

# SIMPLE EMPIRICAL RELATIONS FOR $\alpha$ -DECAY HALF LIVES OF SUPERHEAVY NUCLEI

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*Abstract.* Simple relations for  $\alpha$ -decay half-lives are obtained from the systematics of experimental decay data and calculated decay properties. The parameters of systematics are obtained by the fit of  $\alpha$ -decay half-lives of 80 nuclei at which there are accurate  $Q_\alpha$  measurements (with errors not greater than 50 keV). The comparative analysis of experimental and calculated half-lives (within the shell and “one-body” models) allows us to estimate the spectroscopic factor in  $\alpha$ -decay. The  $\alpha$ -decay half-life predictions are performed for the region of nuclei with  $Z=104-118$ .

*Key words:*  $\alpha$ -decay; superheavy nuclei.

## 1. INTRODUCTION

The major difficulties in studies of superheavy nuclei (SHN) are related to reaction mechanism for their production at very small cross-sections and to study of their nuclear decay properties for weak reaction channels [1–6]. However, the observation of narrow  $\alpha$ -resonances in fusion-evaporation reactions is of great importance to study of weak channels since they may be interpreted as energy levels of formed nucleus and investigated *via*  $\alpha$ - emission spectroscopy. Such an interpretation together with the use of some reaction decay data as input parameters of the nuclear models for clustering and scattering amplitude contribute directly to detailed studies of nuclear structure.

## 2. BROWN SYSTEMATICS OF $\alpha$ -HALF-LIVES

Various generalizations of the Geiger-Nuttall law [7] ( $T_\alpha \sim Q_\alpha^{-1/2}$ ) originate from the common quantum penetrability factor that depends linearly on  $Q_\alpha^{-1/2}$  [8–15]. The relations for the  $\alpha$ -decay half-lives obtained from the fit of experimental and calculated [shell-model (SM) and “one-body” (ob) models] are shown in Figs. (1-3). The Brown fit formula for the  $\alpha$ -half-lives is taken of the form:

$$\log_{10} T_\alpha^f(\text{sec}) = AZ_d^{0.6} Q_\alpha^{-1/2} - B, rms, \quad (1)$$

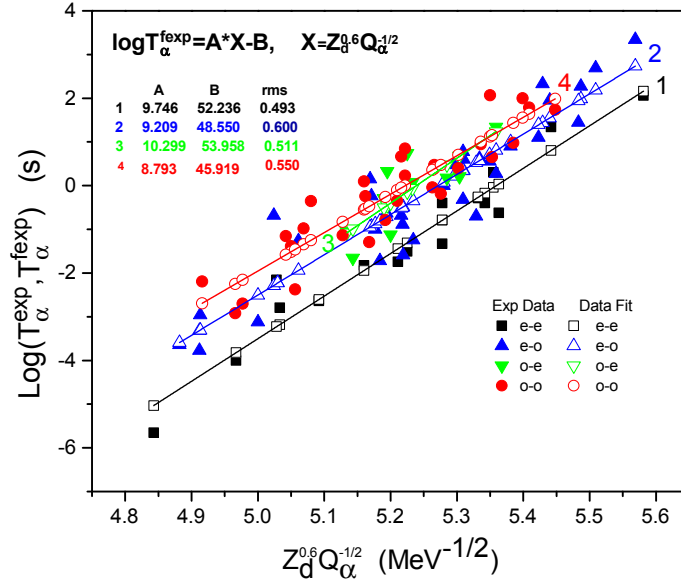


Fig. 1 – Simple relation for the  $\alpha$ -decay half-lives obtained from the Brown systematics of  $\alpha$ -decay data for 80 experimentally measured nuclei. The nuclei with errors in reaction energy greater than 40 keV or unknown branching ratios are not used in the systematics. The parameters of these reactions are obtained for different (Z-N) parities (e-even, o-odd). The solid lines connect the fitted values (open symbols).

where  $A$  and  $B$  are the fit parameters, and  $rms$  is the root mean square error defined as:

$$rms = [N^{-1/2}] \left[ \sum_{i=1}^N (\log_{10}(T_{\alpha,i}^f / T_{\alpha,i}))^2 \right]^{1/2} \quad (2)$$

where  $N$  is the number of nuclei, and  $T_{\alpha}^f$  are the fitted values of  $T_{\alpha}$ . The values  $T_{\alpha}^{fexp}$ ,  $T_{\alpha}^{fSM}$ , and  $T_{\alpha}^{fob}$  for different (Z,N) parities are shown in Figs. (1-3).

### 3. RESULTS AND DISCUSSIONS

The present results for  $\alpha$ -half-lives together with the decay data are summarized in Table 1. From the analysis of experimental and theoretical results we stress the following points: i) the values  $T_{\alpha}^{SM}$  and  $T_{\alpha}^{exp}$  as well as  $T_{\alpha}^{fSM}$  and  $T_{\alpha}^{fexp}$  have very close values; ii) the differences between the values of  $T_{\alpha}^{SM}$  or  $T_{\alpha}^{exp}$  and  $T_{\alpha}^{ob}$  on the one hand, and those between values of  $T_{\alpha}^{fSM}$  or  $T_{\alpha}^{fexp}$  and  $T_{\alpha}^{fob}$  on the other hand, are of the same order of magnitude; iii) the fit produces results for half-lives

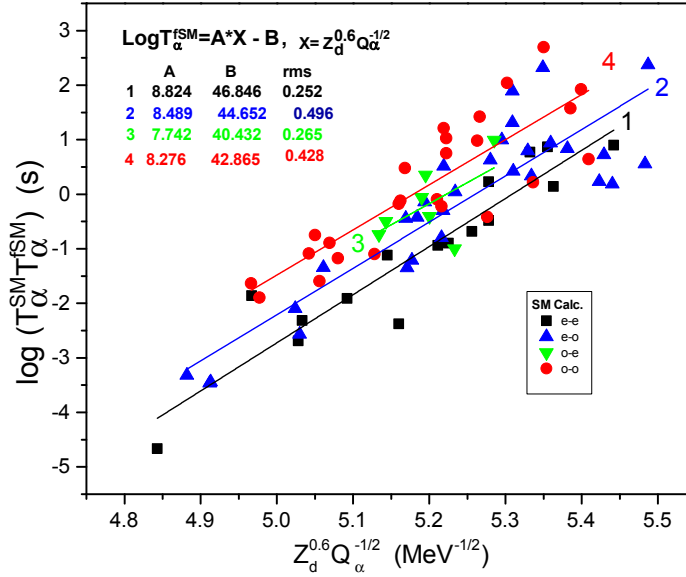


Fig. 2 – The same as in Fig. 1, but for calculated "shell-model"  $\alpha$ -decay half-lives. The solid lines (1, 2, 3, 4) give the fitted  $\alpha$ -decay half-lives (fSM) for nuclei with different (Z, N) parities.

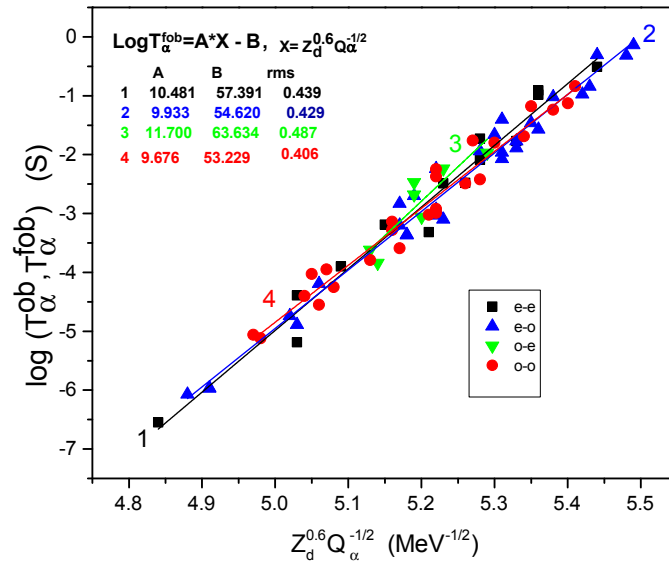


Fig. 3 – The same as in Fig. 2, but for calculated "one-body"  $\alpha$ -decay half-lives. Practically, the values  $T_{\alpha}^{\text{ob}}$  are seated on a single line. This means that these values do not depend on the (Z,N) parity.

and spectroscopic factors that are similar with experimental and theoretical results. The fit procedure doesn't require complicated calculations for clustering amplitudes, search for resonant functions, and channel coupling estimates for  $\alpha$ -half-lives [16–18]. The competition of different decay modes in heaviest nuclei was studied in detail in recent papers [19–22].

#### 4. CONCLUSIONS

The essence of this work is the use of available decay data on SHN as input data in theoretical studies to understand the nuclear properties and structure of these nuclei. The present analysis of experimental and calculated (within the shell and “one body” models)  $\alpha$ -half-lives of SHN allows us to conclude as follows :

- the  $\alpha$ -half-lives are displayed on the four distinct (Geiger-Nuttall) lines that correspond to the four different (Z,N) parities of nuclei. The relation between these half-lives are:  $T_{\alpha}^{e-e} < T_{\alpha}^{e-o} < T_{\alpha}^{o-e} < T_{\alpha}^{o-o}$ , for all the experimental, calculated, and their fitted values.
- a good accordance is obtained between the shell model and experimental half-lives, and also between the fitted shell model and experimental half-lives;
- the differences between shell model and one-body half-lives, and those between experimental and one-body half-lives, have appropriate values and these differences give a measure of the contributions of structure effects and corrections due to finite sizes of nucleons to the increasing of nuclear stability.

We hope that some of our results may help in synthesis and identification of new heaviest nuclei.

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*Table 1*  
 Experimental, calculated (shell model and “one-body”)  $\alpha$ -half-lives and their fitted values (fexp, fSM, and fob).  
 The experimental decay data  $T_{\alpha}^{exp}$  and  $Q_{\alpha}^{exp}$  values are taken from [1–6].

Nucleus	$Q_{\alpha}^{exp}$ (MeV)	$T_{\alpha}^{SM}$ (s)	$T_{\alpha}^{ob}$ (s)	$T_{\alpha}^{exp}$ (s)	$T_{\alpha}^{fSM}$ (s)	$T_{\alpha}^{fob}$ (s)	$T_{\alpha}^{fexp}$ (s)	$T_{\alpha}^{fob}/T_{\alpha}^{fexp}$
<b>Z=even, N=even</b>								
<sup>256</sup> Rf	8.926	$0.371 \times 10^1$	$0.123 \times 10^0$	$0.200 \times 10^1$	$0.710 \times 10^0$	$0.554 \times 10^{-1}$	$0.911 \times 10^0$	$0.608 \times 10^{-1}$
<sup>258</sup> Rf	9.190	$0.844 \times 10^0$	$0.188 \times 10^{-1}$	$0.470 \times 10^{-1}$	$0.151 \times 10^0$	$0.942 \times 10^{-2}$	$0.162 \times 10^0$	$0.583 \times 10^{-1}$
<sup>260</sup> Rf	8.900	$0.692 \times 10^0$	$0.104 \times 10^0$	$0.238 \times 10^0$	$0.830 \times 10^0$	$0.662 \times 10^{-1}$	$0.108 \times 10^1$	$0.610 \times 10^{-1}$
<sup>262</sup> Rf	8.490	$0.400 \times 10^0$	$0.192 \times 10^1$	$0.115 \times 10^3$	$0.107 \times 10^2$	$0.123 \times 10^1$	$0.189 \times 10^2$	$0.653 \times 10^{-1}$
<sup>260</sup> Sg	9.901	$0.383 \times 10^{-1}$	$0.325 \times 10^{-2}$	$0.720 \times 10^{-2}$	$0.107 \times 10^{-1}$	$0.573 \times 10^{-3}$	$0.820 \times 10^{-2}$	$0.889 \times 10^{-1}$
<sup>262</sup> Sg	9.600	$0.632 \times 10^{-1}$	$0.216 \times 10^{-1}$	$0.313 \times 10^{-1}$	$0.531 \times 10^{-1}$	$0.359 \times 10^{-2}$	$0.490 \times 10^{-1}$	$0.733 \times 10^{-1}$
<sup>264</sup> Hs	10.591	$0.242 \times 10^{-2}$	$0.405 \times 10^{-4}$	$0.160 \times 10^{-2}$	$0.114 \times 10^{-2}$	$0.542 \times 10^{-4}$	$0.654 \times 10^{-3}$	$0.830 \times 10^{-1}$
<sup>266</sup> Hs	10.346	$0.612 \times 10^{-2}$	$0.126 \times 10^{-3}$	$0.230 \times 10^{-2}$	$0.372 \times 10^{-2}$	$0.211 \times 10^{-3}$	$0.245 \times 10^{-2}$	$0.862 \times 10^{-1}$
<sup>268</sup> Hs	9.623	$0.164 \times 10^0$	$0.805 \times 10^{-2}$	$0.400 \times 10^0$	$0.159 \times 10^0$	$0.158 \times 10^{-1}$	$0.162 \times 10^0$	$0.971 \times 10^{-1}$
<sup>270</sup> Hs	9.050	$0.398 \times 10^1$	$0.215 \times 10^0$	$0.220 \times 10^2$	$0.427 \times 10^1$	$0.688 \times 10^0$	$0.639 \times 10^1$	$0.108 \times 10^0$
<sup>270</sup> Ds	11.120	$0.692 \times 10^{-1}$	$0.271 \times 10^{-7}$	$0.100 \times 10^{-3}$	$0.312 \times 10^{-3}$	$0.150 \times 10^{-4}$	$0.150 \times 10^{-3}$	$0.998 \times 10^{-1}$
<sup>274</sup> Ds	11.700	$0.108 \times 10^{-4}$	$0.283 \times 10^{-6}$	$0.222 \times 10^{-5}$	$0.257 \times 10^{-4}$	$0.851 \times 10^{-6}$	$0.928 \times 10^{-5}$	$0.917 \times 10^{-1}$
<sup>286</sup> Fl	10.370	$0.104 \times 10^0$	$0.928 \times 10^{-2}$	$0.400 \times 10^0$	$0.107 \times 10^0$	$0.286 \times 10^{-1}$	$0.972 \times 10^{-1}$	$0.191 \times 10^0$
<sup>288</sup> Fl	10.072	$0.295 \times 10^1$	$0.109 \times 10^{-1}$	$0.520 \times 10^0$	$0.502 \times 10^0$	$0.110 \times 10^0$	$0.544 \times 10^0$	$0.203 \times 10^0$
<sup>290</sup> Lv	10.990	$0.209 \times 10^{-2}$	$0.376 \times 10^{-5}$	$0.150 \times 10^{-1}$	$0.160 \times 10^{-1}$	$0.250 \times 10^{-2}$	$0.114 \times 10^{-1}$	$0.219 \times 10^0$
<sup>292</sup> Lv	10.774	$0.578 \times 10^{-1}$	$0.476 \times 10^{-3}$	$0.180 \times 10^{-1}$	$0.449 \times 10^{-1}$	$0.822 \times 10^{-2}$	$0.360 \times 10^{-1}$	$0.228 \times 10^0$
<sup>294</sup> Og	11.820	$0.102 \times 10^{-2}$	$0.664 \times 10^{-5}$	$0.700 \times 10^{-2}$	$0.116 \times 10^{-2}$	$0.143 \times 10^{-3}$	$0.595 \times 10^{-3}$	$0.240 \times 10^0$
<b>Z=even, N=odd</b>								
<sup>253</sup> Rf	9.400	$0.163 \times 10^1$	$0.571 \times 10^{-2}$	$0.260 \times 10^0$	$0.135 \times 10^0$	$0.243 \times 10^{-2}$	$0.327 \times 10^0$	$0.743 \times 10^{-2}$
<sup>257</sup> Rf	9.083	$0.391 \times 10^2$	$0.401 \times 10^{-1}$	$0.595 \times 10^1$	$0.766 \times 10^0$	$0.191 \times 10^{-1}$	$0.220 \times 10^1$	$0.870 \times 10^{-2}$
<sup>259</sup> Rf	9.130	$0.498 \times 10^1$	$0.221 \times 10^{-1}$	$0.301 \times 10^1$	$0.589 \times 10^0$	$0.140 \times 10^{-1}$	$0.165 \times 10^1$	$0.850 \times 10^{-2}$
<sup>261</sup> Rf	8.650	$0.771 \times 10^1$	$0.500 \times 10^0$	$0.895 \times 10^2$	$0.955 \times 10^1$	$0.384 \times 10^0$	$0.351 \times 10^2$	$0.110 \times 10^{-1}$

Nucleus	$Q_{\alpha}^{exp}$ (MeV)	$T_{\alpha}^{SM}$ (s)	$T_{\alpha}^{ob}$ (s)	$T_{\alpha}^{exp}$ (s)	$T_{\alpha}^{fSM}$ (s)	$T_{\alpha}^{fob}$ (s)	$T_{\alpha}^{fexp}$ (s)	$T_{\alpha}^{fob}/T_{\alpha}^{fexp}$
<b>Z=even, N=odd</b>								
$^{263}\text{Rf}$	8.250	$0.993 \times 10^1$	$0.808 \times 10^1$	$0.220 \times 10^4$	$0.117 \times 10^3$	$0.755 \times 10^1$	$0.548 \times 10^3$	$0.138 \times 10^{-1}$
$^{259}\text{Sg}$	9.804	$0.223 \times 10^{-1}$	$0.148 \times 10^{-2}$	$0.580 \times 10^0$	$0.541 \times 10^{-1}$	$0.103 \times 10^{-2}$	$0.117 \times 10^0$	$0.879 \times 10^{-2}$
$^{261}\text{Sg}$	9.714	$0.362 \times 10^0$	$0.181 \times 10^{-1}$	$0.234 \times 10^0$	$0.856 \times 10^{-1}$	$0.177 \times 10^{-2}$	$0.193 \times 10^0$	$0.918 \times 10^{-2}$
$^{263}\text{Sg}$	9.400	$0.212 \times 10^1$	$0.114 \times 10^{-1}$	$0.100 \times 10^1$	$0.448 \times 10^0$	$0.127 \times 10^{-1}$	$0.119 \times 10^1$	$0.107 \times 10^{-1}$
$^{265}\text{Sg}$	9.050	$0.345 \times 10^1$	$0.949 \times 10^{-1}$	$0.800 \times 10^1$	$0.313 \times 10^1$	$0.129 \times 10^0$	$0.100 \times 10^2$	$0.129 \times 10^{-1}$
$^{267}\text{Sg}$	8.630	$0.346 \times 10^0$	$0.156 \times 10^1$	$0.494 \times 10^3$	$0.376 \times 10^2$	$0.250 \times 10^1$	$0.154 \times 10^3$	$0.163 \times 10^{-1}$
$^{269}\text{Sg}$	8.700	$0.118 \times 10^3$	$0.727 \times 10^0$	$0.186 \times 10^3$	$0.246 \times 10^2$	$0.150 \times 10^1$	$0.963 \times 10^2$	$0.156 \times 10^{-1}$
$^{271}\text{Sg}$	8.890	$0.264 \times 10^1$	$0.144 \times 10^0$	$0.214 \times 10^3$	$0.791 \times 10^1$	$0.390 \times 10^0$	$0.277 \times 10^2$	$0.140 \times 10^{-1}$
$^{263}\text{Hs}$	10.730	$0.450 \times 10^3$	$0.196 \times 10^{-4}$	$0.760 \times 10^{-3}$	$0.204 \times 10^{-2}$	$0.256 \times 10^{-4}$	$0.313 \times 10^{-2}$	$0.818 \times 10^{-2}$
$^{265}\text{Hs}$	10.470	$0.227 \times 10^{-1}$	$0.644 \times 10^{-4}$	$0.550 \times 10^{-1}$	$0.670 \times 10^{-2}$	$0.106 \times 10^{-3}$	$0.115 \times 10^{-1}$	$0.917 \times 10^{-2}$
$^{267}\text{Hs}$	10.037	$0.180 \times 10^0$	$0.630 \times 10^{-3}$	$0.142 \times 10^1$	$0.535 \times 10^{-1}$	$0.126 \times 10^{-2}$	$0.113 \times 10^0$	$0.112 \times 10^{-1}$
$^{269}\text{Hs}$	9.370	$0.105 \times 10^3$	$0.349 \times 10^{-1}$	$0.360 \times 10^1$	$0.173 \times 10^1$	$0.800 \times 10^{-1}$	$0.511 \times 10^1$	$0.157 \times 10^{-1}$
$^{271}\text{Hs}$	9.510	$0.132 \times 10^1$	$0.109 \times 10^{-1}$	$0.400 \times 10^1$	$0.811 \times 10^0$	$0.323 \times 10^1$	$0.222 \times 10^1$	$0.145 \times 10^{-1}$
$^{275}\text{Hs}$	9.440	$0.314 \times 10^1$	$0.129 \times 10^{-1}$	$0.200 \times 10^0$	$0.118 \times 10^1$	$0.507 \times 10^{-1}$	$0.336 \times 10^1$	$0.151 \times 10^{-1}$
$^{269}\text{Ds}$	11.510	$0.241 \times 10^{-3}$	$0.850 \times 10^{-6}$	$0.230 \times 10^{-3}$	$0.215 \times 10^{-3}$	$0.213 \times 10^{-5}$	$0.259 \times 10^{-3}$	$0.821 \times 10^{-2}$
$^{271}\text{Ds}$	10.870	$0.100 \times 10^{-2}$	$0.183 \times 10^{-4}$	$0.210 \times 10^0$	$0.329 \times 10^{-2}$	$0.554 \times 10^{-4}$	$0.516 \times 10^{-2}$	$0.107 \times 10^{-1}$
$^{273}\text{Ds}$	11.370	$0.173 \times 10^{-3}$	$0.108 \times 10^{-5}$	$0.170 \times 10^{-3}$	$0.383 \times 10^{-3}$	$0.424 \times 10^{-5}$	$0.488 \times 10^{-3}$	$0.869 \times 10^{-2}$
$^{277}\text{Ds}$	10.840	$0.137 \times 10^{-2}$	$0.128 \times 10^{-4}$	$0.600 \times 10^{-2}$	$0.376 \times 10^{-2}$	$0.650 \times 10^{-4}$	$0.598 \times 10^{-2}$	$0.109 \times 10^{-1}$
$^{279}\text{Ds}$	10.080	$0.803 \times 10^{-1}$	$0.943 \times 10^{-3}$	$0.210 \times 10^0$	$0.135 \times 10^0$	$0.472 \times 10^{-2}$	$0.304 \times 10^0$	$0.155 \times 10^{-1}$
$^{281}\text{Ds}$	9.320	$0.854 \times 10^0$	$0.106 \times 10^0$	$0.127 \times 10^2$	$0.746 \times 10^1$	$0.570 \times 10^0$	$0.248 \times 10^2$	$0.230 \times 10^{-1}$
$^{277}\text{Cn}$	11.620	$0.182 \times 10^{-3}$	$0.110 \times 10^{-5}$	$0.110 \times 10^{-2}$	$0.396 \times 10^{-3}$	$0.533 \times 10^{-5}$	$0.494 \times 10^{-3}$	$0.108 \times 10^{-1}$
$^{281}\text{Cn}$	10.460	$0.307 \times 10^{-1}$	$0.424 \times 10^{-3}$	$0.100 \times 10^0$	$0.653 \times 10^{-1}$	$0.241 \times 10^{-2}$	$0.134 \times 10^0$	$0.181 \times 10^{-1}$
$^{283}\text{Cn}$	9.850	$0.108 \times 10^1$	$0.169 \times 10^{-1}$	$0.420 \times 10^1$	$0.136 \times 10^1$	$0.918 \times 10^{-1}$	$0.374 \times 10^1$	$0.245 \times 10^{-1}$
$^{285}\text{Cn}$	9.320	$0.179 \times 10^1$	$0.485 \times 10^0$	$0.280 \times 10^2$	$0.242 \times 10^2$	$0.288 \times 10^1$	$0.878 \times 10^2$	$0.528 \times 10^{-1}$
$^{285}\text{Fl}$	10.520	$0.250 \times 10^0$	$0.119 \times 10^{-2}$	$0.130 \times 10^0$	$0.147 \times 10^0$	$0.779 \times 10^{-2}$	$0.319 \times 10^0$	$0.244 \times 10^{-1}$
$^{287}\text{Fl}$	10.160	$0.103 \times 10^2$	$0.855 \times 10^{-2}$	$0.480 \times 10^0$	$0.860 \times 10^0$	$0.646 \times 10^{-1}$	$0.221 \times 10^1$	$0.292 \times 10^{-1}$
$^{289}\text{Fl}$	9.970	$0.436 \times 10^1$	$0.267 \times 10^{-1}$	$0.190 \times 10^1$	$0.227 \times 10^1$	$0.207 \times 10^0$	$0.639 \times 10^1$	$0.323 \times 10^{-1}$
$^{291}\text{Lv}$	10.890	$0.190 \times 10^0$	$0.434 \times 10^{-3}$	$0.190 \times 10^{-1}$	$0.770 \times 10^{-1}$	$0.432 \times 10^{-2}$	$0.154 \times 10^0$	$0.281 \times 10^{-1}$
$^{293}\text{Lv}$	10.680	$0.553 \times 10^0$	$0.796 \times 10^{-3}$	$0.570 \times 10^{-1}$	$0.204 \times 10^0$	$0.139 \times 10^{-1}$	$0.448 \times 10^0$	$0.311 \times 10^{-1}$

Nucleus	$Q_{\alpha}^{exp}$ (MeV)	$T_{\alpha}^{SM}$ (s)	$T_{\alpha}^{ob}$ (s)	$T_{\alpha}^{exp}$ (s)	$T_{\alpha}^{fSM}$ (s)	$T_{\alpha}^{fob}$ (s)	$T_{\alpha}^{fexp}$ (s)	$T_{\alpha}^{fob}/T_{\alpha}^{fexp}$
<b>Z=odd, N=even</b>								
<sup>255</sup> Db	9.600	$0.113 \times 10^1$	$0.336 \times 10^{-2}$	$0.213 \times 10^1$	$0.208 \times 10^0$	$0.158 \times 10^{-2}$	$0.353 \times 10^0$	$0.449 \times 10^{-2}$
<sup>257</sup> Db	9.206	$0.378 \times 10^4$	$0.406 \times 10^{-1}$	$0.162 \times 10^1$	$0.143 \times 10^1$	$0.196 \times 10^{-1}$	$0.473 \times 10^1$	$0.415 \times 10^{-2}$
<sup>259</sup> Db	9.620	$0.435 \times 10^0$	$0.208 \times 10^{-2}$	$0.510 \times 10^0$	$0.189 \times 10^0$	$0.140 \times 10^{-2}$	$0.310 \times 10^0$	$0.451 \times 10^{-2}$
<sup>265</sup> Bh	9.680	$0.220 \times 10^1$	$0.576 \times 10^{-2}$	$0.119 \times 10^1$	$0.416 \times 10^0$	$0.492 \times 10^{-2}$	$0.875 \times 10^0$	$0.562 \times 10^{-2}$
<sup>267</sup> Bh	9.230	$0.166 \times 10^3$	$0.853 \times 10^{-1}$	$0.220 \times 10^2$	$0.380 \times 10^1$	$0.886 \times 10^{-1}$	$0.171 \times 10^2$	$0.516 \times 10^{-2}$
<sup>271</sup> Bh	9.490	$0.493 \times 10^1$	$0.107 \times 10^{-1}$	$0.150 \times 10^1$	$0.104 \times 10^1$	$0.163 \times 10^{-1}$	$0.299 \times 10^1$	$0.543 \times 10^{-2}$
<sup>279</sup> Rg	10.520	$0.909 \times 10^{-1}$	$0.240 \times 10^{-3}$	$0.900 \times 10^{-1}$	$0.755 \times 10^{-1}$	$0.802 \times 10^{-3}$	$0.836 \times 10^{-1}$	$0.960 \times 10^{-2}$
<sup>283</sup> Nh	10.480	$0.196 \times 10^0$	$0.876 \times 10^{-3}$	$0.750 \times 10^{-1}$	$0.246 \times 10^0$	$0.460 \times 10^{-2}$	$0.399 \times 10^0$	$0.115 \times 10^{-1}$
<sup>285</sup> Nh	10.030	$0.816 \times 10^4$	$0.150 \times 10^{-1}$	$0.550 \times 10^1$	$0.186 \times 10^1$	$0.659 \times 10^{-1}$	$0.607 \times 10^1$	$0.108 \times 10^{-1}$
<sup>287</sup> Mc	10.740	$0.230 \times 10^2$	$0.649 \times 10^{-3}$	$0.370 \times 10^{-1}$	$0.217 \times 10^0$	$0.474 \times 10^{-2}$	$0.330 \times 10^0$	$0.144 \times 10^{-1}$
<sup>293</sup> Ts	11.180	$0.243 \times 10^1$	$0.344 \times 10^{-3}$	$0.220 \times 10^{-1}$	$0.929 \times 10^{-1}$	$0.136 \times 10^{-2}$	$0.103 \times 10^0$	$0.181 \times 10^{-1}$
<b>Z=odd, N=odd</b>								
<sup>256</sup> Db	9.340	$0.132 \times 10^2$	$0.173 \times 10^{-1}$	$0.296 \times 10^1$	$0.162 \times 10^1$	$0.819 \times 10^{-2}$	$0.245 \times 10^1$	$0.334 \times 10^{-2}$
<sup>258</sup> Db	9.500	$0.533 \times 10^1$	$0.566 \times 10^{-2}$	$0.703 \times 10^1$	$0.704 \times 10^0$	$0.296 \times 10^{-2}$	$0.100 \times 10^1$	$0.296 \times 10^{-2}$
<sup>260</sup> Db	9.500	$0.281 \times 10^1$	$0.428 \times 10^{-2}$	$0.168 \times 10^1$	$0.704 \times 10^0$	$0.296 \times 10^{-2}$	$0.100 \times 10^1$	$0.296 \times 10^{-2}$
<sup>262</sup> Db	9.050	$0.249 \times 10^3$	$0.653 \times 10^{-1}$	$0.116 \times 10^3$	$0.779 \times 10^1$	$0.556 \times 10^{-1}$	$0.133 \times 10^2$	$0.419 \times 10^{-2}$
<sup>260</sup> Bh	10.400	$0.892 \times 10^{-1}$	$0.932 \times 10^{-4}$	$0.410 \times 10^{-1}$	$0.280 \times 10^{-1}$	$0.716 \times 10^{-4}$	$0.304 \times 10^{-1}$	$0.235 \times 10^{-2}$
<sup>262</sup> Bh	10.320	$0.639 \times 10^{-1}$	$0.112 \times 10^{-3}$	$0.105 \times 10^0$	$0.404 \times 10^{-1}$	$0.112 \times 10^{-3}$	$0.451 \times 10^{-1}$	$0.248 \times 10^{-2}$
<sup>264</sup> Bh	9.960	$0.335 \times 10^0$	$0.721 \times 10^{-3}$	$0.124 \times 10^1$	$0.221 \times 10^0$	$0.899 \times 10^{-3}$	$0.281 \times 10^0$	$0.320 \times 10^{-2}$
<sup>266</sup> Bh	9.430	$0.547 \times 10^2$	$0.160 \times 10^{-1}$	$0.250 \times 10^1$	$0.324 \times 10^1$	$0.239 \times 10^{-1}$	$0.503 \times 10^1$	$0.475 \times 10^{-2}$
<sup>270</sup> Bh	9.060	$0.220 \times 10^1$	$0.145 \times 10^0$	$0.610 \times 10^2$	$0.241 \times 10^2$	$0.279 \times 10^0$	$0.436 \times 10^2$	$0.639 \times 10^{-2}$
<sup>272</sup> Bh	9.310	$0.824 \times 10^0$	$0.204 \times 10^{-1}$	$0.880 \times 10^1$	$0.613 \times 10^1$	$0.522 \times 10^{-1}$	$0.999 \times 10^1$	$0.522 \times 10^{-2}$
<sup>274</sup> Bh	8.930	$0.124 \times 10^0$	$0.229 \times 10^0$	$0.540 \times 10^2$	$0.503 \times 10^2$	$0.686 \times 10^0$	$0.962 \times 10^2$	$0.713 \times 10^{-2}$
<sup>266</sup> Mt	11.000	$0.116 \times 10^{-1}$	$0.871 \times 10^{-5}$	$0.120 \times 10^{-2}$	$0.593 \times 10^{-2}$	$0.132 \times 10^{-4}$	$0.561 \times 10^{-2}$	$0.235 \times 10^{-2}$
<sup>268</sup> Mt	10.670	$0.409 \times 10^{-1}$	$0.402 \times 10^{-4}$	$0.700 \times 10^{-1}$	$0.248 \times 10^{-1}$	$0.760 \times 10^{-4}$	$0.261 \times 10^{-1}$	$0.291 \times 10^{-2}$
<sup>270</sup> Mt	10.180	$0.381 \times 10^0$	$0.524 \times 10^{-3}$	$0.570 \times 10^0$	$0.235 \times 10^0$	$0.120 \times 10^{-2}$	$0.293 \times 10^0$	$0.408 \times 10^{-2}$

Nucleus	$Q_{\alpha}^{exp}$ (MeV)	$T_{\alpha}^{SM}$ (s)	$T_{\alpha}^{ob}$ (s)	$T_{\alpha}^{exp}$ (s)	$T_{\alpha}^{fSM}$ (s)	$T_{\alpha}^{fob}$ (s)	$T_{\alpha}^{fexp}$ (s)	$T_{\alpha}^{fob}/T_{\alpha}^{fexp}$
<b>Z=even, N=odd</b>								
$^{274}\text{Mt}$	10.510	$0.337 \times 10^{-1}$	$0.568 \times 10^{-4}$	$0.440 \times 10^0$	$0.508 \times 10^{-1}$	$0.173 \times 10^{-3}$	$0.564 \times 10^{-1}$	$0.324 \times 10^{-2}$
$^{276}\text{Mt}$	9.990	$0.404 \times 10^0$	$0.966 \times 10^{-3}$	$0.450 \times 10^0$	$0.587 \times 10^0$	$0.368 \times 10^{-2}$	$0.785 \times 10^0$	$0.469 \times 10^{-2}$
$^{278}\text{Mt}$	9.460	$0.522 \times 10^4$	$0.230 \times 10^{-1}$	$0.450 \times 10^1$	$0.873 \times 10^1$	$0.100 \times 10^0$	$0.143 \times 10^2$	$0.703 \times 10^{-2}$
$^{272}\text{Rg}$	11.197	$0.636 \times 10^{-2}$	$0.759 \times 10^{-5}$	$0.200 \times 10^{-2}$	$0.744 \times 10^{-2}$	$0.212 \times 10^{-4}$	$0.701 \times 10^{-2}$	$0.303 \times 10^{-2}$
$^{274}\text{Rg}$	11.480	$0.887 \times 10^{-3}$	$0.142 \times 10^{-5}$	$0.640 \times 10^{-2}$	$0.234 \times 10^{-2}$	$0.512 \times 10^{-5}$	$0.202 \times 10^{-2}$	$0.254 \times 10^{-2}$
$^{278}\text{Rg}$	10.850	$0.128 \times 10^{-1}$	$0.284 \times 10^{-4}$	$0.420 \times 10^{-2}$	$0.328 \times 10^{-1}$	$0.131 \times 10^{-3}$	$0.345 \times 10^{-1}$	$0.380 \times 10^{-2}$
$^{280}\text{Rg}$	10.190	$0.299 \times 10^0$	$0.102 \times 10^{-2}$	$0.460 \times 10^1$	$0.674 \times 10^0$	$0.535 \times 10^{-2}$	$0.889 \times 10^0$	$0.602 \times 10^{-2}$
$^{282}\text{Rg}$	9.510	$0.417 \times 10^2$	$0.736 \times 10^{-1}$	$0.100 \times 10^3$	$0.209 \times 10^2$	$0.364 \times 10^0$	$0.358 \times 10^2$	$0.102 \times 10^{-1}$
$^{282}\text{Nh}$	10.780	$0.399 \times 10^{-1}$	$0.161 \times 10^{-3}$	$0.730 \times 10^{-1}$	$0.129 \times 10^0$	$0.857 \times 10^{-3}$	$0.147 \times 10^0$	$0.582 \times 10^{-2}$
$^{284}\text{Nh}$	10.230	$0.478 \times 10^1$	$0.327 \times 10^{-2}$	$0.910 \times 10^0$	$0.166 \times 10^1$	$0.197 \times 10^{-1}$	$0.229 \times 10^1$	$0.863 \times 10^{-2}$
$^{286}\text{Nh}$	9.770	$0.189 \times 10^2$	$0.571 \times 10^{-1}$	$0.950 \times 10^1$	$0.165 \times 10^2$	$0.333 \times 10^0$	$0.270 \times 10^2$	$0.123 \times 10^{-1}$
$^{288}\text{Mc}$	10.630	$0.811 \times 10^1$	$0.119 \times 10^{-2}$	$0.164 \times 10^0$	$0.734 \times 10^0$	$0.880 \times 10^{-2}$	$0.935 \times 10^0$	$0.942 \times 10^{-2}$
$^{290}\text{Mc}$	10.400	$0.192 \times 10^0$	$0.379 \times 10^{-2}$	$0.650 \times 10^0$	$0.215 \times 10^1$	$0.332 \times 10^{-1}$	$0.297 \times 10^1$	$0.112 \times 10^{-1}$
$^{294}\text{Ts}$	11.070	$0.150 \times 10^1$	$0.256 \times 10^{-3}$	$0.510 \times 10^{-1}$	$0.289 \times 10^0$	$0.335 \times 10^{-2}$	$0.336 \times 10^0$	$0.997 \times 10^{-2}$



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