Nuclear half lives for alpha radioactivity of elements with $100 \leq Z \leq 130$

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Abstract

Theoretical estimates for the half lives of about 1700 isotopes of heavy elements with $100 \leq Z \leq 130$ are tabulated using theoretical Q-values. The quantum mechanical tunneling probabilities are calculated within a WKB framework using microscopic nuclear potentials. The microscopic nucleus - nucleus potentials are obtained by folding the densities of interacting nuclei with a density dependent M3Y effective nucleon - nucleon interaction. The α-decay half lives calculated in this formalism using the experimental Q-values were found to be in good agreement over a wide range of experimental data spanning about twenty orders of magnitude. The theoretical Q-values used for the present calculations are extracted from three different mass estimates *viz.* Myers-Swiatecki, Muntian-Hofmann-Patyk-Sobiczewski, and Koura-Tachibana-Uno-Yamada.

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1. Introduction

In 1939 Bohr and Wheeler [1] studied the mechanism of nuclear fission on the basis of the liquid drop model (LDM) which treats the nucleus as a drop of charged liquid without any structure. As long as the surface tension in the drop is larger than the repulsive Coulomb force due to the protons, a potential barrier prevents it from splitting and the LDM suggests that the potential barrier approaches zero when the atomic number $Z > 100$ [2, 3]. This puts an upper limit on the stability of nuclei. In the mid-sixties the importance of nuclear shell effects in stabilizing heavy nuclei was realized and the possible existence of superheavy elements (SHE) was predicted [4, 5, 6]. The nuclear shell model predicted that the next magic proton number beyond Z = 82 would be Z = 114. For neutron number, N = 184 was predicted to be magic with an appreciable shell gap. Due to double magicity the nucleus with Z = 114, N = 184 was predicted to be the center of an island of stability. So far, element 114 with neutron number N = 175 has been discovered. Measured lifetime [7] of this ^{289}114 nucleus is rather short ($2.7^{+1.4}_{-0.7}$ s) but it is still far away from the desired magic N = 184. Inclusion of higher orders of deformation [8, 9, 10] suggested that ground state shell correction energy of deformed nuclei around Z = 108, N = 162 are comparable to that of the doubly magic ^{298}114 nucleus which has zero deformation. In fact, discovery of the high alpha-decay half life of ^{270}Hs, the doubly magic deformed nucleus, provides the first evidence of N = 162 shell stability [11].

Modern microscopic nuclear theories suggest that the island of stability would be around Z = 120, 124, or 126 and N = 184 or 172 [13, 14]. These predictions as well as earlier predictions [15, 16, 17] that some of the superheavy nuclei might have lifetimes comparable to the age of the earth ($\sim$4.567 $\times$ 10^9 years) have encouraged a world-wide effort to search for superheavy neutron-rich, long-lived nuclei in laboratories, as well as in nature [2]. In this context it is imperative to find out whether the predicted wide shell gap (or, shell stabilization of super and hyperheavy nuclei without magic gap) at high Z and N values would lead to high stability of the superheavy nuclei against alpha-decay. In this work we present theoretical estimates for the α-decay half lives of about 1700 heavy and superheavy elements with Z = 100 - 130.

If the existing theoretical predictions are correct, elements on the islands of stability should not decay via spontaneous fission. Instead they should undergo α-decay. As a result, these elements will leave a clear experimental signature: a daughter nucleus that is lighter than its parent by two protons and two neutrons, followed by a granddaughter nucleus that is lighter by four protons and four neutrons, and so on [7, 18]. Heavy elements with Z = 107 - 112 have been successfully synthesized at GSI, Darmstadt [19, 20, 21]. Isotopes of these elements along with Z = 113 - 116 and 118 have been synthesized at JINR-FLNR, Dubna [7, 18, 22] and Z = 110 - 113 have been produced at RIKEN, Japan [23, 24, 25].

The periodic table arranges elements according to their outermost electrons which dictate their chemical properties. Due to the presence of a large number of protons in superheavy nuclei, some orbital electrons move with velocities close to the speed of light. The relativistic effects might significantly alter the order of the elements' electronic orbitals, and thus influence their chemical reactivity. For example, superheavy element 112, provisionally named ununbium, was predicted to belong to either group 12 of the periodic table (which includes the familiar transition metals zinc, cadmium and mercury) or, to act like radon [26]. The heaviest elements which are chemically characterized so far are seaborgium (element 106), bohrium (element 107), hassium (element 108) and recently, the element 112. The first three behave according to their respective positions in groups 6, 7 and 8 of the periodic table, and now it has been confirmed [27] that the element 112 is very volatile and, unlike the inactive radon, reveals a metallic interaction with a gold surface. These adsorption characteristics establish element 112 as a typical element of group 12. There now still exist strong controversies concerning the real observation of superheavy nuclei with charge higher than 112 [28, 29, 30] for which heavy element chemistry would be essential.

While the experiments have already presented concrete evidence in support of measurable stability of several nuclei with $Z > 100$, some recent theoretical calculations in the quantum tunneling model have provided realistic estimation of their α-decay half lives. In fact, the α-decay modes and lifetimes of medium to light heavy nuclei agree well with the predictions of the half life calculations in a WKB framework with the density dependent M3Y (DDM3Y) interaction [31, 32, 33, 34, 35]. Although the generalized liquid drop model (GLDM) [36] or with its parameters refitted to improve predictability [37] are less sophisticated, yet those descriptions provide comparable results in certain cases.

For the heaviest nuclei calculations in the above framework also provide excellent agreement with the measured half lives of 27 new nuclei with atomic numbers between 106 and 118 [32, 33, 34, 35]. The purpose of the present paper is to update and extend the half life estimations into the regions of nuclei far from stability and of SHE using three different mass tables [38, 39, 40, 41, 42] as input data which will be useful for experimental studies seeking the much envisaged island of stability in superheavy nuclei.

2. Calculational details

The α-decay half lives are calculated in the framework of quantum mechanical tunneling of an α-particle from a parent nucleus [35]. The required nuclear interaction potentials are calculated by double folding the density distribution functions of the α-particle and the daughter nucleus with the density dependent M3Y effective interaction. The microscopic α-nucleus potential thus obtained, along with the Coulomb interaction potential, and the minimum centrifugal barrier required for the spin-parity conservation [31], form the potential barrier. The half lives of the nuclear disintegration process via α-particle emissions are calculated using the WKB approximation for barrier penetrability. Spherical charge distributions have been used for calculating the Coulomb interaction potentials. The Q-values of α-decay are obtained directly from Muntian-Patyk-Hofmann-Sobiczewski estimates and using atomic mass excesses from the theoretical mass predictions of Myers-Swiatecki and Koura-Tachibana-Uno-Yamada, but for the α-particle, the measured [43] atomic mass excess (2.42491565 MeV) is used.

2.1. Calculation of theoretical Q-values

From the point of view of the energetics of the decay, spontaneous emission of α-particles is allowed if the released energy

$$Q_{th} = M - (M_\alpha + M_d) = \Delta M - (\Delta M_\alpha + \Delta M_d) \tag{1}$$

is a positive quantity. In this equation, M, M_α, M_d and ΔM, ΔM_α, ΔM_d are the atomic masses and the atomic mass excesses of the parent nucleus, the emitted α-particle and the residual daughter nucleus, respectively, all expressed in the units of energy. The released energy which is called the decay Q-value is obtained from the theoretical (th) estimates for the atomic mass excesses [38, 39, 40, 41, 42].

2.2. Atomic masses used as input quantities

The theoretical Q-values, Q_{th}, used for the present calculations are extracted from three different mass estimates. All the available 314 Q_{th}-values for parent nuclei ($102 \leq Z \leq 120$) from Muntian, Hofmann, Patyk and Sobiczewski (M) [39, 40, 41] are used for half life calculations. Corresponding Q_{th}-values calculated using those from Myers and Swiatecki (MS) [38] are also used. All possible α-decay modes are predicted using theoretical mass estimates of Koura, Tachibana, Uno and Yamada (KUTY) [42] and corresponding half lives have been calculated. In the present work, Q_{th}-values and half lives are tabulated only for $100 \leq Z \leq 130$.

2.3. Selection criteria of parent nuclides

All the 27 new nuclei with atomic numbers between 106 and 118 are selected for theoretical half life calculations using theoretical Q-values and plotted for comparison with the measured half lives. Calculations using experimental Q-values are found to provide excellent estimates [33, 34, 35] for the α-decay half lives. Since the spin parities of SHE and their α-decay daughters are not known while those for many of nuclei with atomic number $Z \leq 102$ are known [31], we use a lower cut-off of Z for parent nuclei at 100. The upper cut-off Z for parent nuclei is kept at 130 which is limited by the availability of the theoretical mass excesses. This selection criteria provides about 1700 positive Q_{th}-values. For all these nuclei, half lives are calculated assuming the minimum centrifugal barrier required for the spin-parity conservation to be zero since the spin parities of SHE and their α-decay daughters are not known.

2.4. Method of calculation of α-decay half lives of superheavy nuclides

The half life of a parent nucleus decaying via α emission is calculated using the WKB barrier penetration probability. The barrier penetrability with the DDM3Y interaction is used to provide estimates of α-decay half lives for $Z = 100-130$ α emitters. This procedure of obtaining the nuclear interaction energy for the α - nucleus interaction is quite fundamental in nature since the strengths of the M3Y interaction were fixed [44] by fitting its matrix elements in an oscillator basis to those elements of the G-matrix obtained with the Reid-Elliott soft-core NN interaction and the density dependence was obtained from nuclear matter calculations [45]. Earlier it was shown that the half lives calculated in this framework were more reliable [31] than by other methods such as the GLDM [36], the analytic super-asymmetric fission model [46, 47] or the Viola-Seaborg semi-empirical relationship [48] with constants determined by Sobiczewski, Patyk and Cwiok [49]. It was also shown [35] that the theoretical Q values Q_{th}^M extracted from the mass formula of Muntian et al. [39, 40, 41] can reasonably reproduce the experimental data for several SHE.

2.4.1. α-decay half life for quantum tunneling with microscopic potential

The barrier penetrability P in the improved WKB [50] framework for any continuous (rounded) potential barrier is given by

$$P = 1/[1+\exp(K)] \tag{2}$$

where K is the action integral and the decay constant $\lambda = \nu P$ where ν is calculated from $E_v = \frac{1}{2}h\nu$, the zero point vibration energy. The zero point vibration energies used in the present calculations are E_v = 0.1045Q for even-even, 0.0962Q for odd Z - even N, 0.0907Q for even Z - odd N, and 0.0767Q for odd-odd parent nuclei and are the same as that described in Ref. [51] immediately after Eq. (4). They were obtained from a fit to a selected set of experimental data on α emitters and include the shell and pairing effects. The assault frequency ν comes out to be 5.481×10^{20} s^{-1} and 7.108×10^{20} s^{-1} for the α decays from nuclei $^{217}100$ and $^{330}130$, respectively, using theoretical Q values calculated from KUTY masses while that for some new superheavy elements using experimental Q values are listed in Ref. [33]. The half life can thus be obtained from $T_{1/2} = \ln 2/\lambda = [(h\ln 2)/(2E_v)][1+\exp(K)]$. The action integral K within the WKB approximation is given by

$$K = (2/\hbar)\int_{R_a}^{R_b} [2\mu(E(R) - E_v - Q)]^{1/2} dR \tag{3}$$

where the total interaction energy $E(R)$ between the α and the residual daughter nucleus is equal to the sum of the nuclear interaction energy $V_N(R)$, Coulomb interaction energy $V_C(R)$ and the centrifugal barrier. Thus

$$E(R) = V_N(R) + V_C(R) + \hbar^2 c^2 l(l+1)/(2\mu R^2) \tag{4}$$

where c is the velocity of light in the vacuum, the reduced mass (in MeV) $\mu = M_\alpha M_d/(M_\alpha + M_d)$ and $V_C(R)$ is the Coulomb potential between the α and the residual daughter nucleus. R_a and R_b are the second and third turning points of the WKB action integral determined from the equations

$$E(R_a) = Q + E_v = E(R_b) \tag{5}$$

whose solutions provide three turning points. The α-particle oscillates between the first and the second turning points and tunnels through the barrier at R_a and R_b. The nuclear interaction potential $V_N(R)$ between the daughter nucleus and the emitted particle is obtained in a double folding model [52] as

$$V_N(R) = \int\int \rho_1(\vec{r_1})\rho_2(\vec{r_2})v[|\vec{r_2} - \vec{r_1} + \vec{R}|]d^3r_1 d^3r_2 \tag{6}$$

where ρ_1 and ρ_2 are the density distribution functions for the two composite nuclear fragments and $v[|\vec{r_2} - \vec{r_1} + \vec{R}|]$ is the effective NN interaction. The density distribution function for the α-particle case has the Gaussian form $\rho(r) = 0.4229\ \exp(-0.7024r^2)$ whose volume integral is equal to $A_\alpha(=4)$, the mass number of α-particle. The matter density distribution for the daughter nucleus can be described by the spherically symmetric Fermi function $\rho(r) = \rho_0/[1 + \exp((r-c)/a)]$ where the equivalent sharp radius r_ρ, the half density radius c and the diffuseness for the leptodermous Fermi density distributions are given by $c = r_\rho(1 - \pi^2 a^2/3r_\rho^2)$, $r_\rho = 1.13A_d^{1/3}$, and $a = 0.54$ fm, and the value of the central density ρ_0 is fixed by equating the volume integral of the density distribution function to the mass number A_d of the residual daughter nucleus.

The distance s between any two nucleons, one belonging to the residual daughter nucleus and other belonging to the emitted α, is given by $s = |\vec{r_2} - \vec{r_1} + \vec{R}|$ while the interaction potential between these two nucleons $v(s)$ appearing in Eq.(6) is given by the factorised DDM3Y effective interaction. The general expression for the DDM3Y realistic effective NN interaction used to obtain the double-folded nucleus-nucleus interaction potential is given by

$$v(s, \rho_1, \rho_2, \varepsilon) = t^{M3Y}(s, \varepsilon)g(\rho_1, \rho_2) \tag{7}$$

where the isoscalar t_{00}^{M3Y} of the M3Y interaction potential [52] supplemented by zero range potential is given by the following equation:

$$t_{00}^{M3Y}(s, \varepsilon) = 7999\frac{\exp(-4s)}{4s} - 2134\frac{\exp(-2.5s)}{2.5s} - 276(1 - \alpha\varepsilon)\delta(s) \tag{8}$$

where ε is the energy per nucleon and the isovector term does not contribute if either one (or, both) of the daughter and emitted nuclei involved in the decay process has $N = Z$. Therefore in α-decay calculations only the isoscalar term contributes. The density dependence term $g(\rho_1, \rho_2)$ can be factorized [33] into a target term times a projectile term as

$$g(\rho_1, \rho_2) = C(1 - \beta\rho_1^{2/3})(1 - \beta\rho_2^{2/3}) \tag{9}$$

where C, the overall normalization constant, is kept equal to unity and the parameter $\beta = 1.6$ fm^2 [33], obtained from the nuclear matter calculation can be related to the mean-free path in the nuclear medium. As above, ρ_1 and ρ_2 are the density distributions of the α-particle and the daughter nucleus respectively.

2.4.2. *Viola-Seaborg-Sobiczewski systematics for α-decay half life*

The α decay half lives estimated by the Viola-Seaborg semi-empirical relationship [48] with constants determined by Sobiczewski, Patyk, and Cwiok [49] is given by

$$\log_{10}[T_{1/2}] = [aZ+b][Q]^{-1/2}+cZ+d+h_{log} \tag{10}$$

where the half-life $T_{1/2}$ is in seconds, the Q-value is in MeV, and Z is the atomic number of the parent nucleus. Instead of using the original set of constants by Viola and Seaborg, more recent values

$$a=+1.66175, \quad b=-8.5166, \quad c=-0.20228, \quad d=-33.9069 \tag{11}$$

that were determined in an adjustment taking account of new data for new even-even nuclei [49] are used. The increased deviations in the neighborhood of magic numbers present with the constants of the original Viola-Seaborg [48] formula get smoothed out by these constants or using the semi-empirical formula based on fission theory [53]. The quantity h_{log} in Eqn.(10) accounts for the hindrances associated with odd proton and odd neutron numbers given by Viola and Seaborg [48], namely

$$\begin{aligned} h_{log} = &\quad 0 \quad \text{for } Z \text{ even} - N \text{ even} \\ = &\quad 0.772 \quad \text{for } Z \text{ odd} - N \text{ even} \\ = &\quad 1.066 \quad \text{for } Z \text{ even} - N \text{ odd} \\ = &\quad 1.114 \quad \text{for } Z \text{ odd} - N \text{ odd}. \end{aligned} \tag{12}$$

The uncertainties in the calculated half lives due to this semi-empirical approach are smaller than the uncertainties due to errors in the calculated energy release.

2.5. *Comparison with experimentally measured α-decay lifetimes*

To study the predictive power of the mass formula, Q-values are also calculated using the mass formulae of Myers-Swiatecki [38], Muntian-Patyk-Hofmann-Sobiczewski [39, 40, 41] and Koura-Tachibana-Uno-Yamada [42].

Figure 1 shows comparison between the experimental α-decay half lives [7, 18, 22, 25] and the theoretical estimates with Q_{th}-values from the mass formulae of Muntian et al. (Q_{th}^{M}) [39, 40, 41] and Koura et al. (Q_{th}^{KUTY}) [42]. The latter highly overpredicts in most of the cases. In a few cases for odd-odd or odd-even nuclei the mass formula M underestimates the experimental data. This arises from non-zero l transfers [31, 34] not considered in the present calculations.

Table 1 contains $T_{1/2}$ predictions for the α-decay half lives of Z =102 - 120 calculated in the WKB framework with the DDM3Y interaction and estimations [35] from the Viola-Seaborg semi-empirical relationship [48] with constants determined by Sobiczewski, Patyk and Cwiok [49] (VSS). The Q-values are extracted from the mass formulae of Myers-Swiatecki [38], and Muntian et al. [39, 40, 41]. Calculations with M do not indicate extra stability at Z = 120 and N = 184, or existence of a SHE above 102 with half life comparable to the age of the earth while the predictions using masses from Koura et al. at high Z, N are sometimes far more than the age of the universe.

Table 2 contains α-decay half lives of nuclei with Z = 100 - 130 using theoretical Q-values from the Koura et al. mass estimates [42]. As shown in Fig. 1, half lives with KUTY mostly overpredict the experimental data at large N. Nevertheless, none of the α-decay half life calculations presented here indicate extra stability of the nuceli with Z = 120 and N = 172 or 184.

2.6. Sources of experimental data

The experimental data for the α-decay energies and measured lifetimes of various SHE are taken from Oganessian et al., JINR-FLNR, Dubna [7, 18, 22], and Morita and co-workers at the RIKEN laboratory in Tokyo, Japan [23, 24, 25].

2.7. Summary

We present theoretical estimates for the α-decay half lives of about 1700 heavy and superheavy elements with Z = 100 - 130 in the WKB framework with the DDM3Y interaction, using theoretical Q-values. This formalism has been found to be quite reliable when experimental Q-values are used [33, 34, 35]. The theoretical Q-values are taken from the mass formulae of Myers-Swiatecki [38], Muntian et al. [39, 40, 41], and Koura et al. [42]. The Viola-Seaborg-Sobiczewski estimates of α-decay half lives using the Q-values from the Muntian et al. [39, 40, 41] and Myers-Swiatecki [38] mass estimates are also presented for comparison. The updated half life estimations in the regions of very heavy and of superheavy nuclei will be useful for further experimental studies.

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Figures

FIGURE A: Plots of α-decay half life ($T_{1/2}$(sec)) versus proton number Z for different mass number A (indicated on top of each coloumn). (a) Hollow columns of solid lines with error bars are experimental α-decay half lives (T [Exp]), (b) filled columns are theoretical half lives (T $[Q\text{-}M]$=$T_{1/2}[Q^{M}_{th}]$) in the WKB frame work with the DDM3Y interaction and Q^{M}_{th} from Muntian-Patyk-Hofmann-Sobiczewski mass formula, (c) hollow columns of dashed lines are (T $[Q\text{-}KUTY]$=$T_{1/2}[Q^{KUTY}_{th}]$) in the same framework but with Q^{KUTY}_{th} from Koura-Tachibana-Uno-Yamada mass estimates.

3. Explanation of tables

We present theoretical estimates for the α-decay half lives of about 1700 heavy and superheavy elements with atomic numbers ranging from 100 to 130 in the WKB framework with the DDM3Y interaction, using theoretical Q-values in Tables 1 and 2.

3.1. *Table 1. α-decay half lives of nuclei using theoretical Q-values (MeV) from Muntian-Hofmann-Patyk-Sobiczewski (M) and Myers-Swiatecki (MS) mass estimates*

For the isotopes of the elements Z=102-120, tabulates the α-decay Q-values calculated using mass esitmates from MS [38] and M [39, 40, 41] and corresponding half lives calculated in the WKB framework with the DDM3Y interaction and using the Viola-Seaborg-Sobeczewiski (VSS) semi-empirical relationship [49].

Z	The atomic number of the parent nucleus
A	The mass number of the parent nucleus
Q_{th}^{MS}	Theoretical Q-value in MeV obtained using MS mass estimates
Q_{th}^{M}	Theoretical Q-value in MeV obtained using M mass estimates
DDM3Y(MS)$\equiv T_{1/2}[Q_{th}^{MS}]$	Half life in seconds calculated using Q_{th}^{MS} and DDM3Y interaction
DDM3Y(M)$\equiv T_{1/2}[Q_{th}^{M}]$	Half life in seconds calculated using Q_{th}^{M} and DDM3Y interaction
VSS(MS)$\equiv T_{1/2}^{VSS}[Q_{th}^{MS}]$	Half life in seconds estimated by VSS formula using Q_{th}^{MS}
VSS(M)$\equiv T_{1/2}^{VSS}[Q_{th}^{M}]$	Half life in seconds estimated by VSS formula using Q_{th}^{M}

3.2. *Table 2. α-decay half lives of nuclei using theoretical Q-values (MeV) from Koura-Tachibana-Uno-Yamada (KUTY) mass estimates*

For the isotopes of the elements Z=100-130, tabulates the α-decay Q-values calculated using mass esitmates from KUTY [42] and corresponding half lives calculated in the WKB framework with the DDM3Y interaction.

[h]

Z	The atomic number of the parent nucleus
A	The mass number of the parent nucleus
Q_{th}^{KUTY}	Theoretical Q-value in MeV obtained using KUTY mass estimates
$T_{1/2}[Q_{th}^{KUTY}]$	Half life in seconds calculated using Q_{th}^{KUTY} and DDM3Y interaction

Table A: α-decay half lives of nuclei using theoretical Q-values (MeV) from Muntian-Patyk-Hofmann-Sobiczewski (M) and Myers-Swiatecki (MS) mass estimates.

Parent	MS	M	DDM3Y(MS)	VSS(MS)	DDM3Y(M)	VSS(M)
^{A}Z	Q_{th}^{MS}	Q_{th}^{M}	$T_{1/2}[Q_{th}^{MS}]$ s	$T_{1/2}^{VSS}[Q_{th}^{MS}]$ s	$T_{1/2}[Q_{th}^{M}]$ s	$T_{1/2}^{VSS}[Q_{th}^{M}]$ s
$^{248}102$	9.15	9.27	$4.26E-02$	$4.94E-02$	$1.87E-02$	$2.16E-02$
$^{249}102$	9.20	9.12	$7.20E-02$	$4.12E-01$	$1.21E-01$	$6.81E-01$
$^{250}102$	8.99	9	$1.20E-01$	$1.46E-01$	$1.07E-01$	$1.32E-01$
$^{251}102$	8.81	8.83	$9.80E-01$	$6.00E+00$	$8.11E-01$	$5.03E+00$
$^{252}102$	8.51	8.53	$3.27E+00$	$4.57E+00$	$2.68E+00$	$3.80E+00$
$^{253}102$	8.36	8.19	$2.53E+01$	$1.66E+02$	$8.92E+01$	$6.00E+02$
$^{254}102$	8.13	8.06	$5.71E+01$	$8.64E+01$	$9.43E+01$	$1.46E+02$
$^{255}102$	8.73	8.32	$1.51E+00$	$1.06E+01$	$3.05E+01$	$2.17E+02$
$^{256}102$	8.74	8.36	$5.52E-01$	$8.49E-01$	$8.31E+00$	$1.37E+01$
$^{257}102$	8.45	8.19	$1.08E+01$	$8.36E+01$	$7.80E+01$	$6.00E+02$
$^{258}102$	8.49	7.99	$3.12E+00$	$5.31E+00$	$1.45E+02$	$2.58E+02$
$^{259}102$	8.00	7.71	$3.53E+02$	$2.88E+03$	$3.75E+03$	$3.18E+04$
$^{260}102$	7.41	7.45	$2.17E+04$	$4.15E+04$	$1.42E+04$	$2.75E+04$
$^{261}102$	7.14	7.1	$7.11E+05$	$6.21E+06$	$9.80E+05$	$8.75E+06$
$^{262}102$	6.75	6.86	$1.34E+07$	$2.79E+07$	$3.83E+06$	$8.39E+06$
$^{263}102$	6.50	6.45	$5.51E+08$	$4.93E+09$	$8.94E+08$	$8.19E+09$
$^{264}102$	6.18	6.25	$7.63E+09$	$1.75E+10$	$3.06E+09$	$7.13E+09$
$^{251}103$	9.28	9.51	$6.82E-02$	$2.72E-01$	$1.45E-02$	$5.90E-02$
$^{252}103$	9.14	9.32	$6.12E-01$	$1.53E+00$	$1.78E-01$	$4.45E-01$
$^{253}103$	8.81	9.03	$1.53E+00$	$6.94E+00$	$3.21E-01$	$1.43E+00$
$^{254}103$	8.65	8.71	$1.86E+01$	$4.88E+01$	$1.14E+01$	$3.03E+01$
$^{255}103$	8.47	8.57	$1.78E+01$	$8.54E+01$	$7.99E+00$	$3.88E+01$
$^{256}103$	9.04	8.85	$1.06E+00$	$3.03E+00$	$3.76E+00$	$1.11E+01$
$^{257}103$	9.04	8.92	$2.75E-01$	$1.38E+00$	$5.97E-01$	$3.07E+00$
$^{258}103$	8.75	8.71	$7.85E+00$	$2.35E+01$	$9.98E+00$	$3.03E+01$
$^{259}103$	8.74	8.47	$2.08E+00$	$1.15E+01$	$1.48E+01$	$8.23E+01$
$^{260}103$	8.37	8.16	$1.25E+02$	$4.04E+02$	$6.18E+02$	$2.04E+03$
$^{261}103$	7.71	7.88	$7.00E+03$	$4.20E+04$	$1.55E+03$	$9.33E+03$
$^{262}103$	7.52	7.61	$1.52E+05$	$5.03E+05$	$6.32E+04$	$2.14E+05$
$^{263}103$	7.12	7.26	$1.58E+06$	$1.01E+07$	$3.65E+05$	$2.47E+06$
$^{264}103$	6.91	6.84	$5.58E+07$	$1.85E+08$	$1.08E+08$	$3.64E+08$
$^{265}103$	6.56	6.62	$5.15E+08$	$3.60E+09$	$2.47E+08$	$1.75E+09$
$^{252}104$	9.72	9.85	$5.41E-03$	$5.89E-03$	$2.38E-03$	$2.56E-03$

Continued...

Table A contd...

Parent	MS	M	DDM3Y(MS)	VSS(MS)	DDM3Y(M)	VSS(M)
^{A}Z	Q_{th}^{MS}	Q_{th}^{M}	$T_{1/2}[Q_{th}^{MS}]$ s	$T_{1/2}^{VSS}[Q_{th}^{MS}]$ s	$T_{1/2}[Q_{th}^{M}]$ s	$T_{1/2}^{VSS}[Q_{th}^{M}]$ s
$^{253}104$	9.50	9.64	$5.17E-02$	$2.78E-01$	$2.05E-02$	$1.10E-01$
$^{254}104$	9.21	9.37	$1.34E-01$	$1.63E-01$	$4.52E-02$	$5.40E-02$
$^{255}104$	8.92	9.04	$2.41E+00$	$1.41E+01$	$9.95E-01$	$5.88E+00$
$^{256}104$	8.94	8.93	$8.14E-01$	$1.05E+00$	$8.29E-01$	$1.09E+00$
$^{257}104$	9.29	9.21	$1.76E-01$	$1.10E+00$	$2.84E-01$	$1.83E+00$
$^{258}104$	9.51	9.29	$1.71E-02$	$2.24E-02$	$6.66E-02$	$9.18E-02$
$^{259}104$	9.15	9.08	$4.19E-01$	$2.85E+00$	$6.39E-01$	$4.45E+00$
$^{260}104$	9.14	8.84	$1.76E-01$	$2.62E-01$	$1.37E+00$	$2.08E+00$
$^{261}104$	8.70	8.53	$9.55E+00$	$6.96E+01$	$3.17E+01$	$2.39E+02$
$^{262}104$	8.10	8.24	$3.76E+02$	$6.38E+02$	$1.12E+02$	$1.97E+02$
$^{263}104$	7.78	7.9	$1.39E+04$	$1.11E+05$	$4.69E+03$	$3.80E+04$
$^{264}104$	7.51	7.64	$5.54E+04$	$1.08E+05$	$1.62E+04$	$3.16E+04$
$^{265}104$	7.17	7.27	$3.81E+06$	$3.19E+07$	$1.35E+06$	$1.15E+07$
$^{266}104$	6.91	7.05	$1.83E+07$	$3.83E+07$	$4.10E+06$	$8.65E+06$
$^{255}105$	9.51	9.62	$7.34E-02$	$2.87E-01$	$3.49E-02$	$1.37E-01$
$^{256}105$	9.22	9.31	$1.85E+00$	$4.37E+00$	$9.61E-01$	$2.30E+00$
$^{257}105$	9.27	9.22	$3.41E-01$	$1.42E+00$	$4.54E-01$	$1.92E+00$
$^{258}105$	9.60	9.48	$1.38E-01$	$3.52E-01$	$2.95E-01$	$7.44E-01$
$^{259}105$	9.80	9.57	$1.06E-02$	$4.52E-02$	$4.19E-02$	$1.88E-01$
$^{260}105$	9.41	9.36	$4.56E-01$	$1.22E+00$	$6.04E-01$	$1.64E+00$
$^{261}105$	9.40	9.11	$1.23E-01$	$5.92E-01$	$8.40E-01$	$4.10E+00$
$^{262}105$	9.00	8.83	$6.93E+00$	$2.02E+01$	$2.21E+01$	$6.61E+01$
$^{263}105$	8.46	8.53	$9.48E+01$	$5.05E+02$	$5.27E+01$	$2.83E+02$
$^{264}105$	8.11	8.2	$5.99E+03$	$1.84E+04$	$2.70E+03$	$8.43E+03$
$^{265}105$	7.75	7.97	$3.15E+04$	$1.83E+05$	$4.28E+03$	$2.60E+04$
$^{266}105$	7.54	7.52	$8.60E+05$	$2.69E+06$	$9.72E+05$	$3.09E+06$
$^{267}105$	7.27	7.41	$2.48E+06$	$1.59E+07$	$6.09E+05$	$3.94E+06$
$^{268}105$	7.37	7.8	$4.00E+06$	$1.33E+07$	$7.26E+04$	$2.47E+05$
$^{269}105$	7.76	8.17	$2.43E+04$	$1.67E+05$	$7.27E+02$	$4.90E+03$
$^{256}106$	9.72	9.97	$2.55E-02$	$2.70E-02$	$5.34E-03$	$5.50E-03$
$^{258}106$	9.64	9.61	$3.92E-02$	$4.52E-02$	$4.53E-02$	$5.31E-02$
$^{259}106$	9.97	9.89	$1.21E-02$	$6.59E-02$	$1.89E-02$	$1.05E-01$
$^{260}106$	10.12	9.95	$2.02E-03$	$2.28E-03$	$5.28E-03$	$6.21E-03$
$^{261}106$	9.82	9.74	$2.83E-02$	$1.67E-01$	$4.44E-02$	$2.69E-01$

Continued...

Table A contd…

Parent	MS	M	DDM3Y(MS)	VSS(MS)	DDM3Y(M)	VSS(M)
^{A}Z	Q_{th}^{MS}	Q_{th}^{M}	$T_{1/2}[Q_{th}^{MS}]$ s	$T_{1/2}^{VSS}[Q_{th}^{MS}]$ s	$T_{1/2}[Q_{th}^{M}]$ s	$T_{1/2}^{VSS}[Q_{th}^{M}]$ s
$^{262}106$	9.80	9.49	$1.28E-02$	$1.63E-02$	$8.91E-02$	$1.16E-01$
$^{263}106$	9.39	9.21	$4.27E-01$	$2.73E+00$	$1.36E+00$	$8.97E+00$
$^{264}106$	8.89	8.94	$5.10E+00$	$7.72E+00$	$3.41E+00$	$5.19E+00$
$^{265}106$	8.56	8.63	$1.50E+02$	$1.07E+03$	$8.38E+01$	$6.01E+02$
$^{266}106$	8.21	8.42	$8.76E+02$	$1.49E+03$	$1.57E+02$	$2.63E+02$
$^{267}106$	8.04	8.09	$9.48E+03$	$7.14E+04$	$5.86E+03$	$4.49E+04$
$^{268}106$	7.77	7.89	$3.50E+04$	$6.41E+04$	$1.16E+04$	$2.13E+04$
$^{269}106$	7.92	8.32	$2.46E+04$	$2.00E+05$	$8.13E+02$	$6.80E+03$
$^{270}106$	8.35	8.74	$2.52E+02$	$4.77E+02$	$1.19E+01$	$2.25E+01$
$^{271}106$	8.59	8.71	$9.90E+01$	$8.47E+02$	$3.81E+01$	$3.28E+02$
$^{272}106$	8.57	8.5	$4.33E+01$	$8.49E+01$	$7.02E+01$	$1.40E+02$
$^{274}106$	8.50	8.12	$6.97E+01$	$1.46E+02$	$1.34E+03$	$3.00E+03$
$^{261}107$	10.53	10.31	$7.01E-04$	$2.53E-03$	$2.32E-03$	$8.80E-03$
$^{262}107$	10.24	10.09	$1.27E-02$	$3.01E-02$	$3.05E-02$	$7.22E-02$
$^{263}107$	10.10	9.84	$7.76E-03$	$3.18E-02$	$3.70E-02$	$1.55E-01$
$^{264}107$	9.83	9.59	$1.48E-01$	$3.73E-01$	$6.48E-01$	$1.70E+00$
$^{265}107$	9.35	9.27	$8.50E-01$	$3.98E+00$	$1.39E+00$	$6.66E+00$
$^{266}107$	9.00	8.95	$3.72E+01$	$1.02E+02$	$5.08E+01$	$1.42E+02$
$^{267}107$	8.66	8.75	$1.12E+02$	$5.82E+02$	$5.39E+01$	$2.83E+02$
$^{268}107$	8.48	8.4	$1.82E+03$	$5.18E+03$	$3.23E+03$	$9.42E+03$
$^{269}107$	8.32	8.19	$1.54E+03$	$8.50E+03$	$4.18E+03$	$2.38E+04$
$^{270}107$	8.36	8.63	$4.44E+03$	$1.35E+04$	$4.82E+02$	$1.55E+03$
$^{271}107$	8.85	9.07	$2.41E+01$	$1.39E+02$	$4.73E+00$	$2.71E+01$
$^{272}107$	9.08	9.08	$1.75E+01$	$5.75E+01$	$1.65E+01$	$5.55E+01$
$^{273}107$	9.02	8.89	$6.64E+00$	$4.02E+01$	$1.60E+01$	$9.99E+01$
$^{274}107$	8.89	8.83	$6.44E+01$	$2.28E+02$	$9.47E+01$	$3.42E+02$
$^{275}107$	9.00	8.64	$7.19E+00$	$4.64E+01$	$9.57E+01$	$6.53E+02$
$^{262}108$	11.09	11	$4.24E-05$	$3.92E-05$	$6.52E-05$	$6.18E-05$
$^{263}108$	10.91	10.81	$2.56E-04$	$1.20E-03$	$4.20E-04$	$2.03E-03$
$^{264}108$	10.77	10.59	$2.21E-04$	$2.24E-04$	$5.70E-04$	$6.02E-04$
$^{265}108$	10.36	10.36	$5.03E-03$	$2.74E-02$	$4.81E-03$	$2.66E-02$
$^{266}108$	9.88	10.04	$3.65E-02$	$4.44E-02$	$1.32E-02$	$1.58E-02$
$^{267}108$	9.53	9.75	$8.46E-01$	$5.06E+00$	$1.87E-01$	$1.15E+00$
$^{268}108$	9.20	9.49	$3.01E+00$	$4.20E+00$	$3.92E-01$	$5.50E-01$

Continued…

Table A contd...

Parent	MS	M	DDM3Y(MS)	VSS(MS)	DDM3Y(M)	VSS(M)
^{A}Z	Q_{th}^{MS}	Q_{th}^{M}	$T_{1/2}[Q_{th}^{MS}]$ s	$T_{1/2}^{VSS}[Q_{th}^{MS}]$ s	$T_{1/2}[Q_{th}^{M}]$ s	$T_{1/2}^{VSS}[Q_{th}^{M}]$ s
$^{269}108$	9.03	9.14	$2.45E+01$	$1.65E+02$	$1.07E+01$	$7.23E+01$
$^{270}108$	8.88	8.87	$2.75E+01$	$4.27E+01$	$2.80E+01$	$4.44E+01$
$^{271}108$	9.02	9.29	$2.48E+01$	$1.78E+02$	$3.56E+00$	$2.51E+01$
$^{272}108$	9.39	9.8	$7.02E-01$	$1.12E+00$	$4.77E-02$	$7.17E-02$
$^{273}108$	9.61	9.78	$3.99E-01$	$2.97E+00$	$1.29E-01$	$9.49E-01$
$^{274}108$	9.65	9.55	$1.21E-01$	$1.96E-01$	$2.19E-01$	$3.68E-01$
$^{275}108$	9.58	9.41	$4.56E-01$	$3.62E+00$	$1.34E+00$	$1.10E+01$
$^{276}108$	9.52	9.19	$2.63E-01$	$4.65E-01$	$2.40E+00$	$4.35E+00$
$^{277}108$	8.93	9.03	$3.93E+01$	$3.43E+02$	$1.82E+01$	$1.59E+02$
$^{278}108$	8.73	8.77	$6.47E+01$	$1.32E+02$	$4.56E+01$	$9.41E+01$
$^{265}109$	11.34	11.74	$3.75E-05$	$1.22E-04$	$5.16E-06$	$1.57E-05$
$^{266}109$	10.98	11.54	$8.51E-04$	$1.83E-03$	$4.45E-05$	$9.36E-05$
$^{267}109$	10.69	11.21	$1.12E-03$	$4.20E-03$	$6.57E-05$	$2.35E-04$
$^{268}109$	10.24	10.88	$5.45E-02$	$1.30E-01$	$1.32E-03$	$3.09E-03$
$^{269}109$	9.82	10.62	$1.87E-01$	$8.20E-01$	$1.50E-03$	$6.09E-03$
$^{270}109$	9.73	10.27	$1.27E+00$	$3.24E+00$	$4.11E-02$	$1.05E-01$
$^{271}109$	9.49	9.91	$1.56E+00$	$7.31E+00$	$9.58E-02$	$4.46E-01$
$^{272}109$	9.62	10.25	$2.46E+00$	$6.70E+00$	$4.36E-02$	$1.19E-01$
$^{273}109$	10.02	10.73	$4.77E-02$	$2.30E-01$	$7.22E-04$	$3.25E-03$
$^{274}109$	10.26	10.63	$4.02E-02$	$1.15E-01$	$4.35E-03$	$1.26E-02$
$^{275}109$	10.26	10.34	$1.06E-02$	$5.23E-02$	$6.36E-03$	$3.14E-02$
$^{276}109$	10.11	10.09	$9.36E-02$	$2.88E-01$	$1.01E-01$	$3.16E-01$
$^{277}109$	10.04	9.84	$3.74E-02$	$2.03E-01$	$1.23E-01$	$6.98E-01$
$^{278}109$	9.58	9.55	$2.65E+00$	$8.75E+00$	$3.09E+00$	$1.04E+01$
$^{279}109$	9.13	9.28	$1.45E+01$	$9.10E+01$	$4.81E+00$	$3.02E+01$
$^{280}109$	8.65	8.88	$2.08E+03$	$7.34E+03$	$3.41E+02$	$1.21E+03$
$^{281}109$	8.28	8.49	$9.38E+03$	$6.64E+04$	$1.62E+03$	$1.14E+04$
$^{266}110$	11.99	12.4	$1.98E-06$	$1.52E-06$	$2.95E-07$	$2.15E-07$
$^{267}110$	11.61	12.21	$2.69E-05$	$1.16E-04$	$1.55E-06$	$6.07E-06$
$^{268}110$	11.15	11.93	$1.18E-04$	$1.11E-04$	$2.38E-06$	$1.99E-06$
$^{269}110$	10.84	11.63	$1.47E-03$	$7.13E-03$	$2.22E-05$	$1.03E-04$
$^{270}110$	10.51	11.36	$3.75E-03$	$4.09E-03$	$3.65E-05$	$3.54E-05$
$^{271}110$	10.38	11.07	$1.89E-02$	$1.03E-01$	$3.74E-04$	$1.94E-03$
$^{272}110$	10.23	10.74	$1.81E-02$	$2.20E-02$	$8.98E-04$	$1.05E-03$

Continued...

Table A contd...

Parent	MS	M	DDM3Y(MS)	VSS(MS)	DDM3Y(M)	VSS(M)
^{A}Z	Q_{th}^{MS}	Q_{th}^{M}	$T_{1/2}[Q_{th}^{MS}]$ s	$T_{1/2}^{VSS}[Q_{th}^{MS}]$ s	$T_{1/2}[Q_{th}^{M}]$ s	$T_{1/2}^{VSS}[Q_{th}^{M}]$ s
$^{273}110$	10.30	11.1	$2.83E-02$	$1.67E-01$	$3.00E-04$	$1.65E-03$
$^{274}110$	10.72	11.57	$9.82E-04$	$1.21E-03$	$1.11E-05$	$1.20E-05$
$^{275}110$	10.92	11.45	$7.65E-04$	$4.55E-03$	$4.52E-05$	$2.58E-04$
$^{276}110$	10.93	11.09	$2.96E-04$	$3.70E-04$	$1.22E-04$	$1.50E-04$
$^{277}110$	10.89	10.79	$8.51E-04$	$5.38E-03$	$1.41E-03$	$9.19E-03$
$^{278}110$	10.61	10.54	$1.61E-03$	$2.28E-03$	$2.38E-03$	$3.33E-03$
$^{279}110$	9.89	10.24	$3.02E-01$	$2.18E+00$	$3.23E-02$	$2.34E-01$
$^{280}110$	9.25	9.91	$8.12E+00$	$1.44E+01$	$9.54E-02$	$1.60E-01$
$^{281}110$	8.75	9.3	$8.28E+02$	$6.93E+03$	$1.36E+01$	$1.14E+02$
$^{282}110$	7.95	8.89	$2.25E+05$	$4.69E+05$	$1.01E+02$	$1.96E+02$
$^{283}110$	7.81	8.54	$2.23E+06$	$1.94E+07$	$3.80E+03$	$3.50E+04$
$^{284}110$	7.77	8.34	$1.07E+06$	$2.42E+06$	$7.22E+03$	$1.55E+04$
$^{285}110$	7.71	8.03	$5.27E+06$	$4.92E+07$	$2.63E+05$	$2.56E+06$
$^{286}110$	7.81	7.99	$6.95E+05$	$1.67E+06$	$1.31E+05$	$3.14E+05$
$^{271}111$	11.21	11.79	$2.77E-04$	$9.37E-04$	$1.46E-05$	$4.48E-05$
$^{272}111$	11.11	11.55	$1.69E-03$	$3.55E-03$	$1.59E-04$	$3.33E-04$
$^{273}111$	11.09	11.2	$5.09E-04$	$1.80E-03$	$2.64E-04$	$9.63E-04$
$^{274}111$	11.07	11.53	$1.97E-03$	$4.42E-03$	$1.66E-04$	$3.70E-04$
$^{275}111$	11.53	12.04	$4.79E-05$	$1.72E-04$	$3.83E-06$	$1.31E-05$
$^{276}111$	11.73	11.94	$5.99E-05$	$1.36E-04$	$2.02E-05$	$4.68E-05$
$^{277}111$	11.71	11.64	$1.80E-05$	$6.87E-05$	$2.53E-05$	$9.56E-05$

Table B: α-decay half lives of nuclei using theoretical Q-values (MeV) from Koura-Tachibana-Uno-Yamada (KUTY) mass estimates.

Parent	KUTY	DDM3Y(KUTY)	Parent	KUTY	DDM3Y(KUTY)
^{A}Z	Q_{th}^{KUTY}	$T_{1/2}[Q_{th}^{KUTY}]$ s	^{A}Z	Q_{th}^{KUTY}	$T_{1/2}[Q_{th}^{KUTY}]$ s
$^{217}100$	12.495	$2.20E-09$	$^{244}100$	8.545	$5.15E-01$
$^{218}100$	12.535	$8.69E-10$	$^{245}100$	8.385	$4.06E+00$
$^{219}100$	12.405	$2.95E-09$	$^{246}100$	8.295	$3.09E+00$
$^{220}100$	12.355	$1.64E-09$	$^{247}100$	8.155	$2.16E+01$
$^{221}100$	11.375	$2.34E-07$	$^{248}100$	8.045	$1.96E+01$
$^{222}100$	10.985	$6.37E-07$	$^{249}100$	7.975	$8.33E+01$
$^{223}100$	10.525	$1.41E-05$	$^{250}100$	7.855	$8.35E+01$

Continued...

Table B contd...

Parent	KUTY	DDM3Y(KUTY)	Parent	KUTY	DDM3Y(KUTY)
^{A}Z	Q_{th}^{KUTY}	$T_{1/2}[Q_{th}^{KUTY}]$ s	^{A}Z	Q_{th}^{KUTY}	$T_{1/2}[Q_{th}^{KUTY}]$ s
$^{224}100$	10.345	$1.54E-05$	$^{251}100$	7.695	$8.08E+02$
$^{225}100$	9.815	$6.61E-04$	$^{252}100$	7.605	$6.54E+02$
$^{226}100$	9.705	$5.22E-04$	$^{253}100$	7.405	$9.47E+03$
$^{227}100$	11.515	$9.78E-08$	$^{254}100$	7.455	$2.25E+03$
$^{228}100$	12.935	$1.34E-10$	$^{255}100$	7.365	$1.27E+04$
$^{229}100$	11.865	$1.98E-08$	$^{256}100$	7.205	$2.02E+04$
$^{230}100$	10.985	$4.85E-07$	$^{257}100$	7.085	$1.61E+05$
$^{231}100$	10.335	$2.88E-05$	$^{258}100$	6.925	$2.77E+05$
$^{232}100$	10.175	$2.89E-05$	$^{259}100$	6.785	$3.10E+06$
$^{233}100$	10.105	$9.65E-05$	$^{260}100$	6.655	$4.23E+06$
$^{234}100$	9.915	$1.17E-04$	$^{261}100$	6.465	$8.76E+07$
$^{235}100$	9.565	$2.03E-03$	$^{262}100$	6.255	$3.25E+08$
$^{236}100$	9.465	$1.53E-03$	$^{263}100$	6.115	$4.88E+09$
$^{237}100$	9.335	$8.07E-03$	$^{264}100$	5.985	$8.02E+09$
$^{238}100$	9.215	$6.98E-03$	$^{265}100$	5.875	$9.01E+10$
$^{239}100$	9.125	$2.87E-02$	$^{266}100$	5.745	$1.60E+11$
$^{240}100$	8.975	$3.08E-02$	$^{267}100$	5.515	$1.06E+13$
$^{241}100$	8.875	$1.40E-01$	$^{268}100$	5.365	$2.91E+13$
$^{242}100$	8.755	$1.27E-01$	$^{269}100$	5.235	$6.38E+14$
$^{243}100$	8.635	$6.88E-01$	$^{270}100$	4.935	$2.32E+16$
$^{271}100$	4.845	$3.31E+17$	$^{298}100$	0.805	$7.41E+121$
$^{272}100$	4.735	$6.66E+17$	$^{299}100$	0.585	$8.33E+153$
$^{273}100$	4.635	$1.29E+19$	$^{300}100$	0.425	$2.15E+188$
$^{274}100$	4.595	$7.89E+18$	$^{219}101$	12.915	$5.93E-10$
$^{275}100$	4.525	$9.47E+19$	$^{220}101$	12.905	$1.75E-09$
$^{276}100$	4.365	$6.51E+20$	$^{221}101$	11.895	$3.49E-08$
$^{277}100$	4.335	$3.97E+21$	$^{222}101$	11.575	$4.31E-07$
$^{278}100$	4.205	$1.65E+22$	$^{223}101$	11.165	$9.08E-07$
$^{279}100$	4.115	$3.91E+23$	$^{224}101$	10.855	$1.28E-05$
$^{280}100$	4.015	$9.94E+23$	$^{225}101$	10.445	$3.21E-05$
$^{281}100$	3.785	$8.34E+26$	$^{226}101$	10.075	$8.17E-04$
$^{282}100$	3.565	$6.59E+28$	$^{227}101$	10.065	$2.36E-04$
$^{283}100$	3.475	$3.23E+30$	$^{228}101$	11.805	$1.25E-07$
$^{284}100$	3.385	$1.07E+31$	$^{229}101$	13.085	$2.19E-10$

Continued...

Table B contd...

Parent	KUTY	DDM3Y(KUTY)	Parent	KUTY	DDM3Y(KUTY)
^{A}Z	Q_{th}^{KUTY}	$T_{1/2}[Q_{th}^{KUTY}]$ s	^{A}Z	Q_{th}^{KUTY}	$T_{1/2}[Q_{th}^{KUTY}]$ s
$^{285}100$	4.235	$2.47E+22$	$^{230}101$	11.925	$6.70E-08$
$^{286}100$	4.905	$2.36E+16$	$^{231}101$	11.035	$1.27E-06$
$^{287}100$	3.865	$9.84E+25$	$^{232}101$	10.615	$3.41E-05$
$^{288}100$	2.845	$6.65E+38$	$^{233}101$	10.555	$1.32E-05$
$^{289}100$	2.145	$7.95E+53$	$^{234}101$	10.505	$5.69E-05$
$^{290}100$	2.015	$3.94E+56$	$^{235}101$	10.405	$2.70E-05$
$^{291}100$	1.835	$6.30E+62$	$^{236}101$	10.035	$6.96E-04$
$^{292}100$	1.675	$3.01E+67$	$^{237}101$	9.865	$5.21E-04$
$^{293}100$	1.525	$1.79E+74$	$^{238}101$	9.765	$3.23E-03$
$^{294}100$	1.455	$2.70E+76$	$^{239}101$	9.645	$1.84E-03$
$^{295}100$	1.255	$3.28E+87$	$^{240}101$	9.555	$1.07E-02$
$^{296}100$	1.055	$3.09E+99$	$^{241}101$	9.455	$5.46E-03$
$^{297}100$	0.955	$3.00E+108$	$^{242}101$	9.305	$4.79E-02$
$^{243}101$	9.175	$2.99E-02$	$^{270}101$	5.685	$1.02E+13$
$^{244}101$	9.055	$2.30E-01$	$^{271}101$	5.515	$2.13E+13$
$^{245}101$	8.965	$1.12E-01$	$^{272}101$	5.155	$2.39E+16$
$^{246}101$	8.845	$9.33E-01$	$^{273}101$	5.055	$2.14E+16$
$^{247}101$	8.725	$5.62E-01$	$^{274}101$	4.975	$4.24E+17$
$^{248}101$	8.585	$5.49E+00$	$^{275}101$	4.905	$2.43E+17$
$^{249}101$	8.455	$3.66E+00$	$^{276}101$	4.855	$3.27E+18$
$^{250}101$	8.365	$2.62E+01$	$^{277}101$	4.695	$9.62E+18$
$^{251}101$	8.265	$1.42E+01$	$^{278}101$	4.625	$1.96E+20$
$^{252}101$	8.155	$1.29E+02$	$^{279}101$	4.565	$1.01E+20$
$^{253}101$	7.985	$1.24E+02$	$^{280}101$	4.515	$1.51E+21$
$^{254}101$	7.955	$5.99E+02$	$^{281}101$	4.385	$3.20E+21$
$^{255}101$	7.895	$2.41E+02$	$^{282}101$	4.105	$7.40E+24$
$^{256}101$	7.795	$2.12E+03$	$^{283}101$	3.885	$1.97E+26$
$^{257}101$	7.735	$8.52E+02$	$^{284}101$	3.835	$4.38E+27$
$^{258}101$	7.485	$2.94E+04$	$^{285}101$	3.765	$3.61E+27$
$^{259}101$	7.395	$1.56E+04$	$^{286}101$	4.595	$2.71E+20$
$^{260}101$	7.275	$1.97E+05$	$^{287}101$	5.255	$6.03E+14$
$^{261}101$	7.105	$2.30E+05$	$^{288}101$	4.135	$3.17E+24$
$^{262}101$	6.945	$4.57E+06$	$^{289}101$	3.105	$8.05E+35$
$^{263}101$	6.795	$4.73E+06$	$^{290}101$	2.615	$1.33E+45$

Continued...

Table B contd...

Parent	KUTY	DDM3Y(KUTY)	Parent	KUTY	DDM3Y(KUTY)
^{A}Z	Q_{th}^{KUTY}	$T_{1/2}[Q_{th}^{KUTY}]$ s	^{A}Z	Q_{th}^{KUTY}	$T_{1/2}[Q_{th}^{KUTY}]$ s
$^{264}101$	6.585	$1.87E+08$	$^{291}101$	2.465	$1.30E+47$
$^{265}101$	6.405	$3.12E+08$	$^{292}101$	2.325	$1.58E+51$
$^{266}101$	6.315	$3.88E+09$	$^{293}101$	2.175	$5.87E+53$
$^{267}101$	6.205	$2.97E+09$	$^{294}101$	2.015	$1.38E+59$
$^{268}101$	5.965	$2.58E+11$	$^{295}101$	1.895	$3.63E+61$
$^{269}101$	5.825	$3.15E+11$	$^{296}101$	1.745	$4.78E+67$

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