5 *MeV*.

Now, consider the negative parity states. The absence of experimental information on 3^- levels makes the situation more complicated. Especially the value of the octupole-octupole interaction constant is unknown. But this is not the main complication, since at any reasonable value of κ_3 in the structure of negative parity states ($I^{\pi} = 5^-, 7^-, 9^-$) the main part is played just by the non-collective, two-quasiparticle components. The main difficulty is in unsatisfactory character of the single-particle scheme. The states with $I^{\pi} = 5^-, 7^-, 9^-$ calculated by the same scheme as the levels with $I^{\pi} = 2^+, 4^+, 6^+, 3^+$ are too low. Thus we have calculated the negative parity with levels on other neutron schemes. For ^{196}Hg we have used the scheme from ref./12/, for $^{198-202}Hg$ from ref./11/, they are given in *Table 1* (E_{II} and E_{III} respectively). For these schemes we have specially calculated new values of the pairing constant ($G_{NII} = 0.150$ *MeV*,

Table 3.

Experimental[14] and theoretical energies of the negative parity states in $^{196-202}Hg$.

Nucleus	$E(3_1^-)$ MeV		$E(5_1^-)$ MeV		$E(7_1^-)$ MeV		$E(9_1^-)$ MeV	
	Exp.	Theor.	Exp.	Theor	Exp.	Theor.	Exp.	Theor.
^{196}Hg	-	1.697	1.757	1.867	1.841	1.784	2.063	1.972
^{198}Hg	-	1.723	1.635	1.940	1.683	1.539	1.910	1.939
^{200}Hg	-	1.612	1.851	2.010	1.963	1.903	2.143	1.912
^{202}Hg	-	1.750	-	2.131	-	2.044	-	2.105

G_{NIII}= 0.135 *MeV*). We have obtained a good description of level energies, however their relative position is not reproduced. The following rule is systematically observed experimentally: $E(5^-)<E(7^-)<E(9^-)$, at the same time we have systematically $E(5^-)>E(7^-)$, and in the $^{198-202}Hg$ isotopes $E(5^-)>E(9^-)$. However, with new schemes the description of positive parity levels becomes noticeably worse. Mainly, it is their structure that becomes worse, in particular, the value of the two-phonon component in the wave function of 2_2^+ states decreases. Note, that the authors of ref.[3] also encountered the difficulties in describing the levels $I^\pi=5^-,7^-$. But in their approach, these states are purely the proton ones (with vibration impurities). Our data point out that the neutron two-quasiparticle states are also important and this is confirmed in the experiment [14].

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