

Investigation of the α -decay half-lives for even-even nuclei within a deformed two-potential approach*

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Abstract: In this study, we systematically investigate the α -decay half-lives of 195 even-even nuclei using a deformed two-potential approach (TPA). The cosh potential with fixed diffuseness parameter is adopted as the nuclear potential, for which deformation parameters are taken from the FRDM, WS4, and DRHBc models. The root mean square deviation (RMSD) decreases from 0.515 to 0.385, 0.401, and 0.436, respectively, indicating that incorporating nuclear deformations enables the deformed TPA to accurately reproduce experimental α -decay half-lives. Furthermore, by fitting the diffuseness parameter across various mass regions, the RMSD is further reduced, from 0.385 to 0.330, 0.401 to 0.343, and 0.436 to 0.363. Additionally, the deformed TPA, combined with the fitted diffuseness parameter, is extended to predict the α -decay half-lives of even-even nuclei with $Z = 118$ and 120. The results suggest that $N = 184$ may be the next neutron magic number, following $N = 126$.

Keywords: alpha-decay half-lives, two-potential approach, nuclear deformation

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I. INTRODUCTION

In 1899, Rutherford discovered the phenomenon of natural α -radioactivity, marking the beginning of significant developments in nuclear decay studies. The process of α decay, explained by quantum tunneling, was first formulated by Gurney and Condon [1] and Gamow [2] in 1928. Within Wenzel-Kramers-Brillouin (WKB) approximation, α -decay is treated as two key stages: (1) the preformation of an α cluster, bound within the parent nucleus with a certain probability known as the α preformation factor P_α , and (2) the escape of the α cluster through quantum tunneling, resulting in an independent α particle with a penetration probability P_0 . α decay is the primary decay mode for many unstable nuclei, and its study provides valuable insights into nuclear structure, including ground-state properties, level structures, and shell closure effects [3–8]. Additionally, α decay plays a vital role in the discovery of new elements and the synthesis of superheavy nuclei [9–11]. Thus, research on α decay is significant in the field of nuclear physics, contributing to both theoretical understanding and experimental advancements.

Various nuclear models have been proposed to study α -decay half-lives, including the generalized liquid drop

model (GLDM) [12–15], Coulomb and proximity potential model (CPPM) [16], two-potential approach (TPA) [17–19], unified fission model (UFM) [9], and density-dependent cluster model (DDCM) [20–22]. Additionally, numerous empirical formulas have been developed for calculating α -decay half-lives, including the Geiger-Nuttall law [23], the Viola-Seaborg formula [24, 25], Brown's formula [26], Royer's formula [12], and the universal decay law (UDL) [27]. To improve the accuracy in describing experimental α -decay half-lives, researchers have proposed several modifications to these formulas [28–33].

Recent studies [34–38] have demonstrated that nuclear deformation plays an essential role in α -decay. Recently, Li *et al.* [38] systematically study the α -decay half-lives of even-even nuclei using a deformed TPA by considering nuclear deformation in the cosh potential. The corresponding root mean square deviation (RMSD) reduces from 0.573 to 0.506, which shows that some improvement can be achieved by considering nuclear deformations. In Ref. [39], the authors emphasized that a nontrivial behavior of the nuclear diffuseness as the system becomes increasingly deformed. For the spherical nucleus, a diffuseness parameter $a_0 = 0.59$ fm is used, whereas for the deformed ^{238}U , the three values are $a_0 =$

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0.494, 0.5504, and 0.5832 fm. These values correspond to the minimal, average, and maximal values of the radial diffuseness, respectively. In addition, in Ref. [40], the authors showed that for different mass numbers, the value of average diffuseness a_0 is different, approximately ranging from 0.27 to 0.65. Within the DDCM+ framework, Ren *et al.* investigated the impacts of diffuseness polarization and anisotropy on α -decay half-lives. They showed that, by introducing an adjustable parameter of deformation-dependent diffuseness in the nuclear density distribution, the model's capability of reproducing the half-lives of α -decay can be improved [21].

In this study, the α -decay half-lives of 195 even-even nuclei are systematically investigated using a deformed TPA. The nuclear potential is modeled using a cosh potential with a fixed diffuseness parameter, and nuclear deformations are taken from the FRDM, WS4, and DRHBc models, respectively. Building on this, a novel approach is introduced: the diffuseness parameter a_0 is refitted to experimental α -decay half-lives across distinct mass regions. To further validate the fitted diffuseness parameter, we apply the deformed TPA model with nuclear deformations from ws4 and DRHBc models. The RMSDs between calculated and experimental α -decay half-lives are then evaluated. These results are compared with those obtained using the fixed diffuseness parameter $a_0 = 0.5958$.

The remainder of this paper is organized as follows. In Sec. II, the detailed framework of the calculation of α -decay half-lives with a deformed TPA is presented. The corresponding calculated results are given and discussed in Sec. III. A brief summary is given in Sec. IV.

II. THEORETICAL FRAMEWORK

In the framework of the two-potential approach, the α -decay half-lives can be obtained using the decay width Γ [40–42]. It can be expressed as follows:

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

where the decay width Γ is defined as

$$\Gamma = \frac{\hbar^2 P_\alpha F P_0}{4\mu}, \quad (2)$$

where P_α and P_0 are the preformation and penetration factors, respectively. $\mu = \frac{m_d m_\alpha}{m_d + m_\alpha}$ represents the reduced mass between the α particle and daughter nucleus, where m_d and m_α denote the masses of the daughter nucleus and α particle, respectively. F is the normalization factor, which characterizes the assault frequency of the α particle.

The α -preformation factor, denoted as P_α , represents the probability of an α -cluster existing within the parent nucleus under the cluster model. A precise determination of P_α is crucial for enhancing the accuracy of theoretical α -decay half-lives. In this study, we employ a formalism extended from the cluster-formation model (CFM), using the formation energy derived from separation energy to estimate P_α , based on the formula provided in references [43, 44].

$$P_\alpha = \frac{E_{f\alpha}}{E_\alpha}. \quad (3)$$

For even-even nuclei, the formation energy $E_{f\alpha}$ and α -cluster separation energy are given by

$$E_{f\alpha} = 2S_p + 2S_n - S_\alpha, \quad (4)$$

$$E_\alpha = S_\alpha(A, Z) = B(A, Z) - B(A-4, Z-2). \quad (5)$$

Here, $B(A, Z)$ denotes the binding energy of a nucleus with mass number A and proton number Z .

For the normalization factor, denoted as F , it can be approximated by the following expression:

$$F = \frac{1}{\int_{r_1}^{r_2} \frac{1}{2k(r)} dr}. \quad (6)$$

The penetration probability P_0 is calculated using the Wentzel-Kramers-Brillouin (WKB) approximation:

$$P_0 = \exp \left[-\frac{2}{\hbar} \int_{r_2}^{r_3} \sqrt{2\mu(r)(V(r) - Q_\alpha)} dr \right], \quad (7)$$

where r_1 , r_2 , and r_3 are the classical turning points of the WKB action integral with $V(r_1) = V(r_2) = V(r_3) = Q_\alpha$, and Q_α is the α -decay energy. When considering the influence of deformation, F and P_0 can be expressed as

$$F = \frac{1}{2} \int_0^\pi \frac{1}{\int_{r_1}^{r_2} \frac{1}{2k(r(\theta))} dr} \sin \theta d\theta, \quad (8)$$

$$P_0 = \frac{1}{2} \int_0^\pi \exp \left[-2 \int_{r_2}^{r_3} k(r(\theta)) dr \right] \sin \theta d\theta, \quad (9)$$

where $k(r(\theta)) = \sqrt{\left(\frac{2\mu}{\hbar^2}\right) |Q_\alpha - V(r(\theta))|}$. θ is the angle between the emission direction of the α particle and the

axis of rotational symmetry of the deformed nucleus.

The effective potential $V(r)$ between the α cluster and the daughter nucleus is expressed as

$$V(r) = V_N(r) + V_C(r) + V_l(r), \quad (10)$$

with $V_N(r)$ being the nuclear potential, $V_C(r)$ being the Coulomb potential, and $V_l(r)$ being the centrifugal potential.

For the nuclear potential $V_N(r)$, we employ the cosh-parametrized form [45]:

$$V_N(r) = \frac{-V_0(1 + \cosh(R'_d/a_0))}{(\cosh(r/a_0) + \cosh(R'_d/a_0))}, \quad (11)$$

where the parameters V_0 and a_0 denote the depth and diffuseness of the potential [46], respectively. The parameter V_0 is given as $V_0 = 192.42 + 31.059 \frac{N_d - Z_d}{A_d}$ [47]. Considering the effects of the deformation, R'_d of the daughter nucleus is given by [48]

$$R'_d(\theta) = R_d(1 + \beta_2 Y_{20}(\theta) + \beta_4 Y_{40}(\theta) + \beta_6 Y_{60}(\theta)), \quad (12)$$

where β_2 , β_4 , and β_6 are quadrupole, hexadecapole, and hexacontatetrapole deformations of daughter nuclei, respectively [49]. Y_{lm} is spherical harmonics function. R_d is the sharp radius of daughter nucleus, which is expressed by an empirical formula.

$$R_d = (1.28A_d^{1/3} - 0.76 + 0.8A_d^{-1/3}) \text{ fm}. \quad (13)$$

Considering the effect of the deformations, the Coulomb potential $V_C(r)$ between the α cluster and the daughter nucleus is expressed as [50]

$$V_C(\vec{r}, \theta) = \int \int \frac{\rho_d(\vec{r}_1) \rho_\alpha(\vec{r}_2)}{|\vec{r} + \vec{r}_2 - \vec{r}_1|} d\vec{r}_2 d\vec{r}_1, \quad (14)$$

where $\vec{r}$ is the vector between the centres of the α particle and daughter nucleus, $\vec{r}_1$ and $\vec{r}_2$ are the radius vectors in the charge distributions of the α particle and daughter nucleus. θ represents the angle between the emission direction of the α particle and the axis of rotational symmetry of deformed nucleus, which are implicit in ρ_α and ρ_d . Properly simplified using Fourier transform, the Coulomb potential can be approximated as

$$V_C(\vec{r}, \theta) = V_C^{(0)}(r) + V_C^{(1)}(\vec{r}, \theta) + V_C^{(2)}(\vec{r}, \theta), \quad (15)$$

where $V_C^{(0)}(r)$, $V_C^{(1)}(\vec{r}, \theta)$, and $V_C^{(2)}(\vec{r}, \theta)$ are the bare Coulomb interaction, linear Coulomb coupling, and second-

order Coulomb coupling, respectively [51].

The centrifugal potential is given by [52]

$$V_l(r) = \frac{\hbar^2}{2\mu r^2} l(l+1), \quad (16)$$

where l is the angular momentum taken away by the α cluster. For even-even nuclei, l is always 0. Hence, the influence of the angular momentum on α -decay half-lives is not considered in this work.

III. RESULTS AND DISCUSSIONS

A. Effect of deformation on α -decay half-lives of the even-even nuclei with $Z = 52 - 118$ within a deformed TPA

In this study, the α -decay half-lives of 195 even-even nuclei are systematically investigated using a two-potential approach improved by considering nuclear deformation. The experimental α -decay half-lives, α -decay energies (Q_α), and binding energies are taken from NUBASE2020 [53] and AME2020 [54]. Using a fixed diffuseness parameter of $a_0 = 0.5958$ in a cosh potential, α -decay half-lives are calculated for the even-even nuclei without considering nuclear deformation, denoted as $\log_{10} T_{1/2}^{\text{Cal}(1)}$. Within the deformed two-potential approach, when the nuclear deformations of the daughter nuclei (β_2 , β_4 , and β_6) are taken from the FRDM2012 [55], WS4 [49], and DRHBc [56] mass models, the corresponding α -decay half-lives are denoted by $\log_{10} T_{1/2}^{\text{Cal}(2)}$, $\log_{10} T_{1/2}^{\text{Cal}(3)}$, and $\log_{10} T_{1/2}^{\text{Cal}(4)}$. Note that the DRHBc mass model does not include the hexadecapole and hexacontatetrapole deformations (β_4 and β_6); therefore, we fix $\beta_4 = \beta_6 = 0$ in the α -decay half-lives calculations.

In Ref. [39], the authors emphasized that the average diffuseness parameter a_0 varies with different mass numbers. In this study, in the deformed TPA, the diffuseness parameter a_0 is determined by fitting the experimental α -decay half-lives of the nuclei within a deformed two-potential approach, when nuclear deformations are taken from the FRDM model. The values of fitted diffuseness parameter a_0 are listed in Table 1 and the corresponding calculated α -decay half-lives of the nuclei is denoted by $\log_{10} T_{1/2}^{\text{Cal}(5)}$. Using the fitted diffuseness parameter a_0 , the

Table 1. Diffuseness parameters a_0 for different mass regions.

A	a_0/fm	A	a_0/fm
102-150	0.6750	152-178	0.6080
180-212	0.5550	214-242	0.6080
244-254	0.5780	256-294	0.5600

α -decay half-lives are also calculated with the deformed TPA approach, using nuclear deformations taken from the WS4 and DRHBc models, denoted by $\log_{10} T_{1/2}^{\text{Cal}(6)}$, and $\log_{10} T_{1/2}^{\text{Cal}(7)}$, respectively.

To precisely compare model predictions of α -decay half-lives with experimental data, we calculate the RMSD for the nuclei as follows:

$$\sigma_i = \sqrt{\sum (\log_{10} T_{1/2}^{\text{Cal}(i)} - \log_{10} T_{1/2}^{\text{exp}})^2 / n}, \quad (17)$$

where $\log_{10} T_{1/2}^{\text{Cal}(i)}$ represents the calculated α -decay half-life using TPA, and $\log_{10} T_{1/2}^{\text{exp}}$ denotes the experimental α -decay half-life. The values σ_1 , σ_2 , σ_3 , and σ_4 correspond to the deviations (σ) between the experimental and calculated α -decay half-lives: $\log_{10} T_{1/2}^{\text{Cal}(1)}$, $\log_{10} T_{1/2}^{\text{Cal}(2)}$, $\log_{10} T_{1/2}^{\text{Cal}(3)}$, and $\log_{10} T_{1/2}^{\text{Cal}(4)}$, with the diffuseness parameter $a_0 = 0.5958$, respectively. Similarly, σ_5 , σ_6 , and σ_7 represent the σ deviations between the experimental and calculated α -decay half-lives: $\log_{10} T_{1/2}^{\text{Cal}(5)}$, $\log_{10} T_{1/2}^{\text{Cal}(6)}$, and $\log_{10} T_{1/2}^{\text{Cal}(7)}$, respectively, where the fitted diffuse parameter a_0 is obtained from Table 1. The corresponding RMSDs between the experimental and calculated α -decay half-lives within the TPA framework are listed in Table 2.

Table 2 shows that when nuclear deformations from the FRDM model [55] are considered within the deformed TPA, and the diffuseness parameter $a_0 = 0.5958$ is used in the cosh potential, the σ -value decreases from 0.515 to 0.385. This confirms that including nuclear deformations enhances the agreement between calculated results of the deformed TPA and experimental data, which is consistent with the conclusions of Ref. [38]. A similar trend is observed when nuclear deformations from the WS4 [49] and DRHBc [56] models are used, with the σ -value decreasing from 0.515 to 0.401 and 0.436, respectively. As shown in Fig. 1, the RMSDs calculated using the deformed TPA are lower than those without considering nuclear deformations. Additionally, when the nuclear deformation are taken from the DRHBc model, the RMSD is higher than those calculated using nuclear deformations from the WS4 and FRDM models. This is because the DRHBc model does not provide values for β_4 and β_6 , which are assumed to be zero in this study. This assumption reduces the accuracy of the α -decay half-life calculations, leading to a higher RMSD than for the res-

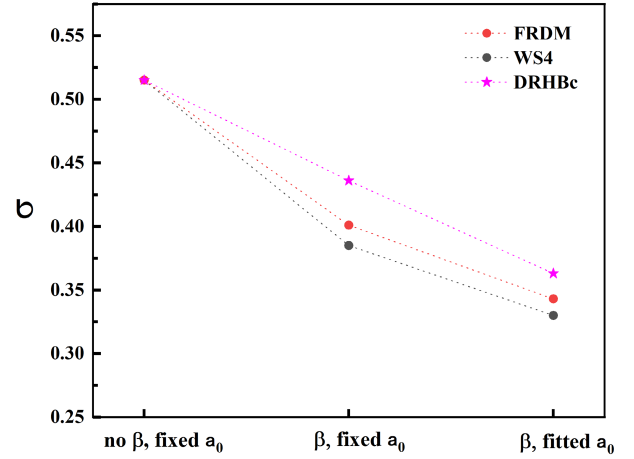


Fig. 1. (color online) Root mean square deviations between the experimental data and calculated results by using the deformed TPA with nuclear deformations obtained from FRDM, WS4, and DRHBc models, respectively.

ults obtained when using deformation parameters from the WS4 and FRDM models.

To gain a more detailed insight, Fig. 2 presents the logarithmic deviations between the experimental data and calculated results using the deformed TPA with deformation parameters from the FRDM model. As shown in Fig. 2, the deviations between the theoretical and experimental values significantly reduce when nuclear deformations are considered, particularly for $158 \leq A \leq 180$ and $222 \leq A \leq 254$. This improvement is attributed to the fact that, for most nuclei in the mass region $158 \leq A \leq 180$, the quadrupole deformation of their daughter nuclei exceeds an absolute value of 0.15. Meanwhile, for nuclei in the $222 \leq A \leq 254$ region, the quadrupole deformation of daughter nuclei of these nuclei has an absolute value greater than 0.2. Previous studies have shown that quadrupole deformation has a more significant impact on α -decay half-lives than other deformations, such as hexadecapole deformations [34]. Therefore, considering quadrupole deformation of the daughter nuclei leads to an improvement in the deviation between calculated and experimental values for these nuclei.

To illustrate the impact of deformation on the α -decay process, we calculated the effective potential $V(r)$ of ^{232}Th with and without considering deformation in TPA. As shown in Fig. 3, when deformation is considered, the width and height of the effective potential $V(r)$ decreases,

Table 2. Root mean square deviations between experimental α -decay half-lives and the calculated results using TPA.

deformation source	TPA without β			TPA with β			
	–	FRDM	WS4	DRHBc			
RMSD	σ_1	σ_2	σ_5	σ_3	σ_6	σ_4	σ_7
value	0.515	0.385	0.330	0.401	0.343	0.436	0.363

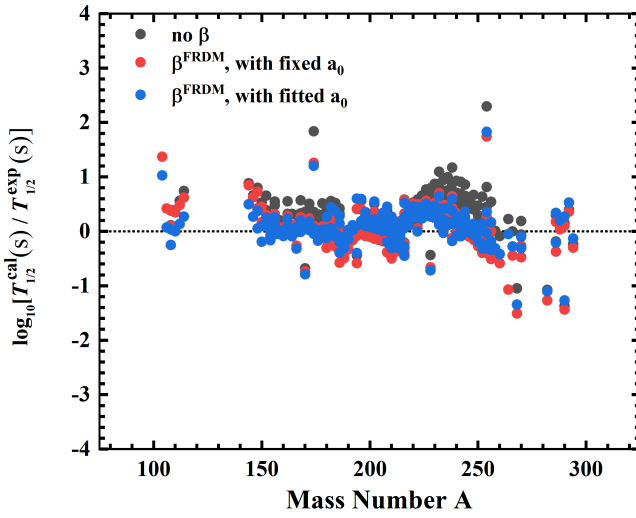


Fig. 2. (color online) Deviations between experimental and calculated α -decay half-lives. The x-axis represents the mass number of the nuclei and y-axis represents the deviation of the decimal logarithms of $T_{1/2}^{\text{cal}}/T_{1/2}^{\text{exp}}$. The black circles represent the theoretical values calculated using the TPA without considering deformation. The red and blue circles represent the theoretical values calculated using the deformed TPA with nuclear deformations obtained from FRDM model, when the diffuseness parameter are taken as fixed and fitted a_0 , respectively.

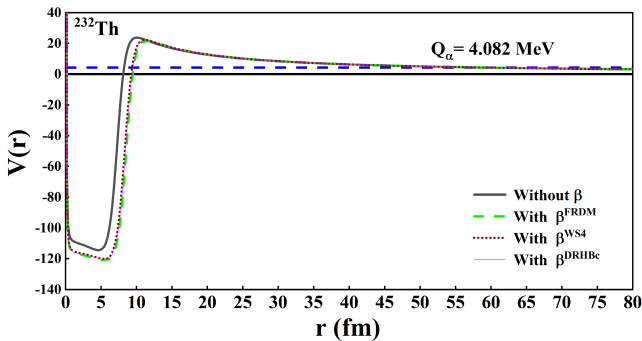


Fig. 3. (color online) Variation in $V(r)$ for the nucleus ^{232}Th in TPA with and without deformation. The black dashed line represents the potential without deformation, whereas the other three curves correspond to the potential changes with deformation from the FRDM (green dashed line), WS4 (brown dashed line), and DRHB (red dashed line) models.

indicating that the α -particle has a higher probability of tunneling through the potential barrier. Specifically, the logarithmic deviation between the theoretical and experimental α -decay half-life for ^{232}Th without considering deformation is 0.988, with the theoretical value being higher than the experimental value. When deformation is considered, the reduction in the width and height of the effective potential $V(r)$ leads to a lower α -decay half-life, resulting in a better agreement with experimental data.

The logarithmic deviation between the theoretical and experimental α -decay half-life after considering deformation is 0.451 (FRDM model), 0.353 (WS4 model), and 0.521 (DRHBc model), showing improved accuracy. These results demonstrate the importance of incorporating deformation effects in TPA to enhance the precision of α -decay half-lives calculations and reduce the discrepancy between theoretical and experimental values.

Additionally, some studies have shown that the average diffuseness parameter a_0 varies across different mass regions, and by adjusting a_0 , the accuracy of the model in calculating α -decay half-lives can be enhanced [21, 39]. To further improve the accuracy of the deformed TPA approach, we fit the diffuseness parameter a_0 for different mass regions based on experimental data. With the fitted a_0 , the deviations between the calculated α -decay half-lives and experimental values are represented by the blue circles in Fig. 2. We observe that, compared with the fixed $a_0 = 0.5958$, these data points lie closer to the zero line, particularly in the regions $100 \leq A \leq 152$ and $180 \leq A \leq 214$. Additionally, the RMSD decreases from 0.385 to 0.330. This demonstrates that adjusting the diffuseness parameter a_0 improves the accuracy of the model in calculating α -decay half-lives.

To further verify the reliability of the fitted a_0 , we calculated the α -decay half-lives using the same approach with deformation parameters from the WS4 and DRHBc models, and the results are compared with experimental values. The deviations are shown in Fig. 4. As observed, with the fitted a_0 , the deviations between the calculated α -decay half-lives and experimental values are further reduced, with the σ -values decreasing from 0.401 to 0.343 and from 0.436 to 0.363 when the deformation parameters are taken from the WS4 and DRHBc models, respectively. This confirms the effectiveness of adjusting the diffuseness parameter a_0 to enhance the accuracy of α -decay half-life calculations.

B. Predictions of α -decay half-lives of even even nuclei with $Z=180$ and 120

Using the deformed TPA with diffuseness $a_0 = 0.5600$ in cosh potential, we predict the α -decay half-lives of even-even nuclei with $Z = 180$ and 120 isotopes. In Table 3, the first column represents the parent nucleus. The binding energies required to calculate P_α and Q_α are taken from the WS4 [49] and FRDM [55] models, respectively, which are shown in second to fifth columns. $\log_{10} T_{1/2}^{\text{Cal}(9)}$ and $\log_{10} T_{1/2}^{\text{Cal}(10)}$ in last two columns represent the logarithms of the calculated α -decay half-lives, when nuclear deformations are taken from the WS4 [49] and FRDM [55] models, respectively.

The calculated α -decay half-lives of the nuclei with $Z = 118$ and 120 are plotted in Fig. 5. From Fig. 5, we observed that for the isotopes $^{306, 308}118$ and $^{316}120$, the val-

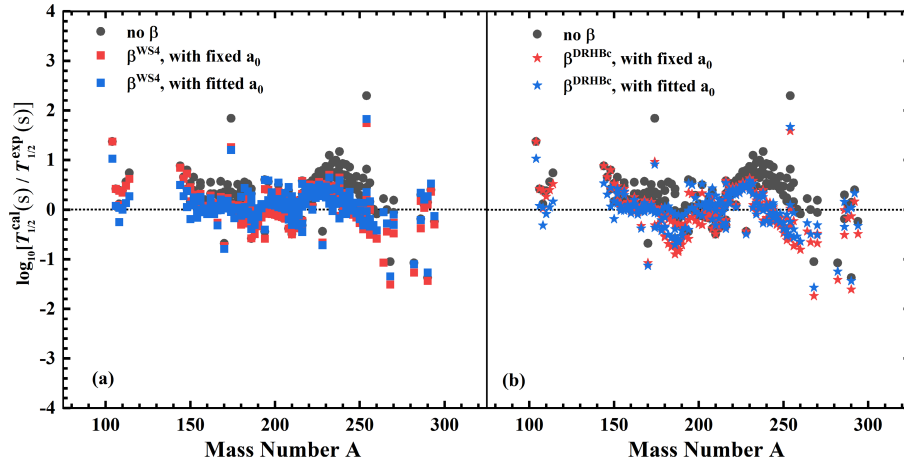


Fig. 4. (color online) Same as Fig. 3 but nuclear deformations are obtained from WS4 (a) and DRHBc (b) models, respectively.

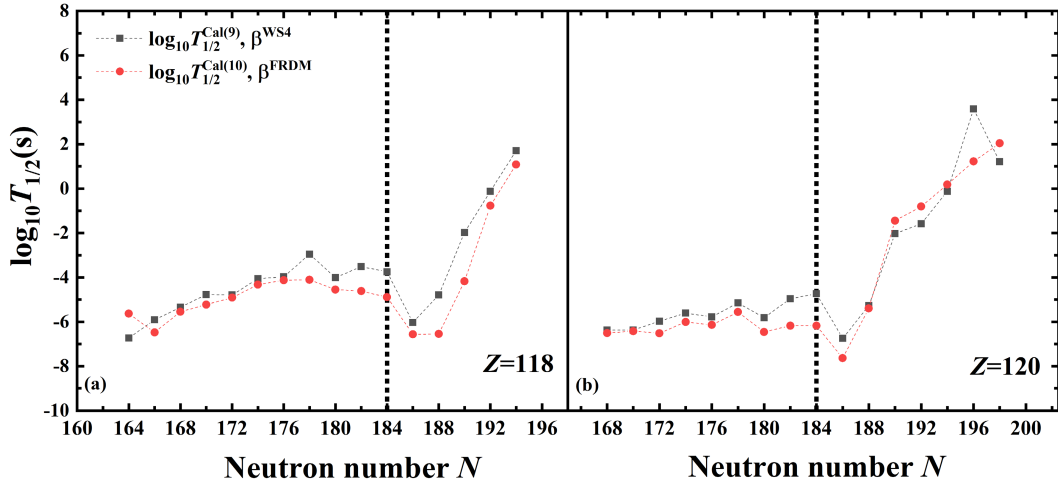


Fig. 5. (color online) Predictions of logarithms of α -decay half-lives of even-even nuclei with $Z=118$ and 120 using the deformed TPA with the fitted a_0 . The Q_α and nuclear deformations β_2 , β_4 , and β_6 are taken from the WS4 [49] and FRDM [55] models, respectively. The corresponding results of logarithms of α -decay half-lives are denoted by $\log_{10} T_{1/2}^{\text{Cal}(9)}$ and $\log_{10} T_{1/2}^{\text{Cal}(10)}$, respectively. The black dashed lines denote the neutron number $N=184$.

ues of $\log_{10}(T_{1/2}^{\text{Cal}(9)}/T_{1/2}^{\text{Cal}(10)})$ exceed 1.7. This is owing to the α -decay energy of these nuclei differences between the WS4 and FRDM models, which are greater than 0.8 MeV. Despite significant differences in $\log_{10} T_{1/2}^{\text{Cal}(9)}$ and $\log_{10} T_{1/2}^{\text{Cal}(10)}$ for certain isotopes, the trends in the α -decay half-lives of the even-even isotopic chains for $Z=118$ and $Z=120$ are generally consistent. We observed that when the neutron number exceeds $N=184$, the α -decay half-lives of the nuclei with $N=186$ decrease significantly, by more than 1.5 orders of magnitude. This change highlights the pronounced shell effects, suggesting that $N=184$ appears to be the next magic number beyond $N=126$. These results not only confirm the pivotal role of decay energy in α -decay but also provide new insights into the stability and nuclear structure of superheavy nuclei.

IV. SUMMARY

This study investigates the α -decay half-lives of 195 even-even nuclei within the framework of a deformed TPA. By incorporating nuclear deformations from three models-FRDM, WS4, and DRHBc-along with a fixed diffuseness parameter in the cosh potential, the deformed TPA can reasonably reproduce the experimental α -decay half-lives. The RMSDs between the calculated and experimental α -decay half-lives are reduced from 0.515 to 0.385, 0.401, and 0.436 for the respective models, suggesting that including nuclear deformations improves the accuracy of α -decay calculations. Additionally, fitting the diffuseness parameter across various mass regions further enhances the deformed TPA's performance, lowering the RMSD values to 0.330, 0.343, and 0.363. The deformed TPA, with the fitted diffuseness parameter, is ex-

Table 3. Predictions of α -decay half-lives of even-even nuclei with $Z=180$ and 120 , with the α -decay energies and nuclear deformations β_2 , β_4 , and β_6 obtained from the WS4 [50] and FRDM [56] mass models, respectively. The logarithms of α -decay half-lives were calculated using the deformed TPA with the fitted a_0 , denoted by $\log_{10} T_{1/2}^{\text{Cal(9)}}$ and $\log_{10} T_{1/2}^{\text{Cal(10)}}$, respectively, with the values of the nuclear deformation obtained from the WS4 and FRDM models.

Nucleus	Q^{WS4}	Q^{FRDM}	$lgP_{\alpha}^{\text{WS4}}$	$lgP_{\alpha}^{\text{FRDM}}$	$\log_{10} T_{1/2}^{\text{Cal(9)}}$	$\log_{10} T_{1/2}^{\text{Cal(10)}}$
$^{282}118$	13.49	13.12	-0.528	-0.663	-6.727	-5.633
$^{284}118$	13.21	13.56	-0.591	-0.663	-5.914	-6.477
$^{286}118$	12.89	13.05	-0.593	-0.719	-5.348	-5.547
$^{288}118$	12.59	12.86	-0.629	-0.723	-4.769	-5.224
$^{290}118$	12.57	12.68	-0.620	-0.728	-4.792	-4.911
$^{292}118$	12.21	12.39	-0.629	-0.744	-4.057	-4.328
$^{294}118$	12.17	12.37	-0.658	-0.926	-3.974	-4.125
$^{296}118$	11.73	12.28	-0.700	-0.796	-2.955	-4.108
$^{298}118$	12.16	12.49	-0.658	-0.803	-4.010	-4.548
$^{300}118$	11.93	12.51	-0.671	-0.795	-3.512	-4.617
$^{302}118$	12.02	12.62	-0.660	-0.791	-3.746	-4.888
$^{304}118$	13.10	13.39	-0.637	-0.646	-6.030	-6.564
$^{306}118$	12.46	13.35	-0.628	-0.622	-4.792	-6.547
$^{308}118$	11.18	12.10	-0.599	-0.518	-1.977	-4.173
$^{310}118$	10.41	10.74	-0.710	-0.703	-0.122	-0.772
$^{312}118$	9.74	10.05	-0.694	-0.678	1.711	1.080
$^{288}120$	13.71	13.85	-0.593	-0.717	-6.368	-6.508
$^{290}120$	13.68	13.75	-0.602	-0.681	-6.368	-6.420
$^{292}120$	13.44	13.78	-0.594	-0.690	-5.972	-6.516
$^{294}120$	13.22	13.49	-0.613	-0.707	-5.608	-6.005
$^{296}120$	13.32	13.59	-0.622	-0.771	-5.777	-6.145
$^{298}120$	12.98	13.24	-0.646	-0.715	-5.151	-5.560
$^{300}120$	13.29	13.70	-0.615	-0.713	-5.813	-6.460
$^{302}120$	12.87	13.55	-0.623	-0.731	-4.960	-6.175
$^{304}120$	12.74	13.55	-0.623	-0.749	-4.738	-6.176
$^{306}120$	13.77	14.28	-0.610	-0.622	-6.750	-7.641
$^{308}120$	12.95	12.96	-0.575	-0.481	-5.273	-5.395
$^{310}120$	11.48	11.29	-0.645	-0.712	-2.030	-1.446
$^{312}120$	11.20	10.71	-0.702	-0.793	-1.584	-0.810
$^{314}120$	10.74	10.33	-1.039	-0.801	-0.123	0.182
$^{316}120$	9.17	9.94	-0.862	-0.783	3.591	1.223
$^{318}120$	9.91	9.66	-0.756	-0.790	1.214	2.043

tended to predict the α -decay half-lives of even-even nuclei with $Z = 118$ and 120 . The results suggest that $N = 184$ could be the next neutron magic number beyond $N = 126$,

providing useful insights into the nuclear structure of superheavy elements.

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