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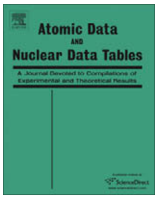

α-Decay half-lives, α-capture, and α-nucleus potential

V. Yu. Denisov*, A.A. Khudenko

Institute for Nuclear Research, Prospect Nauki 47, 03680 Kiev, Ukraine

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ABSTRACT

α-Decay half-lives and α-capture cross sections are evaluated in the framework of a unified model for α-decay and α-capture. In this model α-decay and α-capture are considered as penetration of the α-particle through the potential barrier formed by the nuclear, Coulomb, and centrifugal interactions between the α-particle and nucleus. The spins and parities of the parent and daughter nuclei as well as the quadrupole and hexadecapole deformations of the daughter nuclei are taken into account for evaluation of the α-decay half-lives. The α-decay half-lives for 344 nuclei and the α-capture cross sections of ^{40}Ca, ^{44}Ca, ^{59}Co, ^{208}Pb, and ^{209}Bi agree well with the experimental data. The evaluated α-decay half-lives within the range of $10^{-9} \leqslant T_{1/2} \leqslant 10^{38}$ s for 1246 α-emitters are tabulated.

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* Corresponding author. Tel.: +380 44 525 45 04; fax: +380 44 525 44 63.
E-mail address: denisov@kinr.kiev.ua (V. Yu. Denisov).

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Contents

1. Introduction

α-Decay is a very important process in nuclear physics [1–40]. Experimental information on α-decay half-lives is extensive and is being continually updated (see Refs. [3–14] and papers cited therein). The theory of α-decay was formulated by Gamow [1] and independently by Gurney and Condon [2] in 1928. Subsequently various microscopic [15–21], macroscopic cluster [3,22–30], and fission [4,32] approaches to the description of α-decay have been proposed. Simple empirical relations for description of α-decay half-lives are extensively discussed also (see, for example, Refs. [5,10,23,32–40] and numerous references therein).

The α-decay process involves sub-barrier penetration of α-particles through the barrier, caused by interaction between the α-particle and nucleus. The fusion (α-capture) reaction between α-particle and a nucleus proceeds in the opposite direction to the α-decay reaction. However, the same α-nucleus interaction potential is the principal factor to describe both reactions [29]. Therefore it is natural to use data for both the α-decay half-lives and the near barrier α-capture reactions for determination of the α-nucleus interaction potential [29]. Note that α-decay and α-capture were also discussed simultaneously in Ref. [30] recently.

Here we use a combination of updated α-decay half-lives for the ground-state-to-ground-state transitions from data compilations in *Table of Isotopes* [6,7], *Nubase* [8,9], and Ref. [11] as well as the α-capture cross sections of ^{40}Ca [41,42], ^{44}Ca [41], ^{59}Co [43], ^{208}Pb [44], and ^{209}Bi [44] around the barrier. We stress that the α-decay from the ground-state of the parent nucleus can proceed into both the ground-state and excited states of daughter nucleus [6,7]. Therefore it is necessary to take into account the branching ratio of α-decay relative to other decay modes (fission, β-decay, etc.) [6–9], as well as the branching ratio of α-decay into the ground state [6,7] relative to the total α-decay half-life, during evaluation of the dataset for α-decay half-lives for the ground-state-to-ground-state transition. The carefully updated and selected α-decay half-lives dataset contains reliable data for the 344 ground-state-to-ground-state α-transitions. Note that the α-decay half-lives data for 367 nuclei and the α-capture cross sections of ^{40}Ca, ^{59}Co, and ^{208}Pb around the barrier were used in Ref. [29]. Both of our datasets are wider than those considered in Ref. [30].

By using our dataset for α-decay half-lives and α-capture reactions, we can determine the α-nucleus potential deeply below and near the barrier with a high degree of accuracy. Knowledge of the α-nucleus interaction potential is a key for the analysis of various reactions between α-particles and nuclei. Therefore, the α-nucleus potential obtained can be used for description of various reactions in nuclear physics and astrophysics.

Many α-emitters are deformed. Therefore the α-nucleus potential should depend on the angle θ between the direction of α-emission and the axial-symmetry axis of the deformed nucleus. Both the α-decay half-life and the transmission coefficient for tunneling through the barrier are strongly dependent on θ [15,17–20,22,29] because the transmission coefficient exponentially depends on the α-nucleus potential values. This effect is elaborately discussed in microscopic models [18–20]. The quadrupole deformation and angle effects are considered in the cluster approach in Ref. [29], while the influence of quadrupole and hexadecapole deformations of daughter nuclei was studied in Ref. [26]. Therefore we take into account both quadrupole and hexadecapole deformations of daughter nuclei in the present work.

Nuclei with stable ground state deformation have the most bound at equilibrium shape that is deformed. The difference between binding energies of such nuclei in deformed and spherical shapes is the deformation energy $\mathscr{E}_{\rm def}$ [45–47]. Note that values of $\mathscr{E}_{\rm def}$ are close to 5–10 MeV for well-deformed heavy nuclei [45–47]. If deformed parent and daughter nuclei are considered as spherical, then the energy balance of α-decay should take into account the variation of the deformation energy. This strongly affects the condition of α-emission, because the α-decay half-life is very sensitive to the variation of the energy released in an α-transition.

The interaction potential between an α-particle and nucleus consists of nuclear, Coulomb, and centrifugal parts. The nuclear and Coulomb parts are taken into account in the evaluation of the α-decay half-lives and α-capture cross sections in Ref. [29]. However the centrifugal part of the α-nucleus potential is exactly accounted for in evaluation of α-capture cross sections and ignored in calculation of α-decay half-lives [29], because the spins and parities of the parent and daughter nuclei as well as angular momentum of the α-transitions are neglected. Nevertheless, α-transitions between ground states of even–odd, odd–even, and odd–odd nuclei occur at non-zero values of angular momentum of the α-particle when the spins and/or parities of the parent and daughter nuclei are different. As a result, the centrifugal potential distinctly contributes to the total α-nucleus potential at small distances between the daughter nucleus and the α-particle. The α-decay half-life depends exponentially on the interaction, which is very sensitive to the α-nucleus potential. Therefore accurate consideration of the α-transitions should take into account the spins and parities of the parent and daughter nuclei and the angular momentum of the emitted α-particle [16,20].

Experimental values and theoretical estimates of the ground-state spins and parities are known for many nuclei [8,9]. Moreover the number of nuclei with known values of ground-state spin and parity is always being extended. Therefore we re-evaluate the α-nucleus interaction potential using available updated data for α-decay half-lives, the spins and parities of the ground-states of parent and daughter nuclei and α-capture reaction cross sections. Due to this, our approach becomes more accurate.

Our unified model for α-decay and α-capture (UMADAC) is briefly discussed in Section 2. The selection of adjustable parameters and discussion of the results are given in Section 3. Section 4 is dedicated to conclusions.

2. Unified model for α-decay and α-capture

The α-decay half-life $T_{1/2}$ is calculated as [29]

$$T_{1/2} = \hbar \ln(2)/\Gamma, \tag{1}$$

where

$$\Gamma = \frac{1}{4\pi}\int \gamma(\theta,\phi)d\Omega \tag{2}$$

is the total width of decay, $\gamma(\theta,\phi)$ is the partial width of α-emission in direction θ and ϕ, and Ω is the space angle.

The width of the α-emission in direction θ for axial-symmetric nuclei is given as the following

$$\gamma(\theta) = \hbar\, 10^{\nu}\, t(Q_\alpha,\theta,\ell), \tag{3}$$

where 10^{ν} is the α-particle assault frequency (i.e., the frequency of collisions with the barrier), which takes into account the α-particle preformation, $t(Q_\alpha,\theta,\ell)$ is the transmission coefficient, which gives the probability of penetration through the barrier, and Q_α is the released energy at α-decay.

The transmission coefficient can be obtained in the semiclassical WKB approximation

$$t(Q_\alpha,\theta,\ell) = 1\Big/\left\{1+\exp\left[\frac{2}{\hbar}\int_{a(\theta)}^{b(\theta)} dr\sqrt{2\mu(v(r,\theta,\ell,Q_\alpha)-Q_\alpha)}\right]\right\}, \tag{4}$$

where $a(\theta)$ and $b(\theta)$ are the inner and outer turning points determined from the equations $v(r,\theta,\ell,Q_\alpha)|_{r=a(\theta),b(\theta)} = Q_\alpha$, and μ is the reduced mass. The α-nucleus potential $v(r,\theta,\ell,Q_\alpha)$ consists of Coulomb, $v_C(r,\theta)$, nuclear, $v_N(r,\theta,Q_\alpha)$, and centrifugal, $v_\ell(r)$, parts, i.e.

$$v(r,\theta,\ell,Q_\alpha) = v_C(r,\theta) + v_N(r,\theta,Q_\alpha) + v_\ell(r), \tag{5}$$

where

$$v_C(r,\theta) = \frac{2Ze^2}{r}\left[1+\frac{3R^2}{5r^2}\beta_2 Y_{20}(\theta) + \frac{3R^4}{9r^4}\beta_4 Y_{40}(\theta)\right] \tag{6}$$

for $r \geqslant r_c(\theta)$,

$$v_C(r,\theta) \approx \frac{2Ze^2}{r_c(\theta)}\left[\frac{3}{2} - \frac{r^2}{2r_c(\theta)^2} + \frac{3R^2}{5r_c(\theta)^2}\beta_2 Y_{20}(\theta)\left(2-\frac{r^3}{r_c(\theta)^3}\right) + \frac{3R^4}{9r_c(\theta)^4}\beta_4 Y_{40}(\theta)\left(\frac{7}{2}-\frac{5r^2}{2r_c(\theta)^2}\right)\right] \tag{7}$$

for $r \leqslant r_c(\theta)$,

$$v_N(r,\theta,Q_\alpha) = \frac{V(Q_\alpha)}{1+\exp[(r-r_m(\theta))/d]}, \tag{8}$$

$$v_\ell(r) = \frac{\hbar^2\ell(\ell+1)}{2\mu r^2}. \tag{9}$$

Here Z, R, β_2, and β_4 are, respectively, the number of protons, the radius, the quadrupole and hexadecapole deformation parameters of the nucleus interacting with the α-particle; e is the charge of proton, $Y_{20}(\theta)$ and $Y_{40}(\theta)$ are harmonic functions; $V(Q_\alpha)$ and $r_m(\theta)$ are, respectively, the strength and effective radius of the nuclear part of α-nucleus potential. The inner turning point $a(\theta)$ is close to both $r_m(\theta)$ and $r_c(\theta)$. Presentation of the Coulomb field in the form given in Eq. (6) at distances $r \lesssim r_c(\theta)$ ensures the continuity of the Coulomb field and its derivative at $r = r_c(\theta)$. We choose $r_c(\theta) = r_m(\theta)$ to reduce the number of parameters. Note that Eq. (6) describes the Coulomb potential between spherical and deformed nuclei at distances for which the interacting nuclei are separated [48]. By substituting $\beta_2 = \beta_4 = 0$ we reduce Eq. (7) to the well-known form of the potential for a uniformly charged sphere.

The α-particle emission from nuclei obeys the spin–parity selection rule. Let j_p, π_p and j_d, π_d be the spin and parity values of the parent and daughter nuclei, respectively. The α-particle has a zero value of spin and positive parity, therefore the minimal value of angular momentum $\ell_{\min}$ at the α-transition between states with j_p, π_p and j_d, π_d is

$$\ell_{\min} = \begin{cases} \Delta_j & \text{for even } \Delta_j \text{ and } \pi_p = \pi_d, \\ \Delta_j + 1 & \text{for odd } \Delta_j \text{ and } \pi_p = \pi_d, \\ \Delta_j & \text{for odd } \Delta_j \text{ and } \pi_p \neq \pi_d, \\ \Delta_j + 1 & \text{for even } \Delta_j \text{ and } \pi_p \neq \pi_d, \end{cases} \tag{10}$$

where $\Delta_j = |j_p - j_d|$.

Note that the value of α-particle angular momentum ℓ can be larger than $\ell_{\min}$. This is related to the intrinsic structure of the single-particle levels around the proton and neutron Fermi levels in parent and daughter nuclei and the manner of α-particle formation in parent nuclei. There are many cases of α-transition between ground states with a non-zero value of angular momentum. We suppose that the angular momentum of α-transition between ground states ℓ equals $\ell_{\min}$ for the sake of simplicity. So, the centrifugal part of the α-nucleus potential (see Eq. (9)) is determined according to the spin–parity selection rule for α-transition. The centrifugal contribution to the potential is very important for α-emission from even–odd, odd–even, and odd–odd nuclei. We consider that $\ell_{\min} = 0$ for all even–even nuclei.

The α-capture cross section of axial-symmetric nuclei at near the barrier collision energy (E) in the center-of-mass system is equal to [29]

$$\sigma(E) = \frac{\pi\hbar^2}{2\mu E}\int_0^{\pi/2}\sum_\ell (2\ell+1)t(E,\theta,\ell)\sin(\theta)d\theta. \tag{11}$$

Here the integration over the angle θ is done for the same reason as in Eq. (2). The transmission coefficient $t(E,\theta,\ell)$ can be evaluated using the semiclassical WKB approximation (see Eq. (4)) in the case of collision between an α-particle and stiff magic or near-magic spherical nuclei at collision energies below and slightly above the barrier. The α-nucleus potential is given by Eqs. (5)–(9). The transmission coefficient is approximated by an expression for a parabolic barrier at collision energies higher than or equal to the barrier energy. This approximation for the transmission coefficient is very common in the case of sub-barrier fusion reactions between heavy ions [29,49,50].

3. Discussion and results

3.1. Input data

We chose data for $T_{1/2}$ for 344 α-decay transitions between the ground states of parent and daughter nuclei with accurate values of the half-lives, the α-decay branching ratio relative to the other decay modes (fission, β-decay, etc.), and the branching ratio of ground-state-to-ground-state α-decay transitions relative to α-decay transitions from the ground-state of the parent nucleus to excited states of the daughter nucleus, from tables in Refs. [6–9] and add data from a recent paper [11]. The α-decay half-lives marked in Refs. [8,9] as poorly estimated or with poor limits for the half-life have not been included in our dataset, so that we have selected only well-defined ground-state-to-ground-state α-transitions (however, our selection criterion is not as strict as the one in Ref. [5]). As a result, 136 even–even, 84 even–odd, 76 odd–even, and 48 odd–odd α-emitters are included in the dataset. The selected dataset of α-emitters has very large mass ($106 \leqslant A \leqslant 261$) and charge ($52 \leqslant Z \leqslant 107$) ranges. Due to the selection procedure, the number of α-decay half-lives for even–even nuclei considered here is slightly smaller than the one in Refs. [23,26,29], but much larger than the one in Ref. [5]. Note that 77 α-emitters within the narrow ranges of $146 \leqslant A \leqslant 255$ and $62 \leqslant Z \leqslant 100$ are accounted for in our parameter search but not in that of Ref. [5] due to a very strict selection criterion applied in Ref. [5].

The released energy of α-particles emitted from the nucleus in α-decay is calculated using a recent evaluation of atomic mass data [8]. The effect of atomic electrons on the energy of the α-particles should also be taken into account. Therefore the released energy of the α-particle, Q_α, emitted from a nucleus in α-decay is [27,51]

$$Q_\alpha = \delta\mathscr{M}_{\rm p} - (\delta\mathscr{M}_{\rm d} + \delta\mathscr{M}_\alpha) + k(Z_{\rm p}^{\epsilon} - Z_{\rm d}^{\epsilon}), \tag{12}$$

where $\delta\mathscr{M}_{\rm p}, \delta\mathscr{M}_{\rm d}$, and $\delta\mathscr{M}_\alpha$ are, respectively, the mass-excess of the parent, daughter, and α nuclei. The last term in Eq. (12) describes the effect of the atomic electrons, kZ^{ϵ} represents the total binding energy of Z electrons in the atom, $k = 8.7$ eV and $\epsilon = 2.517$ for nuclei with $Z \geqslant 60$ and $k = 13.6$ eV and $\epsilon = 2.408$ for nuclei with $Z < 60$ [27,51].

The experimental data on deformation parameters β_2 and β_4 are taken from the RIPL-2 database [52]. When no experimental data exist for a nuclide in the RIPL-2 compilation, values of the deformation parameters are taken from the macroscopic–microscopic model [47].

The ground-state-to-ground-state α-transitions of even–even nuclei take place at $\ell = 0$. The value of ℓ for the ground-state-to-ground-state transitions in even–odd, odd–even, and odd–odd nuclei are determined by the spin–parity selection rule, see Eq. (10). The values of spin and parity for nuclei are taken from Ref. [8]. When no data exist for a nuclide in Ref. [8], we use corresponding values from Ref. [9]. Unfortunately, there are cases when the values of spin and parity are absent in both Refs. [8,9]. For such nuclei we assign to the spin and parity values 0^+ in our calculations and leave an empty space in Table 1.

The data for α-capture cross sections of ^{40}Ca, ^{44}Ca, ^{59}Co, ^{208}Pb, and ^{209}Bi were taken from Refs. [41–44]. We consider α-capture cross sections using the same approach as in Ref. [29] (note that we take into account data points for α-capture cross sections of ^{40}Ca, ^{44}Ca for below and near barrier energies, because at high collision energies other processes can become important, and as a result, the one-dimensional model for α-capture is not proper. Therefore we briefly discuss α-capture reactions below).

Note that unified analysis of the experimental data for both α-decay and α-capture gives a unique possibility to evaluate the mass (A), charge (Z), and energy (Q_α) dependencies of the α-nucleus potential in the very wide ranges of $40 \leqslant A \leqslant 293, 50 \leqslant Z \leqslant 118$ and $1.915\ \text{MeV} \leqslant Q_\alpha \leqslant 25$ MeV. The mass, charge, and energy dependencies of the α-nucleus potential obtained can be applied in wider ranges and for various purposes also.

3.2. Parameter search

We describe both the half-lives for ground-state-to-ground-state α-transitions in 344 nuclei and α-capture cross sections of ^{40}Ca (two sets), ^{44}Ca, ^{59}Co, ^{208}Pb, and ^{209}Bi using the UMADAC presented in Section 2. By carrying out this task we parameterize $V(Q_\alpha), r_{\rm m}(\theta)$, d, and v in Eqs. (3)–(9) and determine these parameters by searching for the minimum of function

$$F = (5D_{\rm e-e} + D_{\rm e-o} + D_{\rm o-e} + D_{\rm o-o}) + 20\left(3\,D_\sigma^{208\rm Pb} + 3\,D_\sigma^{209\rm Bi} + D_\sigma^{40\rm Ca,1} + D_\sigma^{40\rm Ca,2} + D_\sigma^{44\rm Ca} + D_\sigma^{59\rm Co}\right). \tag{13}$$

Here

$$D_{\rm e-e} = \sum_{\rm e-e}\left[\log_{10}(T_{1/2}^{\rm theor}) - \log_{10}(T_{1/2}^{\rm exp})\right]^2 = \sum_{\rm e-e}\left[\mathscr{T}^{\rm theor} - \mathscr{T}^{\rm exp}\right]^2 \tag{14}$$

is the difference between the decimal logarithm of theoretical, $T_{1/2}^{\rm theor}$, and experimental, $T_{1/2}^{\rm exp}$, values of the α-decay half-lives for a set of even–even nuclei; $\mathscr{T}^{\rm theor} = \log_{10}(T_{1/2}^{\rm theor})$; $\mathscr{T}^{\rm exp} = \log_{10}(T_{1/2}^{\rm exp})$; $D_{\rm e-o}, D_{\rm o-e}, D_{\rm o-o}$ are the differences similar to Eq. (14) for even–odd, odd–even, and odd–odd datasets, respectively; and

$$D_\sigma = \sum_k \left[\log_{10}(\sigma^{\rm theor}(E_k)) - \log_{10}(\sigma^{\rm exp}(E_k))\right]^2. \tag{15}$$

Here $\sigma^{\rm theor}(E_k)$ and $\sigma^{\rm exp}(E_k)$ are, respectively, the theoretical and experimental values of the α-capture cross sections of the corresponding nucleus at an energy E_k.

By inserting various coefficients in Eq. (13) we take into account that

- α-decay half-lives data are known better than data for α-capture reactions, as a rule;
- description of α-decay half-lives in even–even nuclei is the most accurate in the framework of our model, because there is no angular momentum uncertainty for such α-transitions;
- the value of $D_{\rm e-e}$ is several times smaller then values of $D_{\rm e-o}, D_{\rm o-e}$, or $D_{\rm o-o}$; however, both the data and our description of α-decay half-lives in even–even nuclei are the most accurate, therefore we choose the factor 5 in the first line of Eq. (13) for the sake of reinforcing the role of even–even nuclei during parameter searches (note that $5D_{\rm e-e} \approx 2/3(D_{\rm e-o} + D_{\rm o-e} + D_{\rm o-o})$);
- the cross sections for different α-capture reactions [41–44] are known with different accuracy (moreover, two experimental datasets available for reaction $\alpha + {}^{40}$Ca [41,42] are in poor agreement with each other); taking into account that $D_\sigma^{208\rm Pb}$(or $D_\sigma^{209\rm Bi}$) $\ll D_\sigma^{40\rm Ca,1}$(or $D_\sigma^{40\rm Ca,2}$, or $D_\sigma^{44\rm Ca}$, or $D_\sigma^{59\rm Co}$) and that the cross sections for α-capture on ^{208}Pb and ^{209}Bi are known with highest accuracy, we introduce the factor 3 in the second line of Eq. (13), which enhances the influence of α-capture data on ^{208}Pb and ^{209}Bi in parameter searches.

It is reasonable that the contribution of α-capture reactions in the function F was close to 10%, therefore we multiply by 20 the contribution of α-capture reactions (see Eq. (13)).

As a result of minimization for various forms of the parameters $V(Q_\alpha)$, $r_{\rm m}(\theta)$, and d in Eqs. (6)–(9), we find the minimum of the function F at

$$V(Q_\alpha) = v_1 + \frac{v_2 Z}{A^{1/3}} + v_3 I + \frac{v_4 Q_\alpha}{A^{1/3}} + \frac{v_5 Y_{20}(\theta)\beta_2}{A^{1/6}}, \tag{16}$$

$$r_{\rm m}(\theta) = r_1 + R(1 + \beta_2 Y_{20}(\theta) + \beta_4 Y_{40}(\theta)), \tag{17}$$

$$R = r_2 A^{1/3}(1 + r_3/A + r_4 I), \tag{18}$$

$$d = d_1 + d_2 A^{-1/3}, \tag{19}$$

$$v = 19 + S + v_0 Z^{1/2} A^{1/6} + v_1((-1)^\ell - 1) + v_2\frac{Z}{\sqrt{Q_\alpha}} + v_3 I + v_4\beta_2 + v_5\beta_4 + v_6\frac{\ell(\ell+1)}{A^{1/6}} \tag{20}$$

Table A
The parameters of the α-nucleus potential and the assault frequency.

v_1 (MeV)	−40.1031
v_2 (MeV)	-10.1511×10^{-2}
v_3 (MeV)	−9.1928
v_4	10.8545×10^{-5}
v_5 (MeV)	6.0703×10^{-2}
r_1 (fm)	1.1683
r_2 (fm)	1.2915
r_3	1.4088
r_4	−0.0994
d_1 (fm)	0.6870
d_2 (fm)	−0.3664
v_0 (s)	−0.1348
v_1	0.9132
v_2 (MeV$^{-1/2}$)	-4.1029×10^{-2}
v_3	0.6564
v_4	−1.6442
v_5	−1.2112
v_6	6.8513×10^{-2}

where A and Z are the number of nucleons and protons in the nucleus that is interacting with the α-particle, $I = (A - 2Z)/A = (N - Z)/A$, $S = 4.1382, S = 3.57016, S = 3.8246$ and $S = 3.6625$ for even–even, even–odd, odd–even, and odd–odd nuclei, respectively. Note that 22 parameters are contained in Eqs. (16)–(20). The parameter values are given in Table A.

The strength of the nuclear part of the interaction potential depends on the Coulomb parameter, $Z/A^{1/3}$, the proton–neutron symmetry, I, and the reaction energy, Q_α. The angular and deformation dependences of the interaction strength (see the last term in Eq. (16)) reflect the fact that the strength of the nuclear part of the potential between spherical and deformed nuclei is smaller for the tip orientation of the deformed nucleus and larger for the side orientation [53,48]. We also introduce the quadrupole and hexadecapole deformation dependences of the factor v (see Eq. (20)). The deformation dependence of the factor v shows that the formation of the α-particle on the surface of the deformed parent nucleus is hindered in comparison with the spherical parent nucleus, and the assault frequency is reduced in the deformed nuclei in comparison with the spherical ones due to enlargement of the mean surface radius as a result of surface deformation. Various values of the parameter S for even–even, even–odd, odd–even, and odd–odd nuclei are related to hindrance of α-particle formation on the surface of even–odd, odd–even, and, especially, odd–odd parent nuclei. Moreover, α-particle preformation should be influenced by parity or spin of the α-transition (see factors v_1 and v_6, respectively).

The results of α-decay half-lives and α-capture cross sections evaluated in the framework of our UMADAC are presented below. We start our discussion with detailed consideration of the α-decay half-lives.

3.3. α-Decay half-lives

The evaluated α-decay half-lives agree well with 344 experimental data points (see Graph 1 and Tables 1 and 2). The experimental values of the half-lives are scattered over an extremely wide range from $\sim 10^{-8}$ s to $\sim 10^{27}$ s. The α-decay half-lives are very nicely described in the case of even–even parent nuclei. We see in Graph 1 that the difference between theoretical and experimental values of $\log_{10} T_{1/2}$ are smaller than 0.4 for most cases of even–even nuclei and smaller than 0.8 for most cases of even–odd, odd–even, and odd–odd nuclei.

We present the α-decay half-lives between the ground states of the parent and daughter nuclei obtained in the framework of our UMADAC in Table 1. All possible α-emitters with evaluated α-decay half-lives within the range 10^{-9} s $\leqslant T_{1/2} \leqslant 10^{38}$ s are included in Table 1. As a result, there are 1246 α-emitters in Table 1, among them 344 and 902 α-emitters with known and unknown values of the α-decay half-life, respectively. Note that the $T_{1/2} = (1.9 \pm 0.2) \times 10^{19}$ yr $= (6.0 \pm 0.6) \times 10^{26}$ s is the longest $T_{1/2}$ value for α-decays observed so far [8,11]. Therefore our upper limit for $T_{1/2} \leqslant 10^{38}$ s gives an adequate margin for planning experiments in the foreseeable future.

The root-mean-square (rms) error of the decimal logarithm of the α-decay half-lives is determined as

$$\delta = \sqrt{\frac{1}{N-1}\sum_{k=1}^{N}\left[\log_{10}(T_{1/2}^{\rm theor}) - \log_{10}(T_{1/2}^{\rm exp})\right]^2}. \qquad (21)$$

We use this expression for evaluation of the total, $\delta_{\rm tot}$, and partial (even–even, $\delta_{\rm e-e}$, even–odd, $\delta_{\rm e-o}$, odd–even, $\delta_{\rm o-e}$, and odd–odd, $\delta_{\rm o-o}$) rms errors in the framework of our and other models by using our dataset for $T_{1/2}^{\rm exp}$. The rms errors $\delta_{\rm tot}$, $\delta_{\rm e-e}, \delta_{\rm e-o}, \delta_{\rm o-e}$, and $\delta_{\rm o-o}$ obtained in our model are presented in Table 2. We see in Table 2 that the values of these errors are small.

3.4. α-Capture cross sections

The α-capture cross sections of ^{40}Ca, ^{44}Ca, ^{59}Co, ^{208}Pb, and ^{209}Bi evaluated using Eqs. (4)–(11), (16)–(20) are compared with experimental data [41–44] in Graph 2. We see that the data for α-capture of ^{208}Pb and ^{209}Bi are precisely described in the framework of the UMADAC. The cross section for α-capture of ^{40}Ca is well reproduced at low energies and slightly overestimated at higher energies. In contrast, the cross sections for α-capture of ^{44}Ca and ^{59}Co are well reproduced at high energies and slightly overestimated at very low energies.

In the framework of UMADAC, a one-dimensional model for evaluation of the fusion cross section between an α-particle and a spherical nucleus is used. It is well-known that the coupled-channel effects are very important for the nucleus-nucleus fusion reaction around the barrier [29,49,50,54,55]. Thus, we also calculated the coupled-channel calculation of the fusion cross section for the reaction $\alpha + {}^{208}$Pb by using the CCFULL code [54], and present the results in Graph 2. The effects of nonlinear coupling of the low-energy surface vibrational states in all orders are taken into account in this code. The CCFULL calculation uses the same α-nucleus potential as in the case of the one-dimensional calculation. The values of the excitation energies and surface deformations are taken from Ref. [52]. As we can see in Graph 2, the agreement between our one-dimensional and coupled-channel calculations is very good. The good agreement between CCFULL and one-dimensional calculations can be attributed to the high stiffness of doubly magic nuclei participating in this reaction. Note that due to this reason we select for our consideration α-capture reactions of ^{40}Ca, ^{44}Ca, ^{59}Co, ^{208}Pb, and ^{209}Bi. All these nuclei are very stiff.

3.5. Comparison with other approaches

α-Decay is considered in recent Refs. [14,23,26,27,36,37,39]. Our results and those from Ref. [26] are obtained by different cluster model approaches to the α-decay, while results from Refs. [23,36] are evaluated with the help of various empirical relations. The empirical relations used in Refs. [5,10,23,27,32–40] and in numerous references cited in these papers couple $\log_{10}(T_{1/2})$ to the α-particle energy, Q_α, mass, A, and charge, Z, of the parent nuclei by simple functional expressions, i.e., $\log_{10}(T_{1/2}) = f(Q_\alpha, A, Z)$. The empirical relationships are derived by using a pure Coulomb picture of α-decay, which neglects

- the nuclear force between the α-particle and the daughter nucleus,

- the deformation of the daughter nucleus, and
- the spin and parity values of the α-transitions.

The empirical relationships are based on the fitting parameters and special analytical expressions, which are similar to the Viola–Seaborg [34] relationship. The empirical relationships are often used to estimate $\log_{10}(T_{1/2})$ due to their simplicity and acceptable accuracy. The empirical relationship from Ref. [36] was derived especially for the description of $\log_{10}(T_{1/2})$ in heavy and superheavy nuclei. In Ref. [23] four empirical relationships for even–even, even–odd, odd–even, and odd–odd α-decaying nuclei were established.

We compare values of the rms errors of the decimal logarithm of the α-decay half-lives $\delta_{\rm tot}$, $\delta_{\rm e-e}, \delta_{\rm e-o}, \delta_{\rm o-e}$, and $\delta_{\rm o-o}$ obtained in the framework of our UMADAC and other models [5,23,27,35] in Table 2. All values of the rms errors are evaluated for our dataset for $T_{1/2}^{\rm exp}$. The lowest values of the rms errors of the decimal logarithm of the α-decay half-lives for any set of nuclei are obtained in our approach. The spectacular reduction of the rms errors $\delta_{\rm e-o}, \delta_{\rm o-e}$, and $\delta_{\rm o-o}$ in our model is obtained due to careful consideration of the spin–parity selection rules. It should be noted here that the values of rms errors for some relationships, which are given in original papers related to corresponding relationships, can deviate from values presented in Table 2, because different datasets for experimental α-decay half-lives are used in the original papers. The difference the datasets may be caused by three reasons.

- Various nuclei are included into the datasets of different papers.
- Different values for α-decay half-lives and/or Q_α are included in the datasets from various experiments. Note that experimental data are always being improved and extended.
- The data for α-decay half-lives for the ground-state-to-ground-state transitions are only included in our dataset in contrast to some other datasets.

The empirical relationships gives reasonable accuracy for the α-transitions in even–even nuclei, because the angular momentum of the ground-state-to-ground-state α-transition equals zero. However, the empirical relationships are too rough for even–odd, odd–even, and odd–odd α-emitters, because the angular momentum of the α-transition in such nuclei is often non-zero.

Some empirical relationships are established for very heavy α-emitters. Therefore we compare values of the rms errors $\delta_{\rm tot}, \delta_{\rm e-e}, \delta_{\rm e-o}, \delta_{\rm o-e}$, and $\delta_{\rm o-o}$ obtained in our UMADAC and other models [5,10,23,27,35,39,40] for $A \geqslant 208$ and $Z \geqslant 82$ in Table 3. In this case we select 144 α-emitters, among them 59 even–even, 33 even–odd, 34 odd–even, and 18 odd–odd α-emitters. The lowest values of the rms errors $\delta_{\rm tot}, \delta_{\rm e-o}, \delta_{\rm o-e}$, and $\delta_{\rm o-o}$ are obtained in our model, however the value of the rms error $\delta_{\rm e-e}$ evaluated in our model is not the lowest one. The values of rms errors for very heavy α-emitters are larger than the corresponding ones for the total dataset. This is probably related to the fact that the α-decay energy, spins, and parities of the parent and daughter nuclei are least known for very heavy α-emitters. Due to this, more accurate experimental information on the values of the mass excess, spin, parity, and deformations of the ground-state of nuclei can help to improve both the accuracy and predicted reliability of our model. Another reason is related to the fact that some relationships are established by fitting data for very heavy α-emitters, and therefore these relations are better for such a range of α-emitters.

4. Conclusions

We have determined the α-nucleus potential by using data for the α-decay half-lives of 344 α-emitters and near the barrier α-capture cross sections of ^{40}Ca, ^{44}Ca, ^{59}Co, ^{208}Pb, and ^{209}Bi. In the framework of the UMADAC we take into account deformation and spin–parity effects in evaluation of the α-decay half-lives, and the data for α-decay half-lives of 344 spherical and deformed nuclei and for α-capture cross sections of ^{40}Ca, ^{44}Ca, ^{59}Co, ^{208}Pb, and ^{209}Bi are well described in the framework of the UMADAC. Further, we predict α-decay half-lives for the ground-state-to-ground-state transitions in 902 nuclei. By taking into account the spins and parities of parent and daughter nuclei, we obtain spectacular improvement in the description of the α-decay half-lives in even–odd, odd–even, and odd–odd nuclei.

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Explanation of Tables

Table 1. α-Decay half-lives for the ground-state-to-ground-state α-transitions.

The decimal logarithm of α-decay half-lives for 1246 ground-state-to-ground-state α-transitions with evaluated half-lives in the range of 10^{-9} s $\leqslant T_{1/2} \leqslant 10^{38}$ s are presented in the Table. Available experimental data for α-decay half-lives for 344 nuclei from Refs. [6–9,11] are given also. The following notations were used.

A_p	The mass number of the parent nucleus
Z_p	The proton number of the parent nucleus
$\mathscr{T}^{\text{theor}}$	The decimal logarithm of the evaluated α-decay half-life $\mathscr{T}^{\text{theor}} = \log_{10}(T_{1/2}^{\text{theor}})$.
T	he value of $T_{1/2}^{\text{theor}}$ is given in s
$\mathscr{T}^{\text{exp}}$	The decimal logarithm of the experimental α-decay half-life $\mathscr{T}^{\text{exp}} = \log_{10}(T_{1/2}^{\text{exp}})$.
T	he value of $T_{1/2}^{\text{exp}}$ is given in s
β_2	Quadrupole deformation of the daughter nucleus
β_4	Hexadecapole deformation of the daughter nucleus
J_p^{π}	Spin and parity of the parent nucleus
J_d^{π}	Spin and parity of the daughter nucleus
l_{min}	The minimal orbital angular momentum of the emitted α-particle evaluated according to the selection rule (10)

If the experimental values of the α-decay half-lives are not known, then we put a dash.

The energies of ground-state-to-ground-state α-transitions can be easily evaluated using the evaluated atomic mass data [8] and Eq. (11). Due to this, the energies of α-transitions are not given here.

The spin and parity values are presented according to the notations in Ref. [8]. The spin and parity values without and with parentheses are based upon strong and weak assignment arguments [8], respectively. The symbol # indicates spin and/or parity values estimated from systematic trends in neighboring nuclides with the same N and Z.

By default values of half-lives, spins and parities are extracted from Ref. [8]. However, there are special cases, which are indicated by

a: the spin value is extracted from Ref. [9] while the parity value is from Ref. [8];

b: the spin value is taken from Ref. [8] and the parity value is adopted from Ref. [9];

c: both the spin and parity values are taken from Ref. [9].

We leave an empty place for unknown spins and parities. As a result, we substitute $l_{\text{min}} = 0$ for such cases.

The values of the quadrupole and hexadecapole deformation of the daughter nuclei are taken from Refs. [47,52] (see text for details).

Table 2. RMS errors of the decimal logarithm of α-decay half-lives for a full set of α-emitters.

The rms error of the decimal logarithm of α-decay half-lives is evaluated according to Eq. (21). The full set of α-emitters with known half-life values contains 344 nuclei, among them 136 even–even, 84 even–odd, 76 odd–even and 48 odd–odd nuclei. The experimental half-life values were taken from Refs. [8,10,11]. The first line is the result of our UMADAC, while other lines are evaluated by using various relationships. The last column contains the References for the corresponding relationships.

Table 3. RMS errors of the decimal logarithm of α-decay half-lives for nuclei heavier than lead $^{208}_{82}$Pb.

The set of α-emitters heavier than lead with known half-life values contains 144 nuclei, among them 59 even–even, 33 even–odd, 34 odd–even and 18 odd–odd nuclei. The experimental values were taken from Refs. [8,10]. The notations in Table 3 are similar to the ones of Table 2.

Explanation of Graphs

Graph 1 **Comparison between the experimental and theoretical values of $\log_{10}(T_{1/2})$ for α-decays**

Left panels: The experimental (circles) [8–11] and theoretical (crosses) values of $\log_{10}(T_{1/2})$ for α-decays in even–even (e–e), even–odd (e–o), odd–even (o–e), and odd–odd (o–o) parent nuclei.

Right panels: Dots represent the difference between the experimental and theoretical values of $\log_{10}(T_{1/2})$ for α-decays in even–even (e–e), even–odd (e–o), odd–even (o–e), and odd–odd (o–o) parent nuclei.

The $T^{\alpha}_{1/2}$ values are given in s.

Graph 2 **The experimental and theoretical values of the α-capture cross section of ^{40}Ca, ^{44}Ca, ^{59}Co, ^{208}Pb, and ^{209}Bi**

Squares correspond to data for the reaction $\alpha + {}^{208}$Pb from Ref. [44], circles are data for $\alpha + {}^{59}$Co from Ref. [43], up- and down-pointing triangles are data for $\alpha + {}^{40}$Ca from Ref. [42,41], respectively, rhombuses are data for $\alpha + {}^{44}$Ca from Ref. [41], and right-pointing triangles are data for $\alpha + {}^{209}$Bi from Ref. [44]. Lines are the results of calculations obtained in the framework of UMADAC and stars are the results of calculations using the CCFULL code [54].

Table 1
α-Decay half-lives for the ground-state-to-ground-state α-transitions. See page 822 for Explanation of Tables.

A_p	Z_p	$\mathscr{T}^{\text{theor}}$	$\mathscr{T}^{\text{exp}}$	β_2	β_4	j^{π}_{p}	j^{π}_{d}	$l_{\min}$
103	51	6.00	–	0.035	−0.015	$2.5^{+}\#$	$4.5^{+}\#$	2
104	51	7.03	–	0.053	0.001		$(6)^{+}$	0
105	51	9.15	–	0.053	−0.007	(2.5^{+})	$4.5^{+}\#$	2
105	52	−5.75	–	0.027	0.024	$2.5^{+}\#$	$2.5^{+}\#$	0
106	51	14.69	–	0.054	−0.014	(4^{+})	(6^{+})	2
106	52	−4.61	−4.15	0.009	−0.015	0^{+}	0^{+}	0
107	51	22.39	–	0.053	−0.007	$2.5^{+}\#$	$4.5^{+}\#$	2
107	52	−2.60	−2.35	0.018	−0.015	$2.5^{+}\#$	$2.5^{+}\#$	0
108	51	31.92	–	0.071	0.002	(4^{+})	$5^{(+)}$	2
108	52	−0.19	0.49	0.018	0.016	0^{+}	0^{+}	0
108	53	−2.52	–	0.081	0.051	$1^{+}\#$		0
109	52	1.96	2.06	0.026	0.009	(2.5^{+})	(2.5^{+})	0
109	53	−0.98	–	0.081	0.051	(2.5^{+})	(2.5^{+})	0
110	52	5.38	–	0.027	0.016	0^{+}	0^{+}	0
110	53	0.92	–	0.099	0.052	$1^{+}\#$	(4^{+})	4
110	54	−1.26	–	0.099	0.052	0^{+}	0^{+}	0
111	52	6.51	–	0.045	0.001	$2.5^{+}\#$	(2.5^{+})	0
111	53	2.27	–	0.098	0.052	$2.5^{+}\#$	$2.5^{+}\#$	0
111	54	0.33	–	0.134	0.064	$2.5^{+}\#$	$2.5^{+}\#$	0
112	52	9.69	–	0.035	0.009	0^{+}	0^{+}	0
112	53	5.24	5.45	0.107	0.044	$1^{+}\#$	(4^{+})	4
112	54	2.26	2.53	0.134	0.056	0^{+}	0^{+}	0
112	55	−0.43	–	0.152	0.058	$1^{+}\#$	$1^{+}\#$	0
113	52	17.09	–	0.053	0.001	(3.5^{+})	$2.5^{(+)}$	2
113	53	7.00	9.30	0.107	0.044	2.5^{+c}	$2.5^{+}\#$	0
113	54	4.62	3.89	0.142	0.048	$2.5^{+}\#$	(2.5^{+})	0
113	55	2.16	–	0.16	0.06	$2.5^{+}\#$	(2.5^{+})	0
114	52	22.53	–	−0.069	−0.008	0^{+}	0^{+}	0
114	53	11.99	–	0.107	0.028	1^{+}	(4^{+})	4
114	54	6.81	–	0.152	0.049	0^{+}	0^{+}	0
114	55	3.23	–	0.161	0.059	(1^{+})	$1^{+}\#$	0
114	56	2.22	1.77	0.169	0.052	0^{+}	0^{+}	0
115	52	24.88	–	0.045	−0.008	3.5^{+}	3.5^{+}	0
115	53	13.69	–	0.107	0.028	$2.5^{+}\#$	(2.5^{+})	0
115	54	11.36	–	0.161	0.043	(2.5^{+})	$2.5^{+}\#$	0
115	55	7.56	–	0.161	0.051	$4.5^{+}\#$	$2.5^{+}\#$	2
115	56	7.34	–	0.188	0.055	$2.5^{+}\#$	$2.5^{+}\#$	0
116	53	20.85	–	−0.153	0.028	1^{+}	3^{+}	2
116	54	18.97	–	0.161	0.043	0^{+}	0^{+}	0
116	55	9.74	–	0.179	0.053	(1^{+})	$1^{+}\#$	0
116	56	6.70	–	0.188	0.048	0^{+}	0^{+}	0
117	53	23.57	–	0.107	0.02	$(2.5)^{+}$	2.5^{+}	0
117	54	21.42	–	0.17	0.044	$2.5^{(+)}$	(3.5^{+})	2
117	55	13.73	–	0.179	0.046	$4.5^{+}\#$	2.5^{+c}	2
117	56	13.44	–	0.215	0.052	$(1.5^{+\#})$	$2.5^{+}\#$	2
117	57	9.65	–	0.207	0.052	(1.5^{+})	$2.5^{+}\#$	2
118	53	37.70	–	−0.14	0.02	2^{-}	(3^{+})	1
118	54	28.65	–	0.161	0.034	0^{+}	0^{+}	0
118	55	18.05	–	0.207	0.05	2	1^{+}	0
118	56	13.70	–	0.221	0.052	0^{+}	0^{+}	0
118	57	12.42	–	0.252	0.084		(1^{+})	0
119	55	24.83	–	0.197	0.039	4.5^{+}	$2.5^{+}\#$	2
119	56	25.17	–	0.243	0.064	(2.5^{+})	(2.5^{+})	0
119	57	16.49	–	0.252	0.075	$5.5^{-}\#$	$4.5^{+}\#$	1
119	58	12.00	–	0.271	0.095	$2.5^{+}\#$	$2.5^{+}\#$	0
120	56	22.67	–	0.249	0.046	0^{+}	0^{+}	0
120	57	19.97	–	0.271	0.079		(1^{+})	0
120	58	12.97	–	0.28	0.09	0^{+}	0^{+}	0
121	57	28.40	–	0.262	0.061	$5.5^{-}\#$	$4.5^{+}\#$	1
121	58	17.75	–	0.29	0.083	$(2.5^{+\#})$	$(1.5^{+\#})$	2
121	59	15.48	–	0.29	0.1	(1.5^{-})	(1.5^{+})	1
122	57	30.93	–	0.263	0.052		2	0
122	58	17.93	–	0.29	0.067	0^{+}	0^{+}	0
122	59	16.35	–	0.298	0.095			0
123	58	20.52	–	0.291	0.058	$(2.5^{+\#})$	(2.5^{+})	0
123	59	20.10	–	0.299	0.076	$1.5^{+}\#$	$5.5^{-}\#$	5
124	58	26.58	–	0.281	0.039	0^{+}	0^{+}	0
124	59	18.88	–	0.309	0.062			0
124	60	11.01	–	0.308	0.079	0^{+}	0^{+}	0
125	58	28.86	–	0.292	0.024	(3.5^{-})	$2.5^{(+)}$	1
125	59	22.33	–	0.3	0.051	$1.5^{+}\#$	$5.5^{-}\#$	5
125	60	13.06	–	0.319	0.066	$2.5^{(+\#)}$	$(2.5^{+\#})$	0
126	58	33.70	–	0.354	0.012	0^{+}	0^{+}	0
126	59	23.75	–	0.301	0.036	(4)		0
126	60	14.01	–	0.309	0.054	0^{+}	0^{+}	0
126	61	11.17	–	0.319	0.066			0
127	59	26.15	–	0.292	0.017	$1.5^{+}\#$	$5.5^{-}\#$	5
127	60	17.15	–	0.31	0.037	$2.5^{+}\#$	$(2.5^{+\#})$	0
127	61	11.56	–	0.319	0.049	$2.5^{+}\#$	$1.5^{+}\#$	2
128	59	34.22	–	0.293	−0.001	(3^{+})	(7^{-})	5
128	60	18.04	–	0.385	0.026	0^{+}	0^{+}	0
128	61	13.81	–	0.32	0.04	$6^{+}\#$		0
128	62	10.00	–	0.328	0.059	0^{+}	0^{+}	0
129	59	32.63	–	0.283	−0.004	(1.5^{+})	(5.5^{-})	5
129	60	24.37	–	0.302	0.009	$2.5^{+}\#$	(3.5^{-})	1
129	61	15.21	–	0.31	0.037	$2.5^{+}\#$	$1.5^{+}\#$	2
129	62	11.45	–	0.329	0.043	$2.5^{+}\#$	$2.5^{(+\#)}$	0
130	59	35.74	–	0.284	−0.02	$(6^{+\#})$	$(5^{+\#})$	2
130	60	25.51	–	0.325	−0.002	0^{+}	0^{+}	0
130	61	17.52	–	0.31	0.02	(4^{+})	(4)	0
130	62	11.41	–	0.329	0.042	0^{+}	0^{+}	0
130	63	9.60	–	0.329	0.052	$2^{+}\#$		0
131	60	26.52	–	0.294	−0.019	$(2.5^{+\#})$	$2.5^{+}\#$	0
131	61	18.90	–	0.311	0.011	$2.5^{+}\#$	$1.5^{+}\#$	2
131	62	13.06	–	0.321	0.023	$2.5^{+}\#$	$2.5^{+}\#$	0
131	63	8.84	–	0.329	0.043	1.5^{+}	$2.5^{+}\#$	2
132	60	28.10	–	0.298	−0.022	0^{+}	0^{+}	0
132	61	20.03	–	0.303	−0.008	(3^{+})	(3^{+})	0
132	62	15.84	–	0.321	0.014	0^{+}	0^{+}	0
132	63	10.37	–	0.33	0.026		$6^{+}\#$	0
133	60	32.60	–	0.275	−0.031	(3.5^{+})	(2.5^{+})	2
133	61	24.20	–	0.293	−0.002	(1.5^{+})	(1.5^{+})	0
133	62	14.31	–	0.322	−0.003	(2.5^{+})	$2.5^{+}\#$	0
133	63	11.14	–	0.33	0.026	$5.5^{-}\#$	$2.5^{+}\#$	3
134	60	36.99	–	0.258	−0.018	0^{+}	0^{+}	0
134	61	23.17	–	0.283	−0.012	(5^{+})	$(6^{+\#})$	2
134	62	13.79	–	0.37	0.002	0^{+}	0^{+}	0
134	63	9.56	–	0.331	0.007		(4^{+})	0
134	64	6.72	–	0.331	0	0^{+}	0^{+}	0
135	61	25.44	–	0.274	−0.006	(1.5^{+})	(1.5^{+})	0
135	62	16.90	–	0.303	−0.008	(3.5^{+})	$(2.5^{+\#})$	2
135	63	12.21	–	0.33	0.016	$5.5^{-}\#$	$2.5^{+}\#$	3
135	64	9.15	–	0.332	−0.018	1.5^{-}	$2.5^{+}\#$	1
136	61	34.27	–	0.237	−0.012	(5^{-})	(2^{+})	3
136	62	20.17	–	0.349	−0.002	0^{+}	0^{+}	0
136	63	11.67	–	0.331	0.007	(7^{+})	(3^{+})	4
136	64	5.32	–	0.323	−0.012	0^{+}	0^{+}	0
136	65	4.29	–	0.332	−0.019			0
137	61	36.08	–	0.218	−0.015	$2.5^{+}\#$	(1.5^{+})	2
137	62	28.51	–	0.237	−0.02	(4.5^{-})	(3.5^{+})	1
137	63	14.10	–	0.321	0.013	$5.5^{-}\#$	(1.5^{+})	5
137	64	8.15	–	0.323	−0.013	$3.5^{+}\#$	(2.5^{+})	2
137	65	5.77	–	0.323	−0.021	$5.5^{-}\#$	$5.5^{-}\#$	0
138	62	29.17	–	0.249	−0.023	0^{+}	0^{+}	0
138	63	18.18	–	0.321	0.022	(6^{-})	(5^{+})	1
138	64	8.83	–	0.366	−0.006	0^{+}	0^{+}	0
138	65	6.48	–	0.323	−0.013			0
138	66	3.77	–	0.324	−0.038	0^{+}	0^{+}	0
139	63	24.40	–	0.31	0.027	$(5.5)^{-}$	(1.5^{+})	5
139	64	15.31	–	0.303	−0.008	$4.5^{-}\#$	(3.5^{+})	1
139	65	7.62	–	0.323	−0.012	$5.5^{-}\#$	$5.5^{-}\#$	0
139	66	7.33	–	0.313	−0.032	$3.5^{+}\#$	1.5^{-}	3
140	63	31.99	–	0.218	−0.024	1^{+}	(5^{-})	5
140	64	16.29	–	0.293	−0.021	0^{+}	0^{+}	0
140	65	9.76	–	0.312	−0.006	5	(7^{+})	0
140	66	6.59	–	0.304	−0.034	0^{+}	0^{+}	0
140	67	4.72	–	0.314	−0.04	$8^{+}\#$		0
141	63	30.71	–	0.19	−0.028	2.5^{+}	$2.5^{+}\#$	0
141	64	22.55	–	0.218	−0.032	(0.5^{+})	(4.5^{-})	5
141	65	12.75	–	0.303	−0.008	(2.5^{-})	$5.5^{-}\#$	4
141	66	11.58	–	0.295	−0.037	(4.5^{-})	$3.5^{+}\#$	1
141	67	4.81	–	0.314	−0.04	(3.5^{-})	$5.5^{-}\#$	2
142	58	35.87	–	0.093	0	0^{+}	0^{+}	0
142	64	23.59	–	0.208	−0.037	0^{+}	0^{+}	0
142	65	25.09	–	0.218	−0.032	1^{+}	(6^{-})	5
142	66	9.73	–	0.256	−0.036	0^{+}	0^{+}	0
142	67	8.13	–	0.304	−0.034	(6)		0
143	59	25.99	–	0	0	3.5^{+}	3.5^{+}	0
143	64	31.99	–	0.163	−0.04	$(0.5)^{+}$	0.5^{+}	0
143	65	18.39	–	0.209	−0.034	(5.5^{-})	$(5.5)^{-}$	0
143	66	19.00	–	0.219	−0.041	(0.5^{+})	$4.5^{-}\#$	5
143	67	10.11	–	0.294	−0.028	$5.5^{-}\#$	$5.5^{-}\#$	0
143	68	9.47	–	0.286	−0.063	$4.5^{-}\#$	$3.5^{+}\#$	1

Table 1 (*continued*)

A_p	Z_p	$\mathscr{T}^{\text{theor}}$	$\mathscr{T}^{\text{exp}}$	β_2	β_4	j^{π}_{p}	j^{π}_{d}	l_{min}
144	60	23.44	22.86	0	0	0^+	0^+	0
144	65	23.69	–	0.171	−0.039	1^+	1^+	0
144	66	15.97	–	0.21	−0.043	0^+	0^+	0
144	67	16.40	–	0.228	−0.04		5	0
144	68	10.18	–	0.267	−0.05	0^+	0^+	0
145	60	31.25	–	−0.035	0.009	3.5^-	3.5^-	0
145	61	17.92	17.30	0	0	2.5^+	2.5^+	0
145	65	35.05	–	−0.156	−0.022	(1.5^+)	2.5^+	2
145	66	19.56	–	−0.164	−0.036	(0.5^+)	(0.5^+)	0
145	67	15.74	–	0.219	−0.042	(5.5^-)	(2.5^-)	4
145	68	16.03	–	0.228	−0.047	$0.5^+\#$	(4.5^-)	5
145	69	7.00	–	0.286	−0.063	(5.5^-)	(3.5^-)	2
146	61	25.17	–	−0.035	0.009	3^-	2^-	2
146	62	15.63	15.51	0.092	0	0^+	0^+	0
146	63	35.50	–	0.045	−0.008	4^-	1^+	3
146	66	27.55	–	−0.156	−0.029	0^+	0^+	0
146	67	16.20	–	−0.182	−0.026	(10^+)	1^+	10
146	68	17.01	–	0.219	−0.049	0^+	0^+	0
146	69	9.29	–	0.248	−0.062	(6^-)	(6)	0
147	61	31.45	–	0	0	3.5^+	3.5^+	0
147	62	19.20	18.52	−0.035	0.009	3.5^-	3.5^-	0
147	63	11.52	10.98	0	0	2.5^+	2.5^+	0
147	64	33.71	–	−0.053	−0.007	3.5^-	1.5^+	3
147	66	36.40	–	−0.156	−0.045	0.5^+	$(0.5)^+$	0
147	67	25.42	–	−0.164	−0.028	(5.5^-)	(5.5^-)	0
147	68	16.97	–	−0.173	−0.035	(0.5^+)	(0.5^+)	0
147	69	11.41	–	0.238	−0.055	5.5^-	$5.5^-\#$	0
148	61	35.50	–	0.143	0.066	1^-	0^-	2
148	62	23.75	23.34	0	0	0^+	0^+	0
148	63	14.96	14.70	−0.035	0.009	5^-	5^-	0
148	64	9.36	9.37	0.087	0	0^+	0^+	0
148	65	18.80	–	−0.061	−0.007	2^-	1^+	1
148	67	30.23	–	−0.156	−0.045	(1^+)	1^+	0
148	68	20.72	–	−0.164	−0.028	0^+	0^+	0
148	69	10.94	–	−0.19	−0.032	(10^+)		0
148	70	6.74	–	0.22	−0.066	0^+	0^+	0
149	62	26.55	–	0.134	0.064	3.5^-	3.5^-	0
149	63	18.42	–	0	0	2.5^+	2.5^+	0
149	64	11.55	13.27	−0.035	0.009	3.5^-	3.5^-	0
149	65	4.36	4.97	0	0	0.5^+	2.5^+	2
149	66	18.43	–	−0.053	−0.007	$3.5^{(-)}$	0.5^+	3
149	67	36.08	–	−0.148	−0.03	(5.5^-)	(1.5^+)	5
149	68	27.45	–	−0.156	−0.045	(0.5^+)	(0.5^+)	0
149	69	19.04	–	−0.182	−0.034	(5.5^-)	(5.5^-)	0
149	70	9.59	–	−0.19	−0.04	(0.5^+)	$0.5^+\#$	0
150	62	35.99	–	0.152	0.068	0^+	0^+	0
150	63	21.09	–	0.153	0.058	$5^{(-)}$	3^-	2
150	64	13.86	13.75	0	0	0^+	0^+	0
150	65	8.13	–	−0.044	0.009	(2^-)	4^-	2
150	66	2.81	3.08	0	0	0^+	0^+	0
150	67	12.63	–	−0.07	−0.006	2^-	1^+	1
150	68	24.31	–	0	0	0^+	0^+	0
150	69	24.42	–	−0.164	−0.036	(1^+)	(10^+)	10
150	70	10.72	–	−0.173	−0.035	0^+	0^+	0
150	71	9.09	–	−0.199	−0.038	(5^-)	(6^-)	2
151	63	25.55	26.20	0.161	0.059	2.5^+	3.5^+	2
151	64	16.28	15.03	0.143	0.056	3.5^-	3.5^-	0
151	65	8.54	8.82	0	0	$0.5^{(+)}$	2.5^+	2
151	66	4.55	4.28	0.116	0.009	$3.5^{(-)}$	3.5^-	0
151	67	4.29	–	−0.008	0	$5.5^{(-)}$	$0.5^+\#$	5
151	68	12.83	–	−0.061	−0.007	(3.5^-)	0.5^+	3
151	69	20.20	–	−0.156	−0.029	(5.5^-)	(5.5^-)	0
151	70	15.85	–	−0.164	−0.044	(0.5^+)	(0.5^+)	0
151	71	10.12	–	−0.19	−0.04	(5.5^-)	5.5^-	0
152	63	34.80	–	0.189	0.072	3^-	1^-	2
152	64	21.90	21.53	0.142	0.059	0^+	0^+	0
152	65	11.93	–	0.153	0.058	2^-	5^-	4
152	66	6.93	6.93	0	0	0^+	0^+	0
152	67	2.92	3.13	−0.052	0.009	2^-	2^-	0
152	68	0.79	1.06	0	0	0^+	0^+	0
152	69	10.50	–	−0.079	−0.006	$(2\#)^-$	(1^+)	1
152	70	17.12	–	−0.156	−0.037	0^+	0^+	0
152	71	15.55	–	−0.173	−0.043	(5^-)	(10^+)	5
153	64	29.51	–	0.18	0.062	1.5^-	3.5^-	2
153	65	16.16	–	0.17	0.051	2.5^+	2.5^+	0
153	66	8.89	8.39	0.134	0.047	$3.5^{(-)}$	3.5^-	0
153	67	8.24	–	−0.044	0.009	5.5^-	0.5^+	5
153	68	2.18	1.85	−0.044	0.009	$3.5^{(-)}$	$3.5^{(-)}$	0
153	69	0.20	0.21	−0.008	0	(5.5^-)	(5.5^-)	0
153	70	8.41	–	−0.079	−0.013	3.5^{-c}	(0.5^+)	3
153	71	15.09	–	−0.156	−0.037	5.5^-	(5.5^-)	0
153	72	10.90	–	−0.164	−0.044	$0.5^+\#$	(0.5^+)	0
154	65	25.53	–	0.188	0.063	$0^{(+\#)}$	$5^{(-)}$	5
154	66	13.86	13.98	0.161	0.05	0^+	0^+	0
154	67	5.87	6.57	0.143	0.048	2^-	(2^-)	0
154	68	4.43	4.68	0	0	0^+	0^+	0
154	69	0.97	–	−0.052	0.009	(2^-)	2^-	0
154	70	−0.64	−0.36	−0.008	0	0^+	0^+	0
154	71	6.49	–	−0.079	−0.013	(2^-)	(1^+)	1
154	72	11.97	–	−0.156	−0.037	0^+	0^+	0
155	66	18.49	–	0.179	0.053	1.5^-	3.5^-	2
155	67	12.87	–	0.161	0.043	2.5^+	$0.5^{(+)}$	2
155	68	6.14	6.16	0.125	0.039	3.5^-	$3.5^{(-)}$	0
155	69	3.78	3.06	−0.035	0	5.5^{-c}	$5.5^{(-)}$	0
155	70	0.46	0.30	−0.052	0.009	(3.5^-)	(3.5^-)	0
155	71	−1.22	–	0	0	5.5^{-c}	(5.5^-)	0
155	72	5.17	–	−0.07	−0.013	$3.5^-\#$	(0.5^+)	3
155	73	8.76	–	−0.156	−0.045	(5.5^-)	(5.5^-)	0
156	66	32.31	–	0.206	0.05	0^+	0^+	0
156	67	15.23	–	0.188	0.047	4^-	2^-	2
156	68	10.29	–	0.097	0.041	0^+	0^+	0
156	69	5.18	5.12	0.153	0.038	2^-	2^-	0
156	70	2.61	2.42	−0.018	0	0^+	0^+	0
156	71	−0.27	–	−0.052	0.009	$(2)^-$	$(2\#)^-$	0
156	72	−2.00	−1.63	0	0	0^+	0^+	0
156	73	3.00	–	−0.079	−0.013	(2^-)	(5^-)	4
157	67	29.17	–	0.216	0.043	3.5^-	2.5^+	1
157	68	12.52	–	0.17	0.044	1.5^-	$3.5^{(-)}$	2
157	69	10.46	–	0.152	0.041	0.5^+	5.5^-	5
157	70	4.27	3.89	0.107	0.037	3.5^-	$3.5^{(-)}$	0
157	71	4.40	–	−0.018	0	(0.5^+)	(5.5^-)	5
157	72	−0.88	−0.91	−0.052	0.009	3.5^-	3.5^{-c}	0
157	73	−0.16	–	0.008	0.008	0.5^+	5.5^-	5
158	68	18.51	–	0.237	0.041	0^+	0^+	0
158	69	10.89	–	−0.122	0.044	2^-	2^-	0
158	70	6.36	6.63	0.143	0.04	0^+	0^+	0
158	71	3.80	–	0.116	0.029	2^-	(2^-)	0
158	72	0.69	0.81	−0.008	0	0^+	0^+	0
158	73	−1.46	–	−0.053	0.001	(2^-)	(2^-)	0
158	74	−3.19	–	0.008	0	0^+	0^+	0
159	68	26.65	–	0.216	0.051	1.5^-	1.5^-	0
159	69	15.36	–	0.216	0.027	2.5^+	2.5^+	0
159	70	8.62	–	0.161	0.043	$2.5^{(-)}$	3.5^-	2
159	71	7.61	–	0.143	0.032	$0.5^+\#$	5.5^{-c}	5
159	72	1.93	–	−0.096	0.019	3.5^{-c}	(3.5^-)	0
159	73	2.48	0.11	0.035	0	(0.5^+)	5.5^{-c}	5
159	74	−2.08	−2.09	−0.053	0.001	$3.5^-\#$	$3.5^-\#$	0
160	68	27.97	–	0.293	0.046	0^+	0^+	0
160	69	20.90	–	0.216	0.034	1^-	4^-	4
160	70	10.40	–	0.189	0.03	0^+	0^+	0
160	71	7.66	–	0.161	0.034	$2^-\#$	2^-	0
160	72	3.20	2.77	0.125	0.03	0^+	0^+	0
160	73	1.28	–	−0.104	0.012	$(2\#)^-$	$(2)^-$	0
160	74	−1.25	−0.99	0.035	−0.008	0^+	0^+	0
160	75	−2.68	−2.02	−0.053	0.001	(2^-)	(2^-)	0
161	68	33.98	–	0.252	0.065	1.5^-	1.5^-	0
161	69	23.79	–	0.235	0.03	3.5^+	3.5^-	1
161	70	15.26	–	0.207	0.041	1.5^-	1.5^-	0
161	71	10.59	–	0.189	0.022	0.5^+	0.5^+	0
161	72	5.01	–	0.152	0.033	$1.5^-\#$	3.5^-	2
161	73	1.93	–	0.125	0.021	$0.5^+\#$	(0.5^+)	0
161	74	0.14	–	0.089	0.011	$3.5^-\#$	3.5^-	0
161	75	−1.55	–	0.045	0.001	0.5^+	0.5^+	0
162	68	36.80	–	0.326	0.06	0^+	0^+	0
162	69	28.11	–	0.172	0.04	1^-	5^+	5
162	70	15.58	–	0.255	0.034	0^+	0^+	0
162	71	13.23	–	0.207	0.032	$1^{(-)}$	2^-	2
162	72	5.86	5.80	0.194	0.034	0^+	0^+	0
162	73	5.51	3.68	0.152	0.033	$3^+\#$	2^-	1
162	74	0.50	0.46	0.107	0.02	0^+	0^+	0
162	75	−0.81	−0.96	0.089	0.003	(2^-)	(2^-)	0
162	76	−2.95	−2.73	0.018	0	0^+	0^+	0
163	69	29.07	–	0.263	0.035	0.5^+	3.5^-	3

(*continued on next page*)

Table 1 (*continued*)

A_p	Z_p	$\mathscr{T}^{\text{theor}}$	$\mathscr{T}^{\text{exp}}$	β_2	β_4	j_{p}^{π}	j_{d}^{π}	$l_{\min}$
163	70	18.59	—	0.235	0.046	1.5^-	1.5^-	0
163	71	13.83	—	0.217	0.018	$0.5^{(+)}$	2.5^+	2
163	72	8.50	—	0.189	0.029	$1.5^-\#$	$2.5^{(-)}$	2
163	73	4.91	—	0.161	0.026	$0.5^+\#$	$0.5^+\#$	0
163	74	1.90	0.83	0.134	0.031	$1.5^-\#$	3.5^{-c}	2
163	75	−0.09	−0.22	0.107	0.012	(0.5^+)	(0.5^+)	0
163	76	−1.87	—	0.08	0.002	$3.5^-\#$	$3.5^-\#$	0
164	69	29.33	—	0.272	0.044	1^+	5^+	4
164	70	20.65	—	0.304	0.04	0^+	0^+	0
164	71	15.01	—	0.225	0.028	$1^{(-)}$	1^-	0
164	72	9.20	—	0.23	0.016	0^+	0^+	0
164	73	7.99	—	0.18	0.021	(3^+)	$2^-\#$	1
164	74	2.29	2.38	0.152	0.024	0^+	0^+	0
164	75	0.89	—	0.134	0.022		$(2\#)^-$	0
164	76	−1.75	—	0.089	0.003	0^+	0^+	0
164	77	−2.49	—	0.08	0.002	$2^-\#$	(2^-)	0
165	69	35.68	—	0.272	0.037	0.5^+	3.5^-	3
165	70	23.06	—	0.263	0.051	2.5^-	1.5^-	2
165	71	17.26	—	0.254	0.008	0.5^+	3.5^+	4
165	72	11.02	—	0.216	0.026	(2.5^-)	1.5^-	2
165	73	9.73	—	0.198	0.015	$2.5^-\#$	0.5^+	3
165	74	4.16	—	0.161	0.018	$1.5^-\#$	$1.5^-\#$	0
165	75	1.43	—	0.143	0.016	$0.5^+\#$	$0.5^+\#$	0
165	76	−0.62	—	0.116	0.02	(3.5^-)	$3.5^-\#$	0
165	77	−2.21	—	0.08	−0.006	$0.5^+\#$	0.5^+	0
166	69	36.62	—	0.272	0.037	2^+	1^+	2
166	70	24.72	—	0.322	0.037	0^+	0^+	0
166	71	17.66	—	0.264	0.017	$6^{(-)}$	1^-	6
166	72	12.13	—	0.263	0.019	0^+	0^+	0
166	73	9.45	—	0.217	0.009	$(2)^+$	$1^{(-)}$	1
166	74	4.48	4.74	0.158	0.012	0^+	0^+	0
166	75	4.09	—	0.161	0.01	$2^-\#$	$3^+\#$	1
166	76	−0.51	−0.52	0.134	0.015	0^+	0^+	0
166	77	−1.66	−1.95	0.116	0.013	(2^-)	(2^-)	0
166	78	−3.84	—	0.045	−0.008	0^+	0^+	0
167	70	28.52	—	0.272	0.037	2.5^-	2.5^-	0
167	71	19.77	—	0.274	0.003	3.5^+	0.5^+	4
167	72	14.11	—	0.244	0.031	$(2.5)^-$	1.5^-	2
167	73	9.63	—	0.217	0.002	(1.5^+)	$0.5^{(+)}$	2
167	74	5.50	—	0.198	0.015	$1.5^-\#$	$1.5^-\#$	0
167	75	5.45	—	0.17	0.002	$4.5^-\#$	$0.5^+\#$	5
167	76	0.72	—	0.153	0.008	$1.5^-\#$	$1.5^-\#$	0
167	77	−1.09	—	0.125	0.006	0.5^+	(0.5^+)	0
167	78	−2.61	—	0.089	0.003	$3.5^-\#$	$3.5^-\#$	0
168	70	31.74	—	0.333	0.02	0^+	0^+	0
168	71	27.60	—	0.273	0.012	$6^{(-)}$	1^+	5
168	72	14.97	—	0.29	0.01	0^+	0^+	0
168	73	11.25	—	0.226	0.003	(2^-)	$1^{(-)}$	2
168	74	6.46	—	0.197	0.008	0^+	0^+	0
168	75	4.45	—	0.189	−0.002	(5^+)	(3^+)	2
168	76	0.77	0.62	0.161	0.01	0^+	0^+	0
168	77	−0.84	—	0.143	0.007			0
168	78	−2.73	−2.70	0.107	−0.004	0^+	0^+	0
169	71	24.96	—	0.274	−0.005	3.5^+	0.5^+	4
169	72	16.57	—	0.273	0.019	$(2.5)^-$	2.5^-	0
169	73	11.79	—	0.245	−0.002	(2.5^+)	0.5^+	2
169	74	8.43	—	0.217	0.009	(2.5^-)	(2.5^-)	0
169	75	4.36	—	0.199	−0.01	$4.5^-\#$	$2.5^-\#$	2
169	76	1.83	1.59	0.17	0.002	$1.5^-\#$	$1.5^-\#$	0
169	77	0.22	−0.11	0.153	0	$0.5^+\#$	$0.5^+\#$	0
169	78	−1.52	—	0.125	0.006	$1.5^-\#$	(3.5^-)	2
169	79	−3.33	—	0.099	−0.012	$0.5^+\#$	$0.5^+\#$	0
170	70	36.63	—	0.342	0.006	0^+	0^+	0
170	71	29.47	—	0.283	−0.003	0^+	2^+	2
170	72	18.49	—	0.315	0.003	0^+	0^+	0
170	73	16.20	—	0.254	0.008	$(3^{+\#})$	$6^{(-)}$	3
170	74	8.77	—	0.25	0.003	0^+	0^+	0
170	75	6.32	—	0.217	0.002	(5^+)	$(2)^+$	4
170	76	1.98	1.79	0.181	−0.004	0^+	0^+	0
170	77	0.56	0.08	0.162	−0.006		$2^-\#$	0
170	78	−1.78	−1.85	0.134	−0.002	0^+	0^+	0
170	79	−2.39	−2.55	0.107	−0.004	(2^-)	(2^-)	0
171	71	27.23	—	0.284	−0.01	3.5^+	0.5^+	4
171	72	23.23	—	0.274	0.004	$3.5^{(+)}$	2.5^-	1
171	73	16.81	—	0.274	−0.013	(2.5^-)	3.5^+	1
171	74	10.74	—	0.245	0.014	(2.5^-)	$(2.5)^-$	0
171	75	8.31	—	0.217	−0.007	(4.5^-)	(1.5^+)	3
171	76	3.47	2.69	0.198	−0.001	(2.5^-)	$1.5^-\#$	2
171	77	3.14	—	0.162	−0.006	$0.5^+\#$	$4.5^-\#$	5
171	78	−0.81	−1.35	0.153	0	$1.5^-\#$	$1.5^-\#$	0
171	79	−2.31	—	0.116	−0.011	(0.5^+)	0.5^+	0
171	80	−3.45	—	−0.087	−0.012	$1.5^-\#$	$3.5^-\#$	2
172	71	31.30	—	0.294	−0.007	4^-	3^+	1
172	72	20.50	—	0.322	−0.01	0^+	0^+	0
172	73	17.63	—	0.274	−0.013	(3^+)	$6^{(-)}$	3
172	74	10.97	—	0.275	−0.001	0^+	0^+	0
172	75	7.86	—	0.226	−0.006	(5)	(2^-)	0
172	76	3.38	3.98	0.232	0	0^+	0^+	0
172	77	1.70	—	0.181	−0.012	(3^+)	(5^+)	2
172	78	−0.94	—	0.162	−0.006	0^+	0^+	0
172	79	−1.97	—	0.134	−0.009			0
172	80	−3.92	—	−0.096	−0.005	0^+	0^+	0
173	71	33.14	—	0.331	−0.024	3.5^+	0.5^+	4
173	72	26.18	—	0.294	−0.008	0.5^-	3.5^+	3
173	73	17.75	—	0.284	−0.02	2.5^-	3.5^+	1
173	74	13.91	—	0.274	0.003	2.5^-	$(2.5)^-$	0
173	75	10.41	—	0.236	−0.004	(2.5^-)	(2.5^+)	1
173	76	4.93	5.03	0.217	0.002	(2.5^-)	(2.5^-)	0
173	77	4.10	—	0.19	−0.02	(1.5^+)	$4.5^-\#$	3
173	78	0.18	−0.36	0.162	−0.006	$2.5^-\#$	$1.5^-\#$	2
173	79	−1.48	—	0.134	−0.009	(0.5^+)	$0.5^+\#$	0
173	80	−2.57	—	0.107	0.004	$1.5^-\#$	$1.5^-\#$	0
174	71	36.87	—	0.295	−0.024	1^-	1^-	0
174	72	23.97	22.80	0.326	−0.025	0^+	0^+	0
174	73	17.52	—	0.294	−0.017	3^+	0^+	4
174	74	12.86	—	0.301	−0.005	0^+	0^+	0
174	75	10.62	—	0.254	−0.001		$(3^{+\#})$	0
174	76	5.27	5.34	0.24	−0.006	0^+	0^+	0
174	77	2.64	—	0.199	−0.019	(3^+)	(5^+)	2
174	78	0.12	0.03	0.171	−0.014	0^+	0^+	0
174	79	−0.82	−0.81	0.153	−0.007			0
174	80	−2.73	−2.70	0.107	−0.004	0^+	0^+	0
175	72	26.24	—	0.295	−0.024	2.5^-	0.5^-	2
175	73	18.65	—	0.285	−0.035	3.5^+	3.5^+	0
175	74	17.70	—	0.284	−0.01	(0.5^-)	$3.5^{(+)}$	3
175	75	10.68	—	0.255	−0.009	(2.5^-)	(2.5^-)	0
175	76	7.76	—	0.245	0.006	(2.5^-)	(2.5^-)	0
175	77	3.52	3.02	0.209	−0.017	(2.5^-)	(4.5^-)	2
175	78	0.82	1.73	0.19	−0.011	3.5^{-c}	(2.5^-)	2
175	79	−0.54	—	0.153	−0.016	$0.5^+\#$	$0.5^+\#$	0
175	80	−1.44	−1.96	0.126	−0.003	$2.5^-\#$	$1.5^-\#$	2
176	72	27.83	—	0.33	−0.04	0^+	0^+	0
176	73	19.76	—	0.295	−0.033	$(1)^-$	4^-	4
176	74	15.43	—	0.276	−0.019	0^+	0^+	0
176	75	12.10	—	0.274	−0.013	3^+	(3^+)	0
176	76	6.90	—	0.284	−0.001	0^+	0^+	0
176	77	4.40	2.60	0.218	−0.016		(5)	0
176	78	1.26	1.22	0.225	−0.011	0^+	0^+	0
176	79	1.65	—	0.162	−0.015	(5^-)	(3^+)	3
176	80	−1.63	−1.69	0.126	−0.01	0^+	0^+	0
176	81	−2.68	—	−0.105	−0.011			0
177	72	28.95	—	0.297	−0.049	3.5^-	2.5^-	2
177	73	21.89	—	0.286	−0.052	3.5^+	3.5^+	0
177	74	16.52	—	0.295	−0.025	0.5^-	0.5^-	0
177	75	13.08	—	0.275	−0.021	2.5^-	2.5^-	0
177	76	9.13	—	0.265	−0.007	0.5^-	2.5^-	2
177	77	5.02	4.70	0.218	−0.023	2.5^-	(2.5^-)	0
177	78	2.96	2.33	0.226	0.003	2.5^-	(2.5^-)	0
177	79	0.55	—	0.162	−0.023	(0.5^+)	(1.5^+)	2
177	80	−0.45	−0.82	0.153	0	$2.5^-\#$	$2.5^-\#$	0
177	81	−1.74	−1.61	−0.105	−0.011	(0.5^+)	(0.5^+)	0
178	72	31.14	—	0.325	−0.059	0^+	0^+	0
178	73	25.19	—	0.286	−0.052	1^+	1^-	1
178	74	18.97	—	0.286	−0.035	0^+	0^+	0
178	75	13.58	—	0.285	−0.028	(3^+)	3^+	0
178	76	9.11	—	0.251	−0.014	0^+	0^+	0
178	77	5.59	—	0.246	−0.011			0
178	78	2.56	2.45	0.266	−0.006	0^+	0^+	0
178	79	1.37	—	0.171	−0.022		(3^+)	0
178	80	−0.50	—	0.153	−0.007	0^+	0^+	0
178	81	−1.48	—	−0.122	−0.01			0
178	82	−4.03	—	−0.105	−0.027	0^+	0^+	0
179	73	27.13	—	0.287	−0.069	3.5^+	3.5^+	0
179	74	22.84	—	0.286	−0.043	$(3.5)^-$	2.5^-	2

Table 1 (*continued*)

A_p	Z_p	$\mathscr{T}^{\rm theor}$	$\mathscr{T}^{\rm exp}$	β_2	β_4	$j_{\rm p}^{\pi}$	$j_{\rm d}^{\pi}$	$l_{\rm min}$
179	75	15.99	—	0.276	−0.046	$(2.5)^{+}$	3.5^{+}	2
179	76	10.13	—	0.284	−0.019	(0.5^{-})	(0.5^{-})	0
179	77	6.64	—	0.238	−0.029	$(2.5)^{-}$	(2.5^{-})	0
179	78	4.02	—	0.254	0.008	0.5^{-}	(2.5^{-})	2
179	79	1.43	—	0.171	−0.022	$2.5^{-}\#$	(2.5^{-})	0
179	80	1.07	—	0.18	0.004	$2.5^{-}\#$	3.5^{-c}	2
179	81	−0.55	−0.57	−0.122	−0.01	(0.5^{+})	$0.5^{+}\#$	0
179	82	−2.71	—	−0.105	−0.019	$2.5^{-}\#$	$2.5^{-}\#$	0
180	73	36.75	—	0.278	−0.071	1^{+}	7^{-}	7
180	74	25.60	25.75	0.295	−0.062	0^{+}	0^{+}	0
180	75	19.14	—	0.277	−0.045	$(1)^{-}$	$(1)^{-}$	0
180	76	12.10	—	0.266	−0.032	0^{+}	0^{+}	0
180	77	7.65	—	0.247	−0.027	$(4^{+\#})$	3^{+}	2
180	78	4.27	4.24	0.246	−0.011	0^{+}	0^{+}	0
180	79	2.33	—	0.254	0.008			0
180	80	0.67	0.73	0.19	−0.005	0^{+}	0^{+}	0
180	81	−0.42	—	−0.13	−0.009		(5^{-})	0
180	82	−2.88	—	−0.105	−0.027	0^{+}	0^{+}	0
181	74	32.59	—	−0.254	−0.062	4.5^{+}	3.5^{-}	1
181	75	22.94	—	0.277	−0.063	2.5^{+}	3.5^{+}	2
181	76	13.80	—	0.276	−0.037	0.5^{-}	0.5^{-}	0
181	77	9.28	—	0.238	−0.037	$(2.5)^{-}$	2.5^{-}	0
181	78	5.34	4.86	0.255	−0.016	0.5^{-}	0.5^{-}	0
181	79	2.82	3.39	0.181	−0.028	(1.5^{-})	2.5^{-}	2
181	80	1.02	—	0.264	0.018	0.5^{-a}	2.5^{-}	2
181	81	0.93	—	−0.13	−0.009	$0.5^{+}\#$	(0.5^{+})	0
181	82	−1.59	—	−0.105	−0.019	$2.5^{-}\#$	$2.5^{-}\#$	0
182	75	25.92	—	0.277	−0.063	7^{+}	1^{+}	6
182	76	16.41	—	0.267	−0.048	0^{+}	0^{+}	0
182	77	10.82	—	0.247	−0.043	(3^{+})	(3^{+})	0
182	78	5.83	—	0.247	−0.027	0^{+}	0^{+}	0
182	79	3.78	—	0.265	−0.007	(2^{+})		0
182	80	1.58	1.86	0.254	0.008	0^{+}	0^{+}	0
182	81	0.13	—	−0.139	−0.008	$2^{-}\#$		0
182	82	−1.76	—	−0.113	−0.026	0^{+}	0^{+}	0
183	75	33.62	—	0.268	−0.074	2.5^{+}	3.5^{+}	2
183	76	20.59	—	0.268	−0.057	4.5^{+}	$(3.5)^{-}$	1
183	77	14.13	—	0.239	−0.053	2.5^{-}	$(2.5)^{+}$	1
183	78	7.19	7.48	0.256	−0.034	0.5^{-}	(0.5^{-})	0
183	79	3.95	4.15	0.246	−0.019	2.5^{-}	$(2.5)^{-}$	0
183	80	1.96	1.95	0.274	0.003	0.5^{-}	0.5^{-}	0
183	81	4.54	—	−0.139	−0.008	$0.5^{+}\#$	$2.5^{-}\#$	3
183	82	−0.58	—	−0.122	−0.018	(1.5^{-})	$2.5^{-}\#$	2
184	75	32.80	—	0.269	−0.082	$3^{(-)}$	1^{+}	3
184	76	21.06	—	0.254	−0.067	0^{+}	0^{+}	0
184	77	14.07	—	0.248	−0.06	5^{-}	$(1)^{-}$	4
184	78	7.98	—	0.226	−0.045	0^{+}	0^{+}	0
184	79	5.38	—	0.256	−0.026	5^{+}	$(4^{+\#})$	2
184	80	3.11	3.44	0.256	−0.007	0^{+}	0^{+}	0
184	81	1.17	—	−0.148	−0.007	$2^{-}\#$		0
184	82	−0.76	—	−0.122	−0.026	0^{+}	0^{+}	0
184	83	−3.72	—	−0.053	−0.007	$3^{+}\#$		0
185	75	32.31	—	0.269	−0.09	2.5^{+}	3.5^{+}	2
185	76	23.32	—	0.258	−0.075	0.5^{-}	4.5^{+}	5
185	77	15.87	—	0.24	−0.07	2.5^{-}	2.5^{+}	1
185	78	11.88	—	0.248	−0.052	(4.5^{+})	0.5^{-}	5
185	79	5.44	4.99	0.238	−0.038	2.5^{-}	$(2.5)^{-}$	0
185	80	3.18	2.93	0.265	−0.015	0.5^{-}	0.5^{-}	0
185	81	5.52	—	−0.148	−0.007	$0.5^{+}\#$	(1.5^{-})	1
185	82	0.25	2.32	−0.122	−0.018	1.5^{-}	0.5^{-a}	2
185	83	−4.33	—	−0.053	−0.007	0.5^{+c}	$0.5^{+}\#$	0
186	75	34.78	—	0.259	−0.101	1^{-}	3^{-}	2
186	76	22.79	22.80	0.251	−0.084	0^{+}	0^{+}	0
186	77	13.40	—	0.24	−0.07	5^{+}	7^{+}	2
186	78	9.83	—	0.234	−0.062	0^{+}	0^{+}	0
186	79	8.94	—	0.256	−0.042	3^{-}	(3^{+})	1
186	80	5.45	5.71	0.255	−0.026	0^{+}	0^{+}	0
186	81	5.65	—	−0.156	−0.006	(2^{-})	(2^{+})	1
186	82	0.40	0.68	−0.122	−0.018	0^{+}	0^{+}	0
186	83	−1.09	—	−0.053	−0.007	(3^{+})	$2^{-}\#$	1
187	76	23.94	—	−0.305	−0.093	0.5^{-}	0.5^{-}	0
187	77	14.78	—	0.23	−0.08	1.5^{+}	2.5^{+}	2
187	78	11.05	—	0.24	−0.069	1.5^{-}	4.5^{+}	3
187	79	9.81	—	0.238	−0.054	0.5^{+}	2.5^{-}	3
187	80	6.02	—	0.256	−0.034	1.5^{-}	0.5^{-}	2
187	81	7.50	—	−0.156	−0.006	(0.5^{+})	2.5^{-}	3
187	82	1.39	—	−0.13	−0.017	(1.5^{-})	0.5^{-}	2
187	83	−1.03	—	−0.053	−0.007	$4.5^{-}\#$	$0.5^{+}\#$	5
188	76	33.76	—	0.236	−0.095	0^{+}	0^{+}	0
188	77	16.77	—	0.23	−0.089	1^{-}	$3^{(-)}$	2
188	78	12.17	12.53	0.213	−0.071	0^{+}	0^{+}	0
188	79	7.53	—	0.239	−0.063	$1^{(-)}$	5^{-}	4
188	80	8.46	8.72	0.224	−0.044	0^{+}	0^{+}	0
188	81	6.47	—	−0.156	−0.006	(2^{-})	5^{+}	3
188	82	2.22	2.06	0.16	−0.017	0^{+}	0^{+}	0
188	83	0.47	—	−0.053	−0.007	$3^{+}\#$	$2^{-}\#$	1
188	84	−3.91	—	0.009	−0.008	0^{+}	0^{+}	0
189	76	37.88	—	0.241	−0.105	1.5^{-}	1.5^{-}	0
189	77	22.48	—	0.221	−0.091	1.5^{+}	2.5^{+}	2
189	78	13.72	—	0.23	−0.08	1.5^{-}	0.5^{-}	2
189	79	12.75	—	0.211	−0.066	0.5^{+}	2.5^{-}	3
189	80	11.55	—	0.248	−0.052	1.5^{-}	(4.5^{+})	3
189	81	10.26	—	−0.156	−0.006	(0.5^{+})	2.5^{-}	3
189	82	3.63	—	−0.139	−0.016	(1.5^{-})	0.5^{-}	2
189	83	0.62	—	−0.053	−0.007	(4.5^{-})	$0.5^{+}\#$	5
189	84	−2.36	—	0.009	0.015	$1.5^{-}\#$	1.5^{-}	0
190	77	25.40	—	0.221	−0.099	4^{-}	1^{-}	4
190	78	19.22	19.31	0.2	−0.082	0^{+}	0^{+}	0
190	79	16.83	—	0.211	−0.074	1^{-}	5^{+}	5
190	80	13.03	—	0.198	−0.062	0^{+}	0^{+}	0
190	81	7.75	—	−0.156	−0.006	$2^{(-)}$	3^{-}	2
190	82	4.13	4.25	0.132	−0.025	0^{+}	0^{+}	0
190	83	1.85	—	−0.061	−0.007	(3^{+})	(2^{-})	1
190	84	−2.72	−2.59	0	−0.008	0^{+}	0^{+}	0
191	77	36.44	—	0.212	−0.1	1.5^{+}	2.5^{+}	2
191	78	21.69	—	0.212	−0.092	1.5^{-}	0.5^{-}	2
191	79	17.94	—	0.183	−0.07	1.5^{+}	1.5^{+}	0
191	80	16.81	—	0.229	−0.072	$1.5^{(-)}$	1.5^{-}	0
191	81	11.90	—	−0.156	−0.014	(0.5^{+})	0.5^{+}	0
191	82	5.64	—	−0.139	−0.024	(1.5^{-})	1.5^{-}	0
191	83	2.39	2.85	−0.053	−0.007	(4.5^{-})	(0.5^{+})	5
191	84	−1.41	—	0	−0.015	$1.5^{-}\#$	(1.5^{-})	0
192	78	30.62	—	0.186	−0.086	0^{+}	0^{+}	0
192	79	21.98	—	0.173	−0.071	1^{-}	1^{-}	0
192	80	19.33	—	0.186	−0.013	0^{+}	0^{+}	0
192	81	14.48	—	−0.156	−0.022	(2^{-})	$1^{(-)}$	2
192	82	6.23	6.57	−0.13	−0.025	0^{+}	0^{+}	0
192	83	3.76	—	−0.061	−0.007	(3^{+})	(2^{-})	1
192	84	−1.52	−1.48	0	−0.008	0^{+}	0^{+}	0
193	78	37.81	—	0.148	−0.087	0.5^{-}	1.5^{-}	2
193	79	28.43	—	0.164	−0.064	1.5^{+}	1.5^{+}	0
193	80	23.97	—	−0.164	−0.021	1.5^{-}	1.5^{-}	0
193	81	15.67	—	−0.148	−0.023	$0.5^{(+\#)}$	0.5^{+}	0
193	82	8.40	—	0.148	−0.031	(1.5^{-})	1.5^{-}	0
193	83	4.29	4.50	−0.053	−0.007	(4.5^{-})	(0.5^{+})	5
193	84	−0.12	—	0	−0.008	$1.5^{-}\#$	(1.5^{-})	0
193	85	−1.48	—	−0.052	0.009	$4.5^{-}\#$	(4.5^{-})	0
194	80	27.94	—	0.149	−0.022	0^{+}	0^{+}	0
194	81	17.87	—	−0.156	−0.022	2^{-}	1^{-}	2
194	82	9.13	9.99	−0.13	−0.032	0^{+}	0^{+}	0
194	83	5.77	—	−0.061	−0.007	(3^{+})	$2^{(-)}$	1
194	84	−0.37	−0.38	0	−0.008	0^{+}	0^{+}	0
194	85	−0.63	—	−0.052	0.009	$3^{+}\#$	(3^{+})	0
195	80	35.57	—	−0.156	−0.029	0.5^{-}	1.5^{-}	2
195	81	21.90	—	−0.148	−0.03	0.5^{+}	1.5^{+}	2
195	82	11.66	—	−0.139	−0.031	$1.5\#^{-}$	$1.5^{(-)}$	0
195	83	6.42	6.79	−0.053	−0.007	(4.5^{-})	(0.5^{+})	5
195	84	1.23	0.79	−0.008	−0.015	$1.5^{-}\#$	(1.5^{-})	0
195	85	1.21	—	−0.052	0.009	0.5^{+c}	(4.5^{-})	5
195	86	−1.59	−2.22	0.275	−0.031	$1.5^{-}\#$	$1.5^{-}\#$	0
196	81	26.82	—	−0.148	−0.03	2^{-}	1^{-}	2
196	82	12.76	—	−0.13	−0.032	0^{+}	0^{+}	0
196	83	8.66	—	−0.044	−0.014	(3^{+})	(2^{-})	1
196	84	0.86	0.77	0	−0.008	0^{+}	0^{+}	0
196	85	−0.38	−0.57	−0.052	0.009	$3^{+}\#$	(3^{+})	0
196	86	−2.38	—	−0.207	0.008	0^{+}	0^{+}	0
197	81	29.76	—	−0.207	−0.031	0.5^{+}	1.5^{+}	2
197	82	16.39	—	−0.087	−0.04	1.5^{-}	1.5^{-}	0
197	83	9.70	—	−0.053	−0.007	(4.5^{-})	$0.5^{(+\#)}$	5
197	84	2.58	2.09	0	−0.015	(1.5^{-})	(1.5^{-})	0
197	85	−0.23	−0.44	−0.052	0.009	(4.5^{-})	(4.5^{-})	0
197	86	−1.13	—	−0.215	0.009	$1.5^{-}\#$	$1.5^{-}\#$	0
198	81	34.97	—	−0.148	−0.038	2^{-}	1^{-}	2

(*continued on next page*)

Table 1 (*continued*)

A_p	Z_p	$\mathscr{T}^{\text{theor}}$	$\mathscr{T}^{\text{exp}}$	β_2	β_4	j_{p}^{π}	j_{d}^{π}	$l_{\min}$
198	82	17.07	–	−0.13	−0.04	0^+	0^+	0
198	83	10.41	–	−0.053	−0.014	(2^+)	2^-	1
198	84	2.26	2.27	0	−0.008	0^+	0^+	0
198	85	0.72	0.64	−0.052	0.009	(3^+)	(3^+)	0
198	86	−1.11	−1.18	0.026	0.009	0^+	0^+	0
199	82	21.66	–	−0.112	−0.04	1.5^-	0.5^-	2
199	83	11.31	–	−0.053	−0.014	4.5^-	0.5^+	5
199	84	4.13	3.44	−0.026	−0.015	(1.5^-)	1.5#$^-$	0
199	85	0.97	0.90	−0.052	0.009	(4.5^-)	(4.5^-)	0
199	86	0.59	–	0.071	0.002	1.5^-#	1.5^-#	0
199	87	−2.32	–	−0.215	0.009	0.5^+#	0.5^{+c}	0
200	82	23.42	–	0.116	−0.032	0^+	0^+	0
200	83	12.92	–	−0.071	−0.014	7^+	2^-	5
200	84	3.71	3.66	0	−0.008	0^+	0^+	0
200	85	1.87	1.88	−0.052	0.009	(3^+)	(3^+)	0
200	86	0.02	–	0	0.015	0^+	0^+	0
200	87	−1.48	–	−0.207	0.001	3^+#	3^+#	0
201	82	27.68	–	−0.13	−0.039	2.5^-	0.5^-	2
201	83	14.75	–	−0.044	−0.014	4.5^-	0.5^+	5
201	84	5.11	4.77	0.019	−0.008	1.5^-	1.5^-	0
201	85	2.18	2.08	−0.052	0.009	(4.5^-)	(4.5^-)	0
201	86	1.53	0.95	0.062	0.001	(1.5^-)	(1.5^-)	0
201	87	−1.34	−1.21	−0.207	0.001	(4.5^-)	(4.5^-)	0
202	82	31.30	–	0.106	−0.032	0^+	0^+	0
202	83	15.83	–	−0.044	−0.014	$5^{(+\#)}$	2^-	3
202	84	5.05	5.13	0	−0.008	0^+	0^+	0
202	85	2.86	3.01	−0.052	0.009	$(2)^+$	(2^+)	0
202	86	1.34	–	0	−0.015	0^+	0^+	0
202	87	−0.73	–	−0.207	−0.007	(3^+)	(3^+)	0
202	88	−2.94	–	−0.215	0.002	0^+	0^+	0
203	82	36.18	–	−0.142	−0.032	2.5^-	0.5^-	2
203	83	17.87	–	−0.044	−0.014	4.5^-	0.5^+	5
203	84	6.83	8.30	0	−0.008	2.5^-	1.5^-	2
203	85	3.52	3.16	−0.044	0.009	4.5^-	4.5^-	0
203	86	2.53	1.83	0	−0.015	$(1.5)^-$	(1.5^-)	0
203	87	0.22	−0.24	0.08	0.002	4.5^-#	(4.5^-)	0
203	88	−1.39	–	−0.207	0.001	(1.5^-)	1.5^-#	0
204	83	19.22	–	−0.044	−0.014	6^+	2^-	5
204	84	6.27	6.28	−0.025	−0.008	0^+	0^+	0
204	85	4.32	4.15	−0.044	0.009	7^+	7^+	0
204	86	1.79	2.01	−0.106	−0.015	0^+	0^+	0
204	87	0.68	0.39	0.089	−0.006	(3^+)	(3^+)	0
204	88	−1.71	–	−0.207	−0.007	0^+	0^+	0
205	83	21.44	–	−0.044	−0.014	4.5^-	0.5^+	5
205	84	7.64	7.18	0	−0.008	2.5^-	2.5^-	0
205	85	4.36	4.20	−0.044	0.009	4.5^-	4.5^-	0
205	86	3.60	4.61	0	−0.015	2.5^-	1.5^-	2
205	87	0.92	0.59	0.071	−0.007	(4.5^-)	(4.5^-)	0
205	88	−0.55	−0.66	−0.199	−0.016	(1.5^-)	(1.5^-)	0
206	83	23.27	–	−0.044	−0.014	$6^{(+)}$	2^-	5
206	84	7.08	7.14	−0.022	−0.008	0^+	0^+	0
206	85	5.06	7.36	−0.009	0.001	$(5)^+$	$5^{(+\#)}$	0
206	86	2.85	2.74	0.009	−0.015	0^+	0^+	0
206	87	1.58	1.28	0.062	−0.007	(2^+)	$(2)^+$	0
206	88	−0.61	−0.62	−0.104	0.004	0^+	0^+	0
206	89	−1.80	−1.60	−0.207	−0.015	(3^+)	(3^+)	0
207	83	25.76	–	−0.035	−0.015	4.5^-	0.5^+	5
207	84	7.97	8.00	−0.068	−0.008	2.5^-	2.5^-	0
207	85	4.99	4.88	−0.035	0.009	4.5^-	4.5^-	0
207	86	4.09	3.43	0	−0.015	2.5^-	2.5^-	0
207	87	1.29	1.19	0.045	−0.008	4.5^-	4.5^-	0
207	88	0.50	0.42	−0.104	0.004	(1.5^-)	$(1.5)^-$	0
207	89	−1.61	–	−0.19	−0.018	4.5^-#	4.5^-#	0
208	83	28.55	–	−0.044	−0.023	$(5)^+$	2^-	3
208	84	7.36	–	0.041	−0.008	0^+	0^+	0
208	85	5.80	6.04	−0.044	0.009	6^+	6^+	0
208	86	3.01	3.37	−0.086	−0.015	0^+	0^+	0
208	87	1.94	1.82	−0.053	−0.007	7^+	7^+	0
208	88	−0.09	–	−0.087	0.003	0^+	0^+	0
208	89	−1.06	−1.01	−0.19	−0.024	(3^+)	(3^+)	0
209	81	29.26	–	0.008	0	(0.5^+)	1.5^+	2
209	83	27.08	26.78	0.067	−0.015	4.5^-	0.5^+	5
209	84	9.94	10.21	−0.028	−0.015	0.5^-	2.5^-	2
209	85	5.71	5.68	−0.035	−0.008	4.5^-	4.5^-	0
209	86	4.40	4.00	0.018	−0.015	2.5^-	2.5^-	0
209	87	1.78	1.75	0.035	−0.008	4.5^-	4.5^-	0
209	88	1.06	0.67	−0.079	0.002	2.5^-	2.5^-	0

Table 1 (*continued*)

A_p	Z_p	$\mathscr{T}^{\text{theor}}$	$\mathscr{T}^{\text{exp}}$	β_2	β_4	j_{p}^{π}	j_{d}^{π}	$l_{\min}$
209	89	−0.97	−1.04	−0.113	0.005	(4.5^-)	(4.5^-)	0
209	90	−2.10	–	−0.19	−0.024	2.5^-#	(1.5^-)	2
210	82	16.59	16.57	−0.008	0	0^+	0^+	0
210	83	8.73	–	−0.018	−0.008	1^-	0^-	2
210	84	6.28	7.08	0.032	−0.008	0^+	0^+	0
210	85	6.53	7.73	−0.004	−0.015	$(5)^+$	$6^{(+)}$	2
210	86	3.48	3.95	−0.077	−0.008	0^+	0^+	0
210	87	2.52	2.43	−0.053	−0.007	6^+	$(5)^+$	2
210	88	0.82	0.57	−0.044	−0.007	0^+	0^+	0
210	89	0.09	–	−0.113	0.005	7^+#	(2^+)	6
210	90	−2.03	–	−0.13	−0.002	0^+	0^+	0
211	82	22.17	–	−0.018	0.008	4.5^+	(4.5^+)	0
211	83	2.28	–	−0.008	0	4.5^-	0.5^+	5
211	84	0.02	−0.28	−0.008	0	4.5^+	0.5^-	5
211	85	4.59	4.79	−0.026	−0.015	4.5^-	4.5^-	0
211	86	5.59	5.75	−0.026	−0.015	0.5^-	2.5^-	2
211	87	2.65	2.37	−0.035	−0.015	4.5^-	4.5^-	0
211	88	1.44	1.15	−0.053	−0.007	$2.5^{(-)}$	2.5^-	0
211	89	−0.60	−0.67	−0.104	0.004	4.5^-#	4.5^-	0
211	90	−1.00	–	−0.13	−0.002	2.5^-#	(1.5^-)	2
212	82	23.63	–	−0.008	0	0^+	0^+	0
212	83	4.67	4.57	−0.018	0.008	$1^{(-)}$	$5^{(+)}$	5
212	84	−6.67	−6.52	0.055	0	0^+	0^+	0
212	85	−0.26	−0.42	−0.018	−0.008	(1^-)	$(5)^+$	5
212	86	2.79	3.16	−0.018	−0.008	0^+	0^+	0
212	87	3.59	4.10	−0.044	−0.023	5^+	6^+	2
212	88	1.16	1.18	−0.026	−0.008	0^+	0^+	0
212	89	0.00	–	−0.087	0.003	6^+#	7^+	2
212	90	−1.65	–	−0.104	0.004	0^+	0^+	0
212	91	−2.27	−2.10	−0.19	−0.024	7^+#	(3^+)	4
213	82	29.65	–	−0.018	−0.008	(4.5^+)	4.5^+#	0
213	83	5.44	5.15	−0.008	0.008	4.5^-	(0.5^+)	5
213	84	−5.08	−5.38	−0.008	0.008	4.5^+	4.5^+	0
213	85	−6.79	−6.90	−0.008	0.008	4.5^-	4.5^-	0
213	86	−1.17	−1.71	−0.008	0	(4.5^+)	0.5^-	5
213	87	1.62	1.54	−0.035	−0.015	4.5^-	4.5^-	0
213	88	2.70	2.66	−0.044	−0.015	0.5^-	2.5^-	2
213	89	0.42	−0.14	−0.044	−0.015	4.5^-#	4.5^-	0
213	90	−0.64	−0.85	−0.087	−0.005	2.5^-#	2.5^-	0
213	91	−2.34	–	−0.122	−0.002	4.5^-#	(4.5^-)	0
214	82	32.86	–	−0.026	−0.008	0^+	0^+	0
214	83	7.43	7.16	−0.018	0.008	1^-	5^+#	5
214	84	−3.84	−3.78	0.022	0.008	0^+	0^+	0
214	85	−5.99	−6.25	−0.018	0.015	1^-	1^-	0
214	86	−6.75	−6.57	0.014	0.008	0^+	0^+	0
214	87	−1.73	−2.27	−0.018	−0.008	(1^-)	$(5)^+$	5
214	88	0.20	0.39	−0.023	−0.008	0^+	0^+	0
214	89	0.66	1.23	−0.052	−0.022	5^+#	6^+	2
214	90	−1.13	–	−0.053	−0.007	0^+	0^+	0
214	91	−1.76	–	−0.105	−0.004		7^+#	0
215	83	8.94	–	−0.018	0.008	(4.5^-)	0.5^+#	5
215	84	−2.19	−2.75	0.008	0.008	4.5^+	4.5^+	0
215	85	−3.94	−4.00	−0.018	0.008	4.5^-	4.5^-	0
215	86	−5.11	−5.64	−0.008	0.008	4.5^+	4.5^+	0
215	87	−6.60	−7.07	−0.041	0.008	4.5^-	4.5^-	0
215	88	−2.14	−2.79	−0.008	0	4.5^+#	0.5^-	5
215	89	−0.53	−0.77	−0.035	−0.015	4.5^-	4.5^-	0
215	90	0.09	0.48	−0.053	−0.014	(0.5^-)	$2.5^{(-)}$	2
215	91	−1.76	–	−0.07	−0.006	4.5^-#	4.5^-#	0
216	83	10.38	–	−0.018	0	1^-#	5^+#	5
216	84	−0.63	−0.84	0	0.008	0^+	0^+	0
216	85	−3.17	–	−0.018	0.016	1^{-a}	$1^{(-)}$	0
216	86	−4.03	−4.35	0	0.008	0^+	0^+	0
216	87	−5.88	−6.15	0.018	0.016	(1^-)	(1^-)	0
216	88	−6.73	−6.74	0	0.008	0^+	0^+	0
216	89	−2.93	−3.31	−0.008	0.008	(1^-)	5^+	5
216	90	−1.52	−1.57	−0.035	−0.015	0^+	0^+	0
216	91	−1.11	–	−0.061	−0.014		6^+#	0
217	84	0.97	–	0.009	0.009	2.5^+#	(4.5^+)	2
217	85	−0.90	–	−0.018	0.015	4.5^-	4.5^-	0
217	86	−2.43	−3.27	−0.008	0.008	4.5^+	4.5^+	0
217	87	−4.09	−4.77	0.008	0.008	4.5^-	4.5^-	0
217	88	−5.14	−5.79	−0.018	0.008	(4.5^+)	(4.5^+)	0
217	89	−6.77	−7.16	0.008	0.008	4.5^-	4.5^-	0
217	90	−2.74	−3.62	−0.018	−0.008	(4.5^+)	0.5^-	5
217	91	−2.02	−2.45	−0.044	−0.015	4.5^-#	4.5^-#	0
217	92	−0.75	–	−0.07	−0.021	0.5^-#	2.5^-#	2

Table 1 (*continued*)

A_p	Z_p	$\mathscr{T}^{\rm theor}$	$\mathscr{T}^{\rm exp}$	β_2	β_4	$j_{\rm p}^{\pi}$	$j_{\rm d}^{\pi}$	$l_{\rm min}$
218	84	2.55	2.27	0.009	0.009	0^+	0^+	0
218	85	0.17	–	0.027	0.024	$1^-\#$	1^-	0
218	86	–0.99	–1.46	–0.008	0.008	0^+	0^+	0
218	87	–2.71	–2.97	0.018	0.016	1^-	1^-	0
218	88	–4.26	–4.59	0.008	0.008	0^+	0^+	0
218	89	–5.64	–5.97	0.018	0.016	$1^-\#$	(1^-)	0
218	90	–6.80	–6.96	0.008	0.008	0^+	0^+	0
218	91	–5.63	–3.76	–0.018	0		$5^+\#$	0
218	92	–3.32	–	–0.052	–0.022	0^+	0^+	0
219	84	4.26	–	0.011	0.01	$3.5^+\#$	$2.5^+\#$	2
219	85	2.65	–	–0.026	0.016	$2.5^-\#$	(4.5^-)	2
219	86	0.63	0.70	0.02	0.018	2.5^+	4.5^+	2
219	87	–1.06	–1.69	0.018	0.016	4.5^-	4.5^-	0
219	88	–2.52	–1.48	0.019	0.016	$(3.5)^+$	4.5^+	2
219	89	–4.31	–4.93	0.008	0.008	4.5^-	4.5^-	0
219	90	–5.27	–5.98	–0.018	0.008	$4.5^+\#$	$4.5^+\#$	0
219	91	–6.60	–7.28	0	0.008	4.5^-	4.5^-	0
219	92	–3.06	–4.26	–0.018	–0.008	$4.5^+\#$	(0.5^-)	5
220	85	3.44	–	0.049	0.037	$3^{(-\#)}$	$1^-\#$	2
220	86	2.10	1.75	0.02	0.018	0^+	0^+	0
220	87	3.19	1.62	0.035	0.024	1^+	1^{-a}	1
220	88	–1.34	–1.74	0.008	0.008	0^+	0^+	0
220	89	–2.86	–	0.019	0.017	(3^-)	(1^-)	2
220	90	–4.61	–5.01	0.008	0.008	0^+	0^+	0
220	91	–5.78	–	–0.018	0.008	$1^-\#$	(1^-)	0
220	92	–7.13	–	0.008	0.008	0^+	0^+	0
221	85	5.85	–	0.048	0.036	$1.5^-\#$	$4.5^-\#$	4
221	86	3.87	3.92	0.031	0.02	3.5^{+a}	$2.5^+\#$	2
221	87	2.58	2.55	0.039	0.028	2.5^-	4.5^-	2
221	88	1.60	1.97	0.039	0.028	2.5^+	4.5^+	2
221	89	–1.25	–1.13	0.018	0.008	$4.5^-\#$	4.5^-	0
221	90	–3.22	–2.37	0.028	0.017	(3.5^+)	(4.5^+)	2
221	91	–4.66	–5.23	0.008	0.008	4.5^-	4.5^-	0
221	92	–5.60	–	–0.018	0.008	$4.5^+\#$	(4.5^+)	0
222	85	9.48	–	0.057	0.044		$1^-\#$	0
222	86	5.77	5.52	0.039	0.028	0^+	0^+	0
222	87	6.18	–	0.085	0.063	2^-	$1^-\#$	2
222	88	1.68	1.59	0.04	0.029	0^+	0^+	0
222	89	0.81	0.73	0.05	0.029	1^-	1^-	0
222	90	–2.07	–2.69	0.095	0.01	0^+	0^+	0
222	91	–3.65	–	0.029	0.018		$1^-\#$	0
222	92	–5.29	–	0.008	0.008	0^+	0^+	0
223	86	9.76	–	0.101	0.071	3.5	$3.5^+\#$	0
223	87	7.29	–	0.103	0.072	$1.5^{(-)}$	$2.5^-\#$	2
223	88	5.95	7.99	0.103	0.072	1.5^+	2.5^+	2
223	89	2.58	2.60	0.093	0.071	(2.5^-)	4.5^-	2
223	90	0.43	0.78	0.077	0.055	$(2.5)^+$	$(3.5)^+$	2
223	91	–2.20	–2.03	0.02	0.011	$4.5^-\#$	4.5^-	0
223	92	–3.36	–	0.029	0.018	$3.5^+\#$	$4.5^+\#$	2
224	86	12.61	–	0.11	0.08	0^+	0^+	0
224	87	11.45	–	0.111	0.081	1^-	$3^{(-\#)}$	2
224	88	6.07	5.52	0.127	0.081	0^+	0^+	0
224	89	6.36	5.73	0.111	0.09	0^-	1^+	1
224	90	0.59	0.12	0.103	0.072	0^+	0^+	0
224	91	0.22	–	0.103	0.072	$5^-\#$	(3^-)	2
224	92	–3.16	–	0.03	0.019	0^+	0^+	0
225	87	13.34	–	0.111	0.081	1.5^-	$1.5^-\#$	0
225	88	10.84	–	0.119	0.09	0.5^+	3.5^{+a}	4
225	89	6.22	6.23	0.12	0.091	(1.5^-)	2.5^-	2
225	90	2.66	–	0.111	0.081	$(1.5)^+$	2.5^+	2
225	91	1.02	0.39	0.111	0.081	$2.5^-\#$	$4.5^-\#$	2
225	92	–0.34	–1.14	0.102	0.072	$2.5^+\#$	(3.5^+)	2
225	93	–2.52	–	–0.026	0.009	$4.5^-\#$	4.5^-	0
226	87	16.69	–	0.137	0.099	1^-		0
226	88	11.28	10.73	0.142	0.1	0^+	0^+	0
226	89	8.32	9.25	0.138	0.109	$(1^{-\#})$	2^-	2
226	90	3.58	3.39	0.192	0.092	0^+	0^+	0
226	91	2.53	2.45	0.129	0.099		1^-	0
226	92	–0.18	–0.57	0.153	0.081	0^+	0^+	0
226	93	–0.73	–	0.111	0.081			0
227	87	21.78	–	0.145	0.1	0.5^+	$1.5^-\#$	1
227	88	14.77	–	0.155	0.11	1.5^+	3.5	0
227	89	10.99	11.02	0.146	0.109	1.5^-	$1.5^{(-)}$	0
227	90	5.68	6.82	0.156	0.111	0.5^+	1.5^+	2
227	91	3.89	3.73	0.147	0.11	(2.5^-)	(2.5^-)	0
227	92	2.22	–	0.138	0.1	(1.5^+)	$(2.5)^+$	2
227	93	0.20	–	0.137	0.099	$2.5^-\#$	$4.5^-\#$	2
228	88	17.18	–	0.163	0.111	0^+	0^+	0
228	89	14.56	–	0.164	0.111	3^+	1^-	3
228	90	8.13	7.93	0.179	0.112	0^+	0^+	0
228	91	7.34	7.60	0.165	0.112	3^+	0^-	3
228	92	2.97	2.90	0.164	0.112	0^+	0^+	0
228	93	1.63	–	0.156	0.111		$5^-\#$	0
228	94	–0.29	–	0.146	0.1	0^+	0^+	0
229	88	23.77	–	0.163	0.11	$2.5^{(+)}$	3.5^-	1
229	89	16.41	–	0.163	0.111	(1.5^+)	1.5^-	1
229	90	10.97	–	0.164	0.112	2.5^+	0.5^+	2
229	91	9.19	10.03	0.164	0.111	(2.5^+)	(1.5^-)	1
229	92	5.00	4.43	0.165	0.112	(1.5^+)	$(1.5)^+$	0
229	93	4.73	–	0.165	0.112	$2.5^+\#$	$2.5^-\#$	1
229	94	1.45	–	0.165	0.112	$1.5^+\#$	$2.5^+\#$	2
230	88	24.93	–	0.171	0.102	0^+	0^+	0
230	89	20.70	–	0.171	0.112	(1^+)	1^-	1
230	90	12.74	12.49	0.202	0.112	0^+	0^+	0
230	91	9.76	11.31	0.164	0.111	(2^-)	$(1^{-\#})$	2
230	92	6.40	6.43	0.228	0.111	0^+	0^+	0
230	93	3.97	–	0.165	0.119			0
230	94	2.31	–	0.172	0.111	0^+	0^+	0
231	88	29.75	–	0.18	0.103	(2.5^+)	$2.5^{(+\#)}$	0
231	89	20.27	–	0.181	0.104	(0.5^+)	0.5^+	0
231	90	17.85	–	0.181	0.113	2.5^+	1.5^+	2
231	91	11.24	12.97	0.172	0.112	1.5^-	1.5^-	0
231	92	9.50	–	0.173	0.12	$(2.5^{+\#})$	0.5^+	2
231	93	7.40	–	0.173	0.12	$(2.5^{+\#})$	(2.5^-)	1
231	94	4.20	–	0.182	0.121	$1.5^+\#$	(1.5^+)	0
231	95	1.93	–	0.19	0.114		$2.5^-\#$	0
232	88	31.25	–	0.197	0.098	0^+	0^+	0
232	89	26.47	–	0.189	0.105	(1^+)	2^-	1
232	90	18.11	17.76	0.217	0.113	0^+	0^+	0
232	91	16.82	–	0.181	0.113	(2^-)	3^+	1
232	92	9.53	9.50	0.23	0.112	0^+	0^+	0
232	93	7.50	–	0.182	0.121	(4^+)	3^+	2
232	94	4.09	4.13	0.191	0.114	0^+	0^+	0
232	95	2.71	–	0.191	0.123			0
233	89	26.66	–	0.197	0.106	(0.5^+)	$0.5^+\#$	0
233	90	22.16	–	0.189	0.114	0.5^+	$2.5^{(+)}$	2
233	91	19.05	–	0.189	0.114	1.5^-	(1.5^+)	1
233	92	13.57	12.77	0.19	0.114	2.5^+	2.5^+	0
233	93	9.34	–	0.19	0.114	(2.5^+)	(2.5^+)	0
233	94	6.05	–	0.191	0.123	$2.5^+\#$	(1.5^+)	2
233	95	3.78	–	0.199	0.115		$2.5^+\#$	0
233	96	2.58	–	0.19	0.114	$1.5^+\#$	$1.5^+\#$	0
234	89	29.17	–	0.207	0.1			0
234	90	22.23	–	0.197	0.106	0^+	0^+	0
234	91	19.34	–	0.197	0.115	4^+	(1^+)	4
234	92	13.00	13.04	0.244	0.115	0^+	0^+	0
234	93	12.96	–	0.19	0.123	(0^+)	(2^-)	3
234	94	5.57	5.89	0.262	0.115	0^+	0^+	0
234	95	4.30	–	0.199	0.124			0
234	96	2.27	–	0.198	0.115	0^+	0^+	0
235	89	30.58	–	0.206	0.092	$0.5^+\#$	$0.5^+\#$	0
235	90	25.54	–	0.207	0.1	$0.5^+\#$	(2.5^+)	2
235	91	21.90	–	0.207	0.108	(1.5^-)	(0.5^+)	1
235	92	16.99	17.65	0.198	0.115	3.5^-	2.5^+	1
235	93	14.11	13.94	–0.124	0.115	2.5^+	1.5^-	1
235	94	8.29	–	0.198	0.115	(2.5^+)	$(2.5^{+\#})$	0
235	95	7.09	5.17	0.208	0.117	$2.5^-\#$	$(2.5^{+\#})$	1
235	96	3.58	–	0.198	0.115	$2.5^+\#$	$1.5^+\#$	2
235	97	1.31	–	0.208	0.108			0
236	89	34.44	–	0.215	0.085			0
236	90	25.54	–	0.215	0.093	0^+	0^+	0
236	91	24.13	–	0.207	0.108	$1^{(-)}$	(1^+)	1
236	92	15.03	15.00	0.261	0.108	0^+	0^+	0
236	93	13.39	–	0.207	0.117	(6^-)	(2^-)	4
236	94	7.76	8.11	0.264	0.117	0^+	0^+	0
236	95	6.39	–	0.208	0.117		(4^+)	0
236	96	3.23	–	0.208	0.117	0^+	0^+	0
236	97	2.35	–	0.208	0.117			0
237	90	31.08	–	0.215	0.093	$2.5^+\#$	$0.5^+\#$	2
237	91	22.71	–	0.215	0.102	(0.5^+)	(0.5^+)	0
237	92	18.71	–	0.215	0.102	0.5^+	0.5^+	0
237	93	15.19	16.19	0.207	0.117	2.5^+	1.5^-	1
237	94	11.14	12.12	0.207	0.117	3.5^-	2.5^+	1

(*continued on next page*)

Table 1 (*continued*)

A_p	Z_p	$\mathscr{T}^{\text{theor}}$	$\mathscr{T}^{\text{exp}}$	β_2	β_4	j^{π}_{p}	j^{π}_{d}	l_{min}
237	95	9.01	–	0.207	0.117	$2.5^{(-)}$	(2.5^{+})	1
237	96	5.09	–	0.207	0.117	2.5^{+}#	2.5^{+}#	0
237	97	2.49	–	0.207	0.108	3.5^{+}#		0
237	98	1.08	–	0.207	0.108	2.5^{+}#	1.5^{+}#	2
238	90	30.85	–	0.215	0.085	0^{+}	0^{+}	0
238	91	28.41	–	0.215	0.093	3^{-}#		0
238	92	17.61	17.25	0.241	0.102	0^{+}	0^{+}	0
238	93	15.52	–	0.215	0.11	2^{+}	4^{+}	2
238	94	9.26	9.59	0.272	0.11	0^{+}	0^{+}	0
238	95	8.13	–	0.216	0.118	1^{+}	(0^{+})	2
238	96	5.26	5.51	0.216	0.109	0^{+}	0^{+}	0
238	97	3.26	–	0.216	0.109			0
238	98	0.59	–	0.216	0.102	0^{+}	0^{+}	0
239	91	30.77	–	0.215	0.085	$(1.5^{-\#})$	0.5^{+}#	1
239	92	22.01	–	0.215	0.093	2.5^{+}	0.5^{+}#	2
239	93	18.19	–	0.215	0.102	2.5^{+}	(1.5^{-})	1
239	94	14.21	–	0.215	0.11	0.5^{+}	3.5^{-}	3
239	95	10.41	11.11	0.215	0.11	$(2.5)^{-}$	2.5^{+}	1
239	96	7.92	–	0.215	0.11	(3.5^{-})	(2.5^{+})	1
239	97	5.41	–	0.215	0.11	3.5^{+}#	2.5^{-}#	1
239	98	2.03	–	0.215	0.102	2.5^{+}#	2.5^{+}#	0
240	91	33.81	–	0.224	0.079			0
240	92	21.78	–	0.215	0.094	0^{+}	0^{+}	0
240	93	18.76	–	0.215	0.102	(5^{+})	$1^{(-)}$	5
240	94	11.29	11.45	0.282	0.102	0^{+}	0^{+}	0
240	95	10.08	–	0.215	0.11	(3^{-})	(6^{-})	4
240	96	6.29	6.52	0.215	0.11	0^{+}	0^{+}	0
240	97	4.31	–	0.215	0.11			0
240	98	1.75	2.03	0.215	0.102	0^{+}	0^{+}	0
240	99	0.48	–	0.215	0.093			0
241	92	25.30	–	0.223	0.087	3.5^{+}#	2.5^{+}#	2
241	93	19.48	–	0.215	0.093	(2.5^{+})	(0.5^{+})	2
241	94	13.04	–	0.215	0.102	2.5^{+}	0.5^{+}	2
241	95	12.02	12.60	0.215	0.102	2.5^{-}	2.5^{+}	1
241	96	9.93	11.28	0.215	0.102	0.5^{+}	3.5^{-}	3
241	97	5.84	–	0.215	0.102	(3.5^{+})	$2.5^{(-)}$	1
241	98	4.42	–	0.215	0.102	3.5^{-}#	2.5^{+}#	1
241	99	2.37	–	0.215	0.093	(1.5^{-})	3.5^{+}#	3
242	92	24.75	–	0.224	0.079	0^{+}	0^{+}	0
242	93	21.26	–	0.223	0.087	(1^{+})	3^{-}#	3
242	94	13.46	13.18	0.215	0.093	0^{+}	0^{+}	0
242	95	12.47	–	0.215	0.102	1^{-}	2^{+}	1
242	96	6.86	7.28	0.286	0.102	0^{+}	0^{+}	0
242	97	6.89	–	0.215	0.102	2^{-}#	1^{+}	1
242	98	2.52	–	0.215	0.093	0^{+}	0^{+}	0
242	99	0.84	–	0.215	0.093			0
242	100	–0.88	–	0.215	0.084	0^{+}	0^{+}	0
243	93	20.23	–	0.224	0.079	(2.5^{-})	$(1.5^{-\#})$	2
243	94	15.77	–	0.223	0.087	3.5^{+}	2.5^{+}	2
243	95	13.18	14.16	0.223	0.095	2.5^{-}	2.5^{+}	1
243	96	8.12	–	0.223	0.095	2.5^{+}	0.5^{+}	2
243	97	5.05	–	0.215	0.093	(1.5^{-})	$(2.5)^{-}$	2
243	98	5.74	–	0.215	0.093	(0.5^{+})	(3.5^{-})	3
243	99	3.18	–	0.215	0.093	1.5^{-}#	3.5^{+}#	3
243	100	1.79	–	0.215	0.093	3.5^{-}#	2.5^{+}#	1
244	93	21.71	–	0.224	0.071	(7^{-})		0
244	94	15.80	15.50	0.224	0.079	0^{+}	0^{+}	0
244	95	15.31	–	0.223	0.087	6^{-}#	(5^{+})	1
244	96	8.57	8.87	0.289	0.087	0^{+}	0^{+}	0
244	97	5.40	–	0.262	0.095	4^{-}#	(3^{-})	2
244	98	2.88	–	0.297	0.087	0^{+}	0^{+}	0
244	99	1.91	–	0.224	0.086			0
244	100	–0.24	–	0.215	0.085	0^{+}	0^{+}	0
245	94	19.79	–	0.224	0.071	(4.5^{-})	3.5^{+}#	1
245	95	12.83	–	0.224	0.079	$(2.5)^{+}$	(2.5^{+})	0
245	96	11.19	–	0.224	0.079	3.5^{+}	2.5^{+}	2
245	97	6.94	9.37	0.223	0.087	1.5^{-}	2.5^{-}	2
245	98	4.12	3.94	0.223	0.087	$0.5^{(+)b}$	0.5^{+}	0
245	99	3.73	3.52	0.224	0.079	(1.5^{-})	(3.5^{+})	3
245	100	2.66	–	0.224	0.079	0.5^{+}#	3.5^{-}#	3
245	101	–0.92	–	0.224	0.079	0.5^{-}#	(1.5^{-})	2
246	94	18.45	–	0.224	0.062	0^{+}	0^{+}	0
246	95	15.81	–	0.224	0.071	(7^{-})	(1^{+})	7
246	96	11.10	11.26	0.292	0.071	0^{+}	0^{+}	0
246	97	9.07	–	0.224	0.079	$2^{(-)}$	1^{-}	2
246	98	5.19	4.21	0.224	0.079	0^{+}	0^{+}	0
246	99	2.69	–	0.224	0.079	4^{-}#	2^{-}#	2

Table 1 (*continued*)

A_p	Z_p	$\mathscr{T}^{\text{theor}}$	$\mathscr{T}^{\text{exp}}$	β_2	β_4	j^{π}_{p}	j^{π}_{d}	l_{min}
246	100	0.31	0.17	0.224	0.079	0^{+}	0^{+}	0
246	101	–0.37	–	0.224	0.079			0
247	95	15.42	–	0.224	0.071	2.5#	(2.5^{-})	0
247	96	14.66	15.55	0.224	0.071	4.5^{-}	3.5^{+}	1
247	97	9.94	–	0.224	0.071	(1.5^{-})	2.5^{-}	2
247	98	7.38	–	0.234	0.073	3.5^{+}#	2.5^{+}	2
247	99	5.26	–	0.234	0.073	3.5^{+}#	(1.5^{-})	3
247	100	1.52	–	0.234	0.073	2.5^{+}#	(0.5^{+})	2
247	101	–0.33	–	0.224	0.071	0.5^{-}#	1.5^{-}#	2
248	95	15.04	–	0.224	0.055		(7^{-})	0
248	96	13.14	13.16	0.293	0.062	0^{+}	0^{+}	0
248	97	12.55	–	0.224	0.071	6^{+}#	6^{-}#	1
248	98	7.19	7.56	0.297	0.073	0^{+}	0^{+}	0
248	99	6.89	–	0.234	0.073	0^{+}#	4^{-}#	5
248	100	1.55	1.66	0.234	0.073	0^{+}	0^{+}	0
248	101	0.18	–	0.234	0.073			0
248	102	–1.49	–	0.224	0.071	0^{+}	0^{+}	0
249	96	15.85	–	0.235	0.048	$0.5^{(+)}$	(4.5^{-})	5
249	97	12.10	13.61	0.224	0.062	3.5^{+}	$(2.5)^{+}$	2
249	98	10.34	11.65	0.234	0.064	4.5^{-}	3.5^{+}	1
249	99	7.58	–	0.234	0.064	3.5^{+}	1.5^{-}	3
249	100	3.03	–	0.234	0.065	3.5^{+}#	$0.5^{(+)b}$	4
249	101	0.80	–	0.234	0.065	(3.5^{-})	(1.5^{-})	2
249	102	–0.70	–	0.234	0.064	2.5^{+}#	0.5^{+}#	2
250	96	13.48	–	0.235	0.04	0^{+}	0^{+}	0
250	97	12.57	–	0.235	0.048	2^{-}	(7^{-})	6
250	98	8.45	8.69	0.298	0.057	0^{+}	0^{+}	0
250	99	8.39	–	0.234	0.057	(6^{+})	$2^{(-)}$	5
250	100	3.26	3.38	0.234	0.057	0^{+}	0^{+}	0
250	101	1.43	–	0.234	0.065		4^{-}#	0
250	102	–0.69	–	0.234	0.057	0^{+}	0^{+}	0
251	96	13.74	–	0.235	0.039	(0.5^{+})	0.5^{+}#	0
251	97	11.32	–	0.235	0.04	1.5^{-}#	2.5#	0
251	98	11.30	12.04	0.235	0.04	0.5^{+}	4.5^{-}	5
251	99	7.31	7.48	0.235	0.048	(1.5^{-})	(1.5^{-})	0
251	100	6.24	7.85	0.234	0.057	(4.5^{-})	3.5^{+}#	1
251	101	4.23	–	0.234	0.057	3.5^{-}#	3.5^{+}#	1
251	102	0.11	–	0.234	0.057	3.5^{+}#	2.5^{+}#	2
251	103	–1.32	–	0.235	0.048		0.5^{-}#	0
252	97	12.14	–	0.235	0.039			0
252	98	8.08	8.01	0.297	0.04	0^{+}	0^{+}	0
252	99	8.48	7.83	0.235	0.04	(5^{-})	6^{+}#	1
252	100	4.97	5.04	0.235	0.04	0^{+}	0^{+}	0
252	101	2.93	–	0.235	0.049		0^{+}#	0
252	102	0.59	0.74	0.235	0.049	0^{+}	0^{+}	0
252	103	–0.68	–	0.235	0.049			0
253	97	12.87	–	0.225	0.037			0
253	98	9.67	–	0.235	0.032	(3.5^{+})	$0.5^{(+)}$	4
253	99	6.65	6.29	0.235	0.04	3.5^{+}	3.5^{+}	0
253	100	7.47	8.22	0.235	0.033	$(0.5)^{+}$	4.5^{-}	5
253	101	5.41	–	0.235	0.04	3.5^{-}#	3.5^{+}	1
253	102	3.51	–	0.235	0.04	4.5^{-}#	3.5^{+}#	1
253	103	0.16	–	0.235	0.04	(3.5^{-})	(3.5^{-})	0
253	104	–0.93	–	0.235	0.04	$(3.5^{+\#})$	2.5^{+}#	2
254	98	9.99	9.31	0.225	0.03	0^{+}	0^{+}	0
254	99	9.50	–	0.235	0.032	(7^{+})	2^{-}	5
254	100	4.08	4.14	0.299	0.026	0^{+}	0^{+}	0
254	101	5.30	–	0.244	0.035	(0^{-})	(6^{+})	7
254	102	1.74	1.82	0.235	0.033	0^{+}	0^{+}	0
254	103	0.83	–	0.235	0.033			0
254	104	–1.09	–	0.235	0.032	0^{+}	0^{+}	0
255	98	11.92	–	0.226	0.021	(3.5^{+})	(0.5^{+})	4
255	99	10.03	–	0.235	0.032	(3.5^{+})	1.5^{-}#	3
255	100	5.41	–	0.236	0.024	3.5^{+}	0.5^{+}	4
255	101	2.81	–	0.245	0.027	(3.5^{-})	(1.5^{-})	2
255	102	3.62	4.20	0.245	0.026	(0.5^{+})	(4.5^{-})	5
255	103	1.25	–	0.236	0.024	3.5^{-}#	3.5^{-}#	0
255	104	2.32	–	0.236	0.024	4.5^{-}#	3.5^{+}#	1
255	105	–1.30	–	0.236	0.024			0
256	98	12.22	–	0.226	0.012	0^{+}	0^{+}	0
256	99	9.39	–	0.226	0.021	(0^{-})		0
256	100	5.27	5.14	0.304	0.015	0^{+}	0^{+}	0
256	101	3.13	–	0.236	0.024	(1^{-})	(5^{-})	4
256	102	0.54	0.53	0.245	0.018	0^{+}	0^{+}	0
256	103	0.73	–	0.245	0.018			0
256	104	0.25	–	0.236	0.024	0^{+}	0^{+}	0
256	105	–0.37	–	0.236	0.016			0

Table 1 (*continued*)

A_p	Z_p	$\mathscr{T}^{\text{theor}}$	$\mathscr{T}^{\text{exp}}$	β_2	β_4	j^{π}_{p}	j^{π}_{d}	l_{min}
257	99	10.24	–	0.226	0.012	3.5^+#		0
257	100	7.01	9.18	0.226	0.013	(4.5^+)	(3.5^+)	2
257	101	5.99	7.57	0.236	0.016	(3.5^-)	3.5^+	1
257	102	1.71	–	0.236	0.016	(3.5^+)	$(0.5)^+$	4
257	103	1.78	–	0.246	0.011	4.5^+#	3.5^-#	1
257	104	2.57	–	0.236	0.016	(0.5^+)	4.5^-#	5
257	105	1.95	0.51	0.236	0.016	(4.5^+)	(3.5^-)	1
258	99	11.37	–	0.217	0.003			0
258	100	7.26	–	0.226	0.005	0^+	0^+	0
258	101	7.37	–	0.226	0.013	8^-#	(7^+)	1
258	102	2.04	–	0.237	0.008	0^+	0^+	0
258	103	0.49	–	0.237	0.008		(0^-)	0
258	104	−0.74	–	0.246	0.011	0^+	0^+	0
258	105	−0.43	–	0.237	0.008			0
258	106	−1.15	–	0.237	0.008	0^+	0^+	0
259	100	8.93	–	0.227	−0.004	1.5^+#	(3.5^+)	2
259	101	7.91	–	0.226	0.006	3.5^-#	(3.5^+)	1
259	102	3.69	–	0.237	−0.001	4.5^+#	3.5^+	2
259	103	3.19	–	0.237	0	4.5^+#	(3.5^-)	1
259	104	0.46	–	0.237	0	3.5^+#	(0.5^+)	4
259	105	−1.04	–	0.246	0.002		3.5^-#	0
259	106	0.99	–	0.246	0.001	0.5^+#	4.5^-#	5
260	100	9.76	–	0.218	−0.005	0^+	0^+	0
260	101	7.01	–	0.227	−0.003		(0^-)	0
260	102	3.75	–	0.227	−0.003	0^+	0^+	0
260	103	2.70	–	0.237	−0.001		(1^-)	0
260	104	0.37	–	0.237	−0.001	0^+	0^+	0
260	105	−0.15	–	0.238	−0.009			0
260	106	−1.84	−2.04	0.247	−0.007	0^+	0^+	0
260	107	−2.36	–	0.247	−0.007			0
261	101	9.99	–	0.227	−0.012	3.5^-#	3.5^+#	1
261	102	5.40	–	0.227	−0.012	1.5^+#	(4.5^+)	4
261	103	2.91	–	0.227	−0.011		(3.5^-)	0
261	104	1.85	–	0.238	−0.009	1.5^+#	(3.5^+)	2
261	105	0.15	–	0.238	−0.009		4.5^+#	0
261	106	−0.77	–	0.238	−0.009	3.5^+#	(0.5^+)	4
261	107	−2.79	−1.47	0.247	−0.014		(4.5^+)	0
262	101	10.22	–	0.219	−0.021			0
262	102	6.25	–	0.228	−0.019	0^+	0^+	0
262	103	3.55	–	0.227	−0.012		8^-#	0
262	104	1.77	–	0.228	−0.019	0^+	0^+	0
262	105	0.98	–	0.238	−0.017			0
262	106	−0.92	–	0.238	−0.016	0^+	0^+	0
262	107	−1.91	–	0.238	−0.016			0
263	102	7.97	–	0.228	−0.028		1.5^+#	0
263	103	4.83	–	0.228	−0.019		3.5^-#	0
263	104	3.15	–	0.228	−0.019	1.5^+#	4.5^+#	4
263	105	1.36	–	0.228	−0.019		4.5^+#	0
263	106	0.33	–	0.239	−0.025	4.5^+#	3.5^+#	2
263	107	−1.55	–	0.239	−0.025			0
263	108	−2.32	–	0.248	−0.023	3.5^+#	0.5^+#	4
264	102	8.65	–	0.219	−0.03	0^+	0^+	0
264	103	6.54	–	0.228	−0.028			0
264	104	2.94	–	0.228	−0.028	0^+	0^+	0
264	105	2.12	–	0.228	−0.028			0
264	106	0.25	–	0.228	−0.027	0^+	0^+	0
264	107	−1.06	–	0.239	−0.025			0
264	108	−2.86	–	0.239	−0.025	0^+	0^+	0
265	103	7.52	–	0.219	−0.03		3.5^-#	0
265	104	4.94	–	0.219	−0.03	1.5^+#	1.5^+#	0
265	105	2.47	–	0.228	−0.028			0
265	106	1.25	–	0.228	−0.028	1.5^+#	1.5^+#	0
265	107	−0.67	–	0.228	−0.028			0
265	108	−2.18	–	0.238	−0.025	4.5^+#	3.5^+#	2
265	109	−3.30	–	0.239	−0.034			0
266	103	6.37	–	0.219	−0.038			0
266	104	5.42	–	0.219	−0.039	0^+	0^+	0
266	105	3.72	–	0.219	−0.038			0
266	106	1.22	–	0.229	−0.037	0^+	0^+	0
266	107	0.10	–	0.229	−0.036			0
266	108	−2.22	–	0.229	−0.036	0^+	0^+	0
266	109	−2.97	–	0.239	−0.034			0
267	104	4.87	–	0.22	−0.046			0
267	105	4.65	–	0.22	−0.046			0
267	107	0.43	–	0.229	−0.044			0
267	108	−0.88	–	0.229	−0.044	1.5^+#	4.5^+#	4
267	109	−2.85	–	0.239	−0.042			0
267	110	−5.30	–	0.239	−0.042	4.5^+#	3.5^+#	2
268	104	3.09	–	0.22	−0.054	0^+	0^+	0
268	105	3.69	–	0.22	−0.054			0
268	106	2.87	–	0.22	−0.046	0^+	0^+	0
268	107	1.49	–	0.229	−0.053			0
268	108	−1.07	–	0.229	−0.044	0^+	0^+	0
268	109	−2.32	–	0.229	−0.044	5^+#		0
268	110	−5.21	–	0.229	−0.044	0^+	0^+	0
269	105	2.73	–	0.221	−0.063			0
269	106	2.12	–	0.22	−0.055		1.5^+#	0
269	107	2.10	–	0.229	−0.053			0
269	108	0.34	–	0.229	−0.053		1.5^+#	0
269	109	−2.05	–	0.23	−0.052			0
269	110	−3.81	–	0.23	−0.053	1.5^+#	4.5^+#	4
270	105	3.60	–	0.221	−0.064			0
270	106	0.48	–	0.23	−0.069	0^+	0^+	0
270	107	0.81	–	0.221	−0.063			0
270	108	0.63	–	0.23	−0.061	0^+	0^+	0
270	109	−1.40	–	0.23	−0.061			0
270	110	−3.67	–	0.23	−0.061	0^+	0^+	0
271	106	2.36	–	0.221	−0.071			0
271	107	−0.04	–	0.23	−0.069			0
271	109	−1.05	–	0.23	−0.069			0
271	110	−0.32	–	0.23	−0.062	5.5^-#	1.5^+#	5
272	106	3.10	–	0.221	−0.072	0^+	0^+	0
272	107	0.74	–	0.221	−0.071			0
272	108	−1.72	–	0.231	−0.078	0^+	0^+	0
272	109	−2.08	–	0.23	−0.069			0
272	110	−2.65	–	0.23	−0.069	0^+	0^+	0
272	111	−3.40	–	0.221	−0.071	5^+#	5^+#	0
273	107	1.81	–	0.221	−0.08			0
273	108	−0.55	–	0.222	−0.079	1.5^+#		0
273	109	−2.86	–	0.231	−0.077			0
273	110	−3.52	–	0.231	−0.078	6.5^-#		0
273	111	−3.05	–	0.231	−0.078			0
274	107	3.36	–	0.212	−0.073			0
274	108	−0.05	–	0.221	−0.08	0^+	0^+	0
274	109	−1.89	–	0.222	−0.079			0
274	110	−4.23	–	0.231	−0.086	0^+	0^+	0
274	111	−3.81	–	0.222	−0.079			0
275	108	1.52	–	0.212	−0.082			0
275	109	−1.06	–	0.221	−0.08			0
275	110	−2.92	–	0.222	−0.088			0
275	111	−3.92	–	0.231	−0.087			0
276	108	2.20	–	0.201	−0.074	0^+	0^+	0
276	109	−0.03	–	0.221	−0.089			0
276	110	−2.35	–	0.222	−0.089	0^+	0^+	0
276	111	−3.23	–	0.222	−0.088			0
277	108	4.22	–	0.183	−0.069	1.5^+#		0
277	109	0.65	–	0.212	−0.082			0
277	110	−0.84	–	0.221	−0.09	5.5^+#	1.5^+#	4
277	111	−3.08	–	0.222	−0.089			0
277	112	−1.51	–	0.222	−0.089	1.5^+#	6.5^-#	5
278	109	2.10	–	0.192	−0.076			0
278	110	−0.77	–	0.212	−0.091	0^+	0^+	0
278	111	−1.82	–	0.222	−0.097			0
278	112	−3.61	–	0.222	−0.097	0^+	0^+	0
279	109	3.34	–	0.164	−0.063			0
279	110	1.05	–	0.183	−0.077			0
279	111	−1.31	–	0.212	−0.091			0
279	112	−2.00	–	0.221	−0.098			0
280	110	1.38	–	0.164	−0.063	0^+	0^+	0
280	111	0.14	–	0.202	−0.092			0
280	112	−1.76	–	0.212	−0.091	0^+	0^+	0
281	110	3.18	–	0.145	−0.049	1.5^+#	1.5^+#	0
281	111	1.09	–	0.164	−0.063			0
281	112	−0.01	–	0.173	−0.071	1.5^+#	5.5^+#	4
282	111	2.14	–	0.136	−0.041			0
282	112	0.18	–	0.155	−0.055	0^+	0^+	0
283	111	3.34	–	0.108	−0.019			0
283	112	1.91	–	0.127	−0.033			0
283	113	−0.88	–	0.164	−0.063			0
284	112	2.29	–	0.108	−0.028	0^+	0^+	0
284	113	0.36	–	0.117	−0.027			0
285	112	4.63	–	0.108	−0.028	2.5^+#	1.5^+#	2
285	113	0.81	–	0.099	−0.02			0

(*continued on next page*)

Table 1 (*continued*)

A_p	Z_p	$\mathscr{T}^{\rm theor}$	$\mathscr{T}^{\rm exp}$	β_2	β_4	$j_{\rm p}^{\pi}$	$j_{\rm d}^{\pi}$	$l_{\rm min}$
285	114	−1.13	–	0.089	−0.012	1.5^{+}#	1.5^{+}#	0
286	113	1.98	–	0.099	−0.02			0
286	114	−1.01	–	0.089	−0.012	0^{+}	0^{+}	0
287	113	2.85	–	0.099	−0.036			0
287	114	0.31	–	0.089	−0.012			0
287	115	−1.84	–	0.072	−0.006			0
288	114	0.94	–	0.089	−0.029	0^{+}	0^{+}	0
288	115	−0.94	–	0.08	−0.013			0
289	114	1.92	–	0.089	−0.037	2.5^{+}#	2.5^{+}#	0
289	115	−0.08	–	0.072	−0.022			0
289	116	−2.45	–	−0.096	0.027	2.5^{+}#	1.5^{+}#	2
290	115	0.90	–	0.072	−0.03			0
290	116	−2.18	–	−0.096	0.035	0^{+}	0^{+}	0
291	115	1.54	–	0.062	−0.031			0
291	116	−0.75	–	−0.078	0.034			0
291	117	−2.89	–	−0.096	0.027			0
292	116	−0.40	–	0.053	−0.023	0^{+}	0^{+}	0
292	117	−2.00	–	−0.087	0.018			0
293	118	−2.90	–	0.08	−0.022	0.5^{+}#	2.5^{+}#	2

Table 2

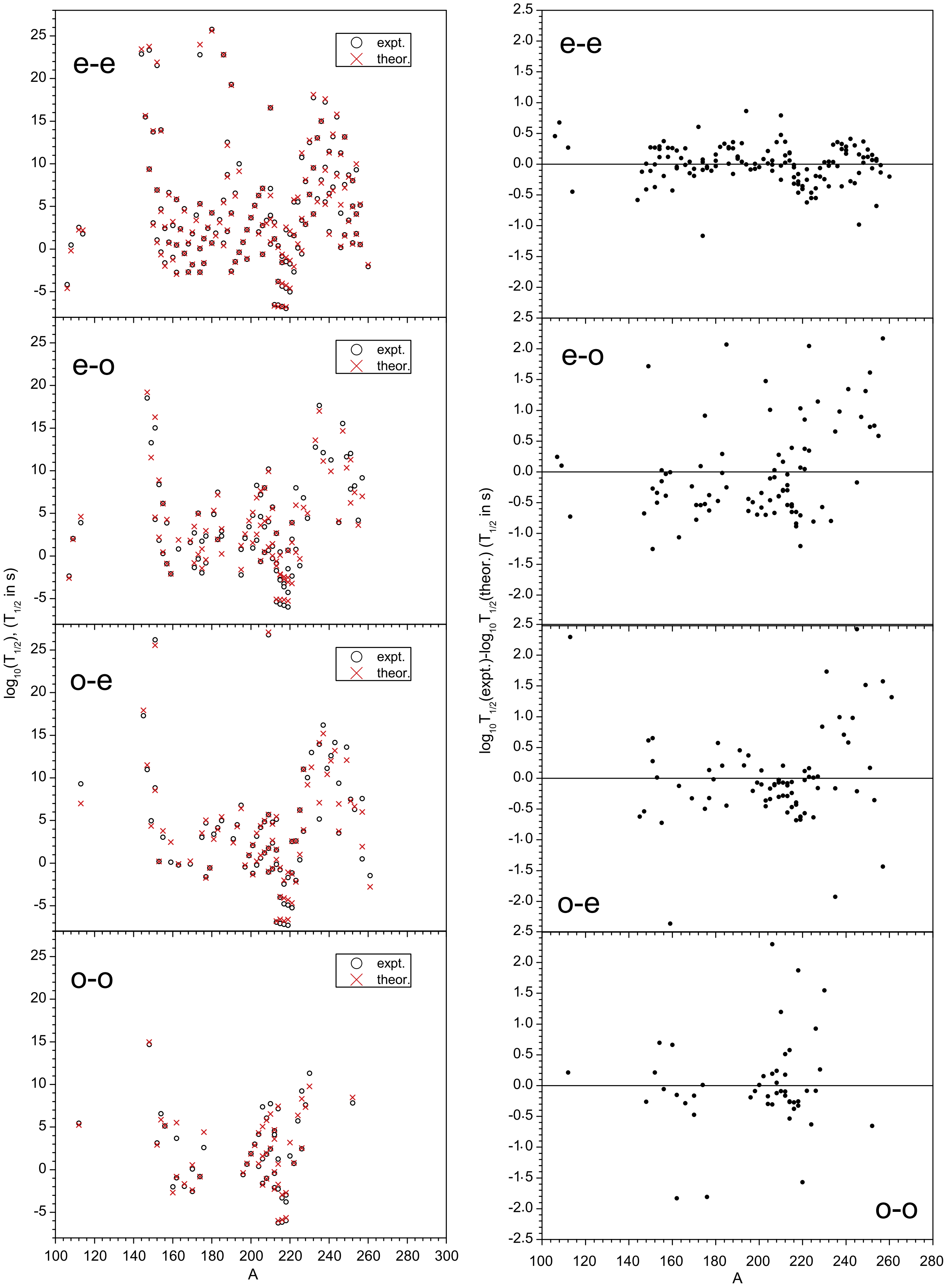
RMS errors of the decimal logarithm of α-decay half-lives for a full set of α-emitters. These have been obtained for different models for 344 (tot), 136 even–even (e–e), 84 even–odd (e–o), 76 odd–even (o–e), and 48 odd–odd (o–o) α-emitters using our dataset for the ground-state-to-ground-state α-transition half-lives. See page 822 for Explanation of Tables.

Tot	e–e	e–o	o–e	o–o	
0.6248	0.3088	0.7816	0.7621	0.7546	UMADAC
1.0185	0.5165	1.1611	1.3348	1.2568	[5]
1.1130	0.3837	1.4762	1.3688	1.3340	[23]
1.1285	0.3712	1.5425	1.3541	1.3307	[27]
1.3813	1.2928	1.4300	1.5607	1.2751	[35]

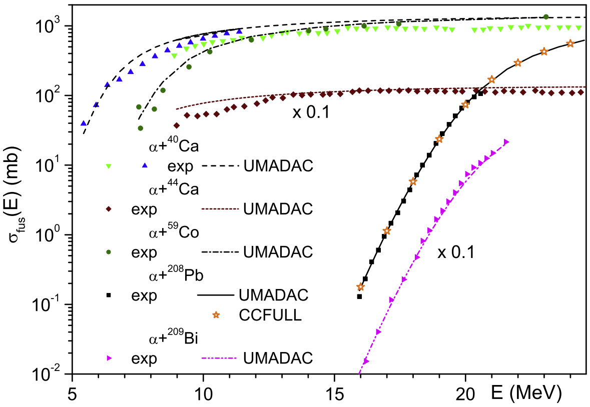
Table 3

RMS errors of the decimal logarithm of α-decay half-lives for nuclei heavier than $^{208}_{82}$Pb. These have been obtained for different models for α-emitters using our dataset for the ground-state-to-ground-state α-transition half-lives. This dataset contains 144 (tot), 59 even–even (e–e), 33 even–odd (e–o), 34 odd–even (o–e), and 18 odd–odd (o–o) α-emitters. See page 822 for Explanation of Tables.

Tot	e–e	e–o	o–e	o–o	
0.7170	0.3135	0.9521	0.9184	0.8032	UMADAC
1.2326	0.2854	1.8008	1.4748	1.4753	[35]
1.2516	0.3861	1.6558	1.5062	1.7615	[5]
1.3410	0.3067	2.0223	1.6186	1.4219	[37]
1.4399	0.2202	2.1371	1.6545	1.8339	[23]
1.4933	0.3701	2.2528	1.6663	1.8292	[27]
1.6926	0.2187	2.5050	1.9202	2.2285	[10]
8.6375	7.6761	9.7315	9.0791	9.3946	[39]



Graph 1. Comparison between the experimental and theoretical values of $\log_{10}(T_{1/2})$ for α-decays.



Graph 2. The experimental and theoretical values of the α-capture cross section of ^{40}Ca, ^{44}Ca, ^{59}Co, ^{208}Pb, and ^{209}Bi.