Binding Energies and Radii of Nuclei with $N \geq Z$ in an Alpha-Cluster Model

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Abstract

As it was shown before in the representation of a nucleus as a core consisting of N_α^{core} α - clusters and some molecule of N_α^{ml} α - clusters the binding energy and the radii of β - stable nuclei are roughly described with the specific density of the core binding energy $\rho = 2.57$ MeV/fm^3 at the radius of one α - cluster r_α= 1.60 fm and $N_\alpha^{ml} = 2 \div 5$. In the present work the phenomenological formula for surface tension energy for $Z \geq 30$ is put in dependence of N_α^{core}. It allowed one to widen the isotopes to be described from narrow strip of β-stability to the ones with $N \geq Z$. The N_α^{ml} is obtained from experimental binding energies and the ρ and the radii are calculated. It is shown that with growing the number of excess neutrons for the isotopes of one Z the value N_α^{ml} decreases to N_α^{ml}=3 and ρ increases to reach its saturation value $\rho = 2.6 \pm 0.1$ MeV/fm^3. Calculated radii are in a good agreement with experimental data.

Key words: nuclear structure; alpha-cluster model; core; Coulomb energy; surface tension energy, binding energy; charge radius.
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1 The formulas to calculate binding energies and radii

In representation of a nucleus as a core plus a nuclear molecule on the surface of the core some formulas have been proposed to calculate binding energies and radii of nuclei [1]. Core is a liquid drop of alpha-clusters built by pn-pair interactions with isospin invariance of nuclear force [2,3]. In the framework of the model some parameters like the binding energy and the energy of Coulomb repulsion between two nearby clusters had been found to be $\epsilon_{\alpha\alpha} = 2.425$ MeV and $\epsilon_{\alpha\alpha}^C = 1.925$ MeV, so that the nuclear force energy is to be $\epsilon_{\alpha\alpha}^{nuc} =$

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$\epsilon_{\alpha\alpha} + \epsilon^C_{\alpha\alpha} = 4.350$ MeV[3] as well as the energy of nuclear force of one α-cluster $\epsilon^{nuc}_\alpha = \epsilon_\alpha + \epsilon^C_\alpha = 29.060$ MeV [3,4], where $\epsilon_\alpha = E_{^4\mathrm{He}} = 28.296$ MeV and $\epsilon^C_\alpha = 0.764$ MeV.

One of the main findings [3] of the phenomenological model was the formula for binding energies E of the stable symmetrical nuclei ($N = Z, Z < 30$) with the number of α - clusters $N_\alpha = Z/2$

$$E = N\epsilon_\alpha + 3(N_\alpha - 2)\epsilon_{\alpha\alpha}, \tag{1}$$

for the odd $Z_1 = Z + 1$ the energy $E_1 = E + 13.8$ MeV. So it was suggested that the number of short range links in a nucleus consisting of N_α α-clusters equals $3(N_\alpha - 2)$ and that the long range part of the Coulomb interactions must be compensated with the surface tension energy E^{st}. Then with applying isospin invariance of nuclear force the empirical values of the Coulomb energy, the energy of surface tension and the empirical values of the distance of the position of the last alpha-cluster in the system of center of masses of the remote $N_\alpha - 4$ α-clusters R_α [3] were found. From the analysis of these values the formulas for Coulomb radius $R_C = 1.869 N_\alpha^{1/3}$fm (see (22)[3]), for the radius of the position of the last α-cluster $R_\alpha = 2.168(N_\alpha - 4)^{1/3}$ fm (see (21)[2,3]) had been found. The charge sphere of the radius R_C has the Coulomb energy $E^C = 3/5Z^2e^2/R_C$, which after simplifying is $1.848(N_\alpha)^{5/3}$ MeV[3]. The binding energy of the excess nn-pairs for the beta-stable nuclei $E_{\Delta N} = \sum_1^{N_{nn}} E_{i_{nn}}$ (see (13)[3]) is the sum of the binding energy of excess nn-pairs in the core . It is believed that the nn-pairs are to fill out the free space in the core which appears due to the difference between the charge and the matter radii of an alpha-clusters. Thus, the binding energy of all β -stable nuclei with an accuracy in a few MeV is calculated as the sum $E = E^{nuc} + E^{st} - E^C + E_{\Delta N}$ where E^{nuc} is the energy of nuclear force in short range links (see (7) [3]).

There is a clear relation between the nuclei $A(Z,N)$ and $A_1(Z_1, N+2)$ where $Z_1 = Z + 1$, N is even number and $N \geq Z$[1–3]. Then $A_1 = A + 3$. The nuclei have equal cores with the same number of excess nn-pairs $N_{nn} = \Delta N/2$, where $\Delta N = N - Z$. In case of the nucleus $A_1(Z_1, N+2)$ one neutron is stuck to the single pn-pair. It has been taken into account [1] that the number of short range links in the core has to be $3(N^{core}_\alpha - 2) + 6$, because the total number of links is $3(N_\alpha - 2) = 3(N^{ml}_\alpha - 2) + 3(N^{core}_\alpha - 2) + 6$. It was taken into account in calculations of the nuclear energy of the short range links and in the Coulomb energy of the short range links by adding the binding energy of the six links $6\epsilon_{\alpha\alpha} = 6(\epsilon^{nuc}_{\alpha\alpha} - \epsilon^C_{\alpha\alpha})$ to the energy of the short range links of N^{core}_α α-clusters (see (16) in [1]).

So the binding energies E and E_1 of the nuclei $A(Z,N)$ and $A_1(Z_1, N+2)$, with the core of the N^{core}_α α-clusters and peripheral molecules of N^{ml}_α and

$N_{\alpha 1}^{ml} = N_\alpha^{ml} + 0.5$ α-clusters, are calculated as it follows, see (4,5)[1]

$$E = E_{N_\alpha^{ml}} - E^C_{N_\alpha^{ml} N_\alpha^{core}} + E_{core}; E_1 = E_{N_\alpha^{ml+0.5}} - E^C_{N_\alpha^{ml} N_\alpha^{core}} + E_{core}, \tag{2}$$

where $E_{N_\alpha^{ml}}$ and $E_{N_\alpha^{ml+0.5}}$ are the experimental binding energies of the nuclei with the total number of alpha-clusters equal to N_α^{ml} and $N_\alpha^{ml+0.5}$ (for example $E_3 = E_{^{12}\mathrm{C}}$ and $E_{3.5} = E_{^{15}\mathrm{N}}$), $E^C_{N_\alpha^{ml} N_\alpha^{core}}$ is the energy of the Coulomb interaction between the core and the peripheral molecule

$$E^C_{N_\alpha^{ml} N_\alpha^{core}} = 2N_\alpha^{ml} 2N_\alpha^{core} e^2 / R_\alpha, \tag{3}$$

E_{core} is the binding energy of core

$$E_{core} = E_{\Delta N} + E_{N_\alpha^{core}}, \tag{4}$$

where the binding energy of excess nn-pairs $E_{\Delta N} = \sum_1^{N_{nn}} E_{i_{nn}}$ was approximated (see (12) in [1]) with the following formula in dependence on the number of excess nn-pairs N_{nn}

$$E_{\Delta N} = (21.93 - 0.762 N_{nn}^{2/3}) N_{nn}, \tag{5}$$

$E_{N_\alpha^{core}}$ stands for the binding energy of N_α^{core} of core α-clusters (see (16) in [1])

$$E_{N_\alpha^{core}} = E^{nuc}_{N_\alpha^{core}} - E^C_{N_\alpha^{core}} + 6\epsilon_{\alpha\alpha} + E^{st}, \tag{6}$$

where $E^{nuc}_{N_\alpha^{core}} = N_\alpha^{core} \epsilon_\alpha^{nuc} + 3(N_\alpha^{core} - 2)\epsilon_{\alpha\alpha}^{nuc}$, $E^C_{N_\alpha^{core}} = 1.848(N_\alpha^{core})^{5/3}$; E^{st} is the surface tension energy

$$E^{st} = (N_\alpha + 1.7)(N_\alpha^{core})^{2/3}. \tag{7}$$

The original formula $E^{st} = (N_\alpha + 1.7)(N_\alpha - 4)^{2/3}$ (see (17) in Ref. [1]) was proposed in Ref. [3] as an approximation function to the sum of square radii of $N_\alpha - 4$ clusters for the nuclei with $Z \geq 30$. The formula is at work here, therefore the other isotopes with the $Z < 30$ are not considered here. The part $(N_\alpha - 4)^{2/3}$ is changed here for $(N_\alpha^{core})^{2/3}$. In case $N_\alpha^{ml} = 4$ the two formulas are equal.

In case of two molecules with N_α^{ml1} and N_α^{ml2} alpha-clusters on the surface of the core the binding energy is as it follows [1]

$$E = E_{N_\alpha^{ml1}} + E_{N_\alpha^{ml2}} - (E^C_{N_\alpha^{ml1}(N_\alpha^{core} + N_\alpha^{ml2})} + E^C_{N_\alpha^{ml2} N_\alpha^{core}}) + E_{core}. \tag{8}$$

For the odd nucleus $A_1(Z_1, N+2)$ to calculate E_1 in the formula the first term (either the first or the second) is exchanged for $E_{N_\alpha^{ml1+0.5}}$. The value E_{core} is calculated by (4) with $N_\alpha^{core} = N_\alpha - (N_\alpha^{ml1} + N_\alpha^{ml2})$. Then unlike [1] the total number of short links in the nucleus with two molecules is less than $3(N_\alpha - 2)$.

The following formulas (9-12) have been proposed to estimate radii of the nuclei $A(Z, N)$ [1–3]. The radius of the odd nucleus $A_1(Z_1, N+2)$ is calculated (9-12) with the value $N_\alpha + 0.5$. The simplest one for $Z \geq 30$ is

$$R = r_\alpha N_\alpha^{1/3}, \tag{9}$$

where r_α=1.60 fm. In the nuclei the core prevails, so the value r_α is to be the radius of a core α-cluster. To refine r_α the empirical radii in the Ref.[5], Table IIIA, with 111 data of the isotopes $A(Z, N)$ and $A_1(Z_1, N+2)$ have been fitted. In that table the muonic atom transition energies are analyzed with using the same model for all observed there isotopes for the nuclei with $Z \leq 60$ and $Z > 77$. A value $r_\alpha = 1.595$ fm has been obtained here with the rms deviation from the experimental data δ =0.031 fm.

The charge radius can be estimated from adding the volumes of the charges of the core and the peripheral clusters (1)[1]

$$R^3 = r_{^4He}^3 N_\alpha^{ml} + r_\alpha^3 N_\alpha^{core}, \tag{10}$$

where the radius of a peripheral alpha-cluster $r_{^4He}$=1.71 fm. Fitting the data of the Table IIIA[5] with the $N_\alpha^{ml} = 3$ (see section 2) gives the value of the core alpha-clusters $r'_\alpha = 1.574$ fm with $\delta = 0.032$ fm.

Another way to calculate radius is as it follows [2]

$$N_\alpha R^2 = N_\alpha^{core}(r_\alpha (N_\alpha^{core})^{1/3})^2 + N_\alpha^{ml} R_\alpha^2, \tag{11}$$

where the square core radius and the square distance of the position of the last $N^{ml} = 2, 3$ α-clusters (see section 2) in the center of mass of the core are added with their weights to be equal to the square radius of the nucleus weighed with N_α. The value $r_\alpha = 1.595$ fm gives $\delta = 0.035$ fm.

The mass radius for the nucleus $A(Z, N)$ in accordance with the model is determined by the volume of the charge of the peripheral N_α^{ml} α-clusters and the volume of the core mass, consisting of the space occupied by the bodies of the core alpha-clusters and the volume of the excess nn-pairs [2]

$$R_m^3 = N_\alpha^{ml} r_{^4He}^3 + N_\alpha^{core}(4r_{p/n}^3) + N_{nn}(2r_n^3), \tag{12}$$

where $r_{p/n}$=0.954 fm stands for the radius of the volume occupied by the body of one nucleon of a core α-cluster, r_n=0.796 fm is the radius of one neutron of nn-pair. The deviation $\delta = 0.027$ fm for the N_α^{ml} = 2,3 (see section 2). The radius of a core α - cluster $4^{1/3}r_{p/n}$ is not really its mass radius. It rather defines the space which can't be occupied by excess neutrons, because there is some structure made of pn-pairs. Generally speaking, the value $r_{p/n}$ may change from nucleus to nucleus. The real mass radii of all nucleons considered as elementary bricks of a nucleus should be equal, because the binding energies are too small in comparison with their masses. Well known formula $R = r_0 A^{1/3}$ with the fitted value r_0=0.95 fm for the data of the Table IIIA [5] gives the considerably bigger deviation $\delta = 0.067$ fm.

The other isotopes with $60 < Z \leq 77$ are treated in [5], Table IIIC, as deformed ones. Fitting the data of 143 $A(Z, N)$ and $A_1(Z_1, N+2)$ isotopes of both Table IIIA and Table IIIC gives a little bit bigger values of the parameters, for example in (9) $r_\alpha = 1.60 fm$ with $\sigma = 0.043$ fm.

2 Binding energies and radii of isotopes with $N \geq Z$ for the nuclei with $Z \geq 30$

In the representation of core and a molecule on its surface beside Z and A there is another feature parameter, this is N_α^{ml} which can be found from the analysis of experimental binding energies. The specific density of core binding energy is calculated as $\rho = E_{core}/(N_\alpha^{core} v_\alpha)$ where $v_\alpha = 4/3\pi r_\alpha^3$ at the charge radius of the core $r_\alpha = 1.595$ fm (9) and (11). The value ρ grows with the number of excess neutrons and at β-stable nuclei it reaches a saturation with $\rho \approx 2.6 \pm 0.1$MeV/fm^3. Great majority of the β-stable nuclei with $30 \leq Z, Z_1 \leq 82$ have N^{ml}=3. Some of the β -stable isotopes with $Z, Z_1 = 33, 38, 39, 40, 41, 42, 43$ have $N^{ml} = 2$ and some of the ones with $66 \leq Z, Z_1 \leq 78$ have N_{ml}= 4. The isotopes with $Z, Z_1 \geq 84$ have N^{ml}=4,5. For example all β-stable isotopes with $Z = 30$, 60 and 80 have N^{ml}= 3 and $\rho = 2.5 \div 5.7$ MeV/fm^3, $2.5 \div 2.6$ MeV/fm^3 and 2.5 MeV/fm^3 respectively. So the conclusion made in [1] that some particular intensity of the binding forces in core features the stability is proved here too. Thus, one can roughly describe the narrow strip of binding energies of β - stability with one feature parameter N_α by the formula

$$E = E_{N_\alpha^{ml}} + (N_\alpha - N_\alpha^{ml})v_\alpha\rho - 2N_\alpha^{ml}2(N_\alpha - N_\alpha^{ml})e^2/R_\alpha, \tag{13}$$

with N_α^{ml} =3 and $\rho = 2.6 \pm 0.1$ MeV/fm^3 (for the nuclei with $N_\alpha \leq 9$, $Z \leq 18$, the empirical values R_α obtained from analysis of ΔE_{pn}, see (17,18) [3], are used). The number of excess neutrons is defined by the binding energy of excess neutrons $E_{\Delta N}$ (5), which is needed to fill out the phase volume provided by

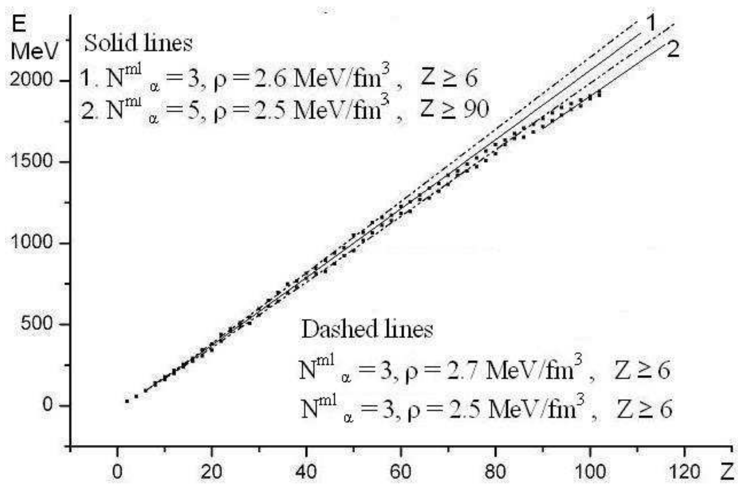

Fig. 1. The binding energy of beta-stable isotopes. Dots indicate the experimental energies of the lightest and the heaviest even beta-stable isotopes. Four lines indicate the function (13)

the core. In Fig. 1 the function (13) is given in comparison with experimental values of the lightest and the heaviest even Z beta-stable isotopes depicting the boundaries of β-stability.

The further nn-pairs come out on the surface of the core with the binding energy less than E_{inn} provided by (5) without affecting the core density. It is understandable that the separation energy of an excess nn-pair $E^{sep}_{N_{nn}} = E_{A'(Z,N+2)} - E_{A(Z,N)}$ is equal to the binding energy of the pair, if at adding the pair the configuration of the nucleus stays unchange (N^{ml}_{α}=const). The energy E (2) or (8) with $E_{\Delta N}$ (5) can be calculated only for those isotopes that have the excess neutrons inside the core, i.e. for the $A \leq A^{st}$ where A^{st} is the mass of the heaviest β-stable isotope. For heavier isotopes the binding energy is equal to the sum of E (2) for the isotope with A^{st} plus $\sum E^{sep}_{i_{nn}}$ of the last nn-pairs. Examples are given in Table1(see Appendix) for the isotopes of the nuclei with Z = 30,31, 60,61 and 80,81. For Z=30 and 31 all the isotopes with known energies are given to show that for the isotopes with $A > A^{st}$ $E^{sep}_{N_{nn}} \leq E_{N_{nn}}$ and that the values $E^{sep}_{N_{nn}}$ for both isotopes $A(Z,N)$ and $A_1(Z_1, N+2)$ in most of the cases are almost equal. For the other nuclei only the data of the isotopes with $A \leq A^{st}$ are given.

One can see from Table 1, that the separation energies $E^{sep}_{N_{nn}}$ for the most of the pairs of $A(Z,N)$ and $A_1(Z_1, N+2)$ differ within 1 MeV. It allows one to make a prediction of some isotopes, when the complementary nucleus is already measured. For example in Table 1 such value is indicated by 'Pr' in the column of E_{exp}. And some other predicted values are $E_{123(45,78)}$ =1007 MeV, $E_{126(46,80)}$ = 1034 MeV, $E_{139(51,88)}$= 1132 MeV, $E_{145(53,92)}$ = 1171 MeV, $E_{148(54,94)}$ = 1193 MeV, $E_{189(73,116)}$=1500 MeV, $E_{193(75,118)}$=1529 MeV, $E_{175(81,94)}$=1348 MeV, $E_{261(101,160)}$=1929 MeV.

In accordance with the representation of core as a liquid drop one can suggest that the excess nn-pairs may concentrate inside the core near its surface due to the surface tension, so that the filling out the space inside the core goes from surface to center. Even the very first nn-pairs may be at the boundary of the core defined by core's charge radius. Therefore it is suggested that for the isotopes lighter than stable isotopes the charge radii calculated by (9-11) should be close to the real values, which are measured in experiments. For the β - stable isotopes and heavier ones with the nn-pairs out of the the core the mass radii (12) might gives the nuclear size. Then the nuclear radii with growing A should first decrease according to decreasing N_{α}^{ml} (10,11) till the stable isotopes which have approximately equal radii (9-12) and then they should slowly increase because the growing amount of nn-pairs on the surface of the core (12).

It is shown here that the nuclear binding energies and radii of the nuclei with $N \geq Z$ are well described in the representation of a nucleus as a core made of bosons with β - stable nuclear molecules outside. In such a consideration there can be only one nucleon (fermion) not having its pair. It is expected to be on the periphery of the nucleus determining shell effects coming from its spin-orbit interaction with the surface molecule at the presence of the core.

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3 Appendix

Table 1. Binding energies and radii of the isotopes with Z=30, 31 60, 61,80,81. ΔN is the number of excess neutrons in the core. E_{exp} is from [6], E_{nn}^{sep} is the separation energy of the last nn-pair, N_{α}^{ml} is the number of alpha-clusters out of the core, R_{exp} is from [5].*indicates a β-stable nucleus

Z	ΔN	A	E_{exp}	E_{nn}^{sep}	N_{α}^{ml}	$E(2,8)$	R_{exp}	$R(12)$	$R(11)$	$R(10)$	$R(9)$
			MeV	MeV		MeV	fm	fm	fm	fm	fm
30	0	60	515	0	3	514		3.841	3.914	3.954	3.934
31	0	63	541	0	3	538		3.897	3.949	4.006	3.977
30	2	62	538	23	3	535		3.864	3.914	3.954	3.934
31	2	65	563	22	3	559		3.919	3.949	4.006	3.977
30	4	*64	559	21	3	556	3.928	3.886	3.914	3.954	3.934
31	4	67	583	20	3	579		3.941	3.949	4.006	3.977
30	6	*66	578	19	3	575	3.948	3.908	3.914	3.954	3.934
31	6	*69	602	19	3	599	3.996	3.962	3.949	4.006	3.977
30	8	*68	595	17	3	594	3.965	3.930	3.914	3.954	3.934
31	8	*71	619	17	3	618	4.011	3.984	3.949	4.006	3.977
30	10	70	610	16	3	613	3.983	3.952	3.914	3.954	3.934
31	10	73	635	16	3	636		4.005	3.949	4.006	3.977
30	12	72	626	16	3			3.973	3.914	3.954	3.934
31	12	75	650	16	3			4.025	3.949	4.006	3.977
30	14	74	640	14	3			3.995	3.914	3.954	3.934
31	14	77	663	13	3			4.046	3.949	4.006	3.977
30	16	76	652	13	3			4.015	3.914	3.954	3.934
31	16	79	676	13	3			4.067	3.949	4.006	3.977
30	18	78	663	11	3			4.036	3.914	3.954	3.934
31	18	81	688	12	3			4.087	3.949	4.006	3.977
30	20	80	674	11	3			4.057	3.914	3.954	3.934
31	20	83	695	7	3			4.107	3.949	4.006	3.977
30	22	82	681	7	3			4.077	3.914	3.954	3.934
31	22	85	702	7	3			4.127	3.949	4.006	3.977
60	6	126	1023		1+3	1024		4.839	4.985	4.951	4.956
61	6	129	1046		1+3	1048		4.875	5.013	4.985	4.983

Z	ΔN	A	E_{exp}	E^{sep}_{nn}	N^{ml}_{α}	$E(2,8)$	R_{exp}	$R(12)$	$R(11)$	$R(10)$	$R(9)$
60	8	128	1046	23	1+3	1044		4.854	4.985	4.951	4.956
61	8	131	1069	23	1+3	1067		4.889	5.013	4.985	4.983
60	10	130	1069	23	4	1073		4.868	4.985	4.951	4.956
61	10	133	1091	22	4	1093		4.903	5.013	4.985	4.983
60	12	132	1090	21	4	1091		4.882	4.985	4.951	4.956
61	12	135	1121	20	3	1121		4.895	5.001	4.970	4.983
60	14	134	1110	20	4	1108		4.896	4.985	4.951	4.956
61	14	137	1132	11	4	1128		4.931	5.013	4.985	4.983
60	16	136	1130	20	3	1132		4.889	4.973	4.936	4.956
61	16	139	1152	20	3	1156		4.923	5.001	4.970	4.983
60	18	138	1149	19	3	1149		4.903	4.973	4.936	4.956
61	18	141	1171	19	3	1172		4.937	5.001	4.970	4.983
60	20	140	1167	18	3	1165		4.917	4.973	4.936	4.956
61	20	143	1189	18	3	1189		4.951	5.001	4.970	4.983
60	22	*142	1185	18	3	1181	4.914	4.931	4.973	4.936	4.956
61	22	145	1204	15	3	1204		4.965	5.001	4.970	4.983
60	24	*144	1199	14	3	1197	4.941	4.944	4.973	4.936	4.956
61	24	147	1218	14	3	1220		4.978	5.001	4.970	4.983
60	26	*146	1212	13	3	1212	4.968	4.958	4.973	4.936	4.956
61	26	149	1231	13	3	1235		4.992	5.001	4.970	4.983
60	28	*148	1225	13	3	1226	4.998	4.972	4.973	4.936	4.956
80	12	172	1327		3+3	1327		5.362	5.512	5.458	5.455
81	12	175	1348Pr		3+3	1349		5.391	5.536	5.486	5.477
80	14	174	1348	21	3+3	1343		5.373	5.512	5.458	5.455
81	14	177	1369	21	3+3	1367		5.385	5.522	5.474	5.477
80	16	176	1370	22	2+3	1369		5.367	5.498	5.446	5.455
81	16	179	1390	21	2+3	1392		5.396	5.522	5.474	5.477

Z	ΔN	A	E_{exp}	E_{nn}^{sep}	N_{α}^{ml}	$E(2{,}8)$	R_{exp}	$R(12)$	$R(11)$	$R(10)$	$R(9)$
80	18	178	1390	20	2+3	1386		5.379	5.498	5.446	5.455
81	18	181	1410	20	2+3	1409		5.408	5.522	5.474	5.477
80	20	180	1410	20	1+4	1411		5.391	5.498	5.446	5.455
81	20	183	1430	20	1+4	1431		5.419	5.522	5.474	5.477
80	22	182	1430	20	1+4	1427		5.402	5.498	5.446	5.455
81	22	185	1450	20	1+4	1448		5.431	5.522	5.474	5.477
80	24	184	1449	20	1+3	1450		5.396	5.485	5.433	5.455
81	24	187	1468	18	1+4	1463		5.425	5.509	5.461	5.477
80	26	186	1467	18	1+3	1466		5.408	5.485	5.433	5.455
81	26	189	1487	19	1+3	1489		5.436	5.509	5.461	5.477
80	28	188	1485	18	1+3	1480		5.419	5.485	5.433	5.455
81	28	191	1504	17	1+3	1504		5.447	5.509	5.461	5.477
80	30	190	1502	17	4	1505		5.431	5.485	5.433	5.455
81	30	193	1526	22	4	1525		5.459	5.509	5.461	5.477
80	32	192	1519	17	4	1519		5.442	5.485	5.433	5.455
81	32	195	1539	13	5	1536		5.487	5.522	5.474	5.477
80	34	194	1535	16	4	1533		5.453	5.485	5.433	5.455
81	34	197	1555	16	4	1553		5.481	5.509	5.461	5.477
80	36	*196	1551	16	3	1554		5.448	5.475	5.421	5.455
81	36	199	1571	16	4	1566		5.492	5.509	5.461	5.477
80	38	*198	1566	15	3	1567	5.448	5.459	5.475	5.421	5.455
81	38	201	1586	15	3	1590		5.487	5.499	5.449	5.477
80	40	*200	1581	15	3	1580	5.457	5.470	5.475	5.421	5.455
81	40	*203	1601	15	3	1603	5.472	5.498	5.499	5.449	5.477
80	42	*202	1595	14	3	1592	5.467	5.481	5.475	5.421	5.455
81	42	*205	1615	14	3	1615	5.483	5.509	5.499	5.449	5.477
80	44	*204	1609	14	3	1604	5.478	5.492	5.475	5.421	5.455
81	44	207	1628	13	3	1627		5.520	5.499	5.449	5.477