SCIENTIFIC REPORT

concerning the project implementation during the period January – December 2012

Comparison of the accuracy of the theoretical models (ASAF model, UNIV and UDL universal curves, and semFIS relationship) for nuclei with measured decay modes.

During this period we used the experimental data of 534 alpha emitters (173 even-even, 134 even-odd, 123 odd-even and 104 odd-odd) as well as cluster decay modes (A_e=14-34) of 27 nuclei (16 even-even, 6 even-odd and 5 odd-odd) to determine the optimum parameters of theoretical models allowing to get the smallest standard rms deviation with respect to experimental data. The improved methods with new parameters will be used in future to make predictions in the regions of nuclear charts not experimentally explored up to now (e.g. Superheavy nuclei with Z > 118).

The simplest illustration of mentioned data is given in figure 1: both in UNIV and UDL models the 534 experimental data for alpha decay and 27 for cluster decay [1] are lying on a straight line.

We may see in detail the systematic deviations for alpha decay of 173 even-even nuclei calculated with the UNIV and UDL models versus the neutron number (left-hand side) and versus the atomic number (right-hand side) in figure 2. It is clear from this figure that UNIV and UDL models are not able to reproduce fully the shell effects. Consequently we may see large deviations in the neighbourhood of spherical and deformed magic numbers (82, 126, 172) and (162), respectively for neutrons and of spherical (82) and deformed (108) proton magic numbers. The deformed magic number of neutrons , N=152 makes an exception. No clear maximum appears in figure 2 at N=152 despite the fact that the magicity of this number is evident in figures representing the Q-value or the half-life , T.

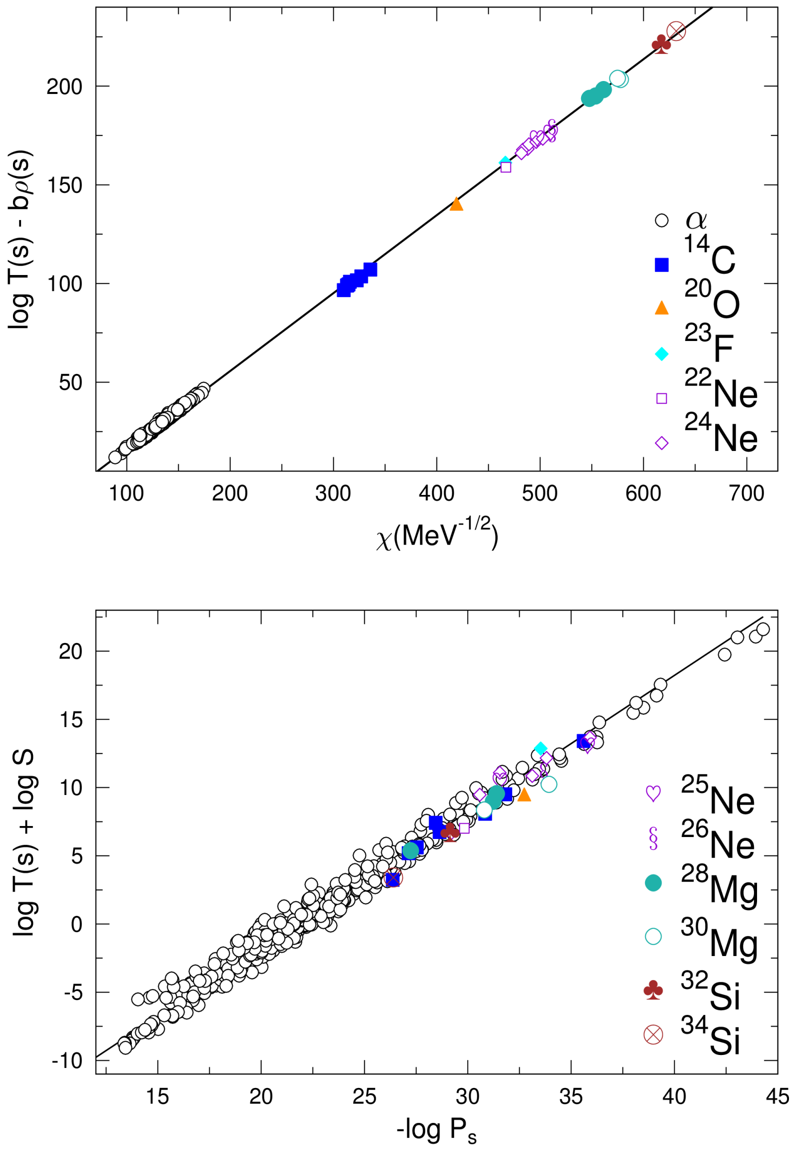

Figure 1 A single straight line UNIV (bottom) and UDL (top) for the alpha decay of 534 nuclei and 27 cluster decay modes (8 decays by ^{14}C emission, 6 emissions of ^{24}Ne, 3 of ^{28}Mg, 2 of ^{25}Ne and one of ^{20}O, ^{23}Fe, ^{22}Ne, ^{26}Ne, ^{30}Mg, ^{32}Si and ^{34}Si).

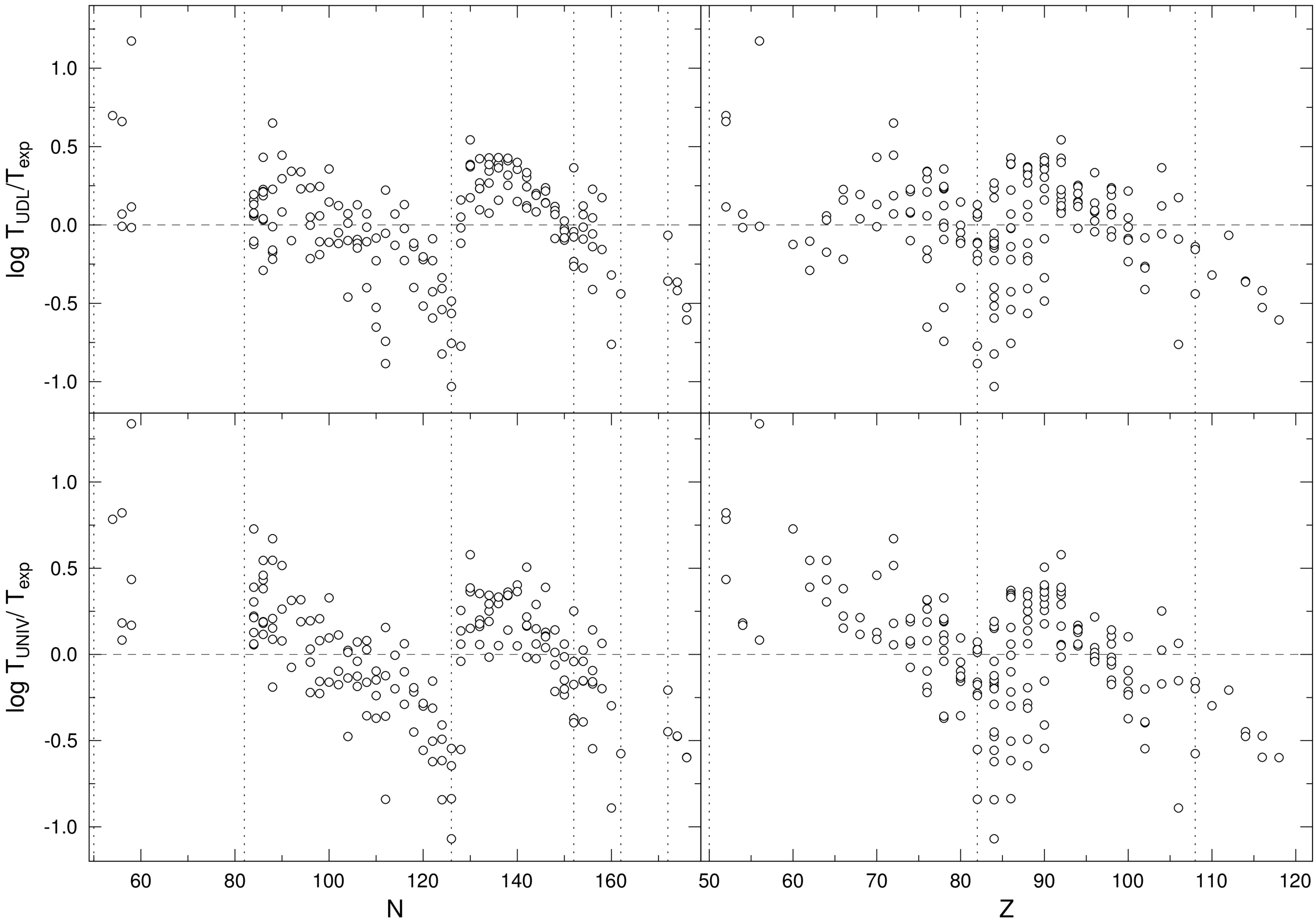

Figure 2 Deviation of half-lives relative to alpha decay of 173 even-even nuclei calculated with UNIV model (bottom) and UDL (top) versus the neutron number (left-hand side) and atomic number (right-hand side). Vertical dotted lines from the left panel correspond to magic numbers 50, 82, 126, 152, 162, 172 and those from the right panel to 50, 82, 108.

A global evaluation of the accuracy of a a given model may be obtained by using the standard rms deviation

$$\sigma = \{\sum_{i=1}^{n}[\log_{10}(T_i / T_{\exp})]^2 / (n-1)\}^{1/2}$$

where n is the total number of employed experimental data.

Before making half-life calculations we updated the Q-values using the latest experimental data of atomic masses , AME11, released by G. Audi and Wang Meng the last year.

For calculations with UNIV model of all 27 experimental data we obtained σ = 0.797 if the value of the additional constant was h=0.010. Within UDL σ = 0.889 if c = - 25.973. The ASAF model nonoptimized gives an overall σ=1.156. The table 1 presents the results for cluster decay modes. No odd-odd emitter had been experimentally observed up to now.

Table 1 Standard deviation, σ, for UNIV, UDL and ASAF models. Cluster radioactivities.

n	Parent nucl. parity	σ_{UNIV}	h_{UNIV}	σ_{UDL}	c_{UDL}	σ_{ASAF}
27	all	0.797	0.010	0.889	- 25.973	1.156
16	e - e	0.564	- 0.386	0.578	- 26.421	0.971
6	e - o	0.859	0.595	1.151	- 25.494	2.011
5	o - e	0.677	0.585	0.405	- 25.116	0..305

The similar data for α decay are given in Table 2. This time we also have the model semFIS (semiempirical relationship based on fission theory). UNIV is the acronym of universal, also based on fission theory. UDL is a similar model for an universal approach based on a microscopic theory of α decay. ASAF is the acronym of „Analytical SuperAsymmetric Fission".

Table 2 Standard deviation, σ, for UNIV, UDL, semFIS and ASAF models. α decay.

n	Parity	σ_{UNIV}	h_{UNIV}	σ_{UDL}	c_{UDL}	σ_{semFIS} standard	σ_{semFIS} optimum	σ_{ASAF}
534	all	0.699	0.417	0.647	- 20.432			0.663
173	e - e	0.354	0.030	0.329	- 20.796	0.239	0.222	0.421
134	e - o	0.640	0.528	0.606	- 20.327	0.544	0.501	0.733
123	o - e	0.565	0.379	0.538	- 20.481	0.473	0.434	0.642
104	o - o	0.826	0.961	0.804	- 19.904	0.599	0.567	0.891

From both tables it may be seen that the ASAF model should be further improved in order to compete with the other models; one can try to change the parameters in order to optimize the model. Presently the minimum errors are obtained using semFIS only valid for alpha decay. It is followed by UNIV and UDL. Previously we obtained similar results for a smaller set of heavy and superheavy alpha emitters. For 44 even-even nuclei we got σ = 0.164 within semFIS, σ = 0.267 within UNIV and σ = 0.402 within ASAF. For 25 odd-odd nuclei σ = 0.451, 0.456 and 0.795, respectively.

A comparison of calculations with ASAF and semFIS models for alpha decay of Shs with Z=121-124, which have not been produced until now, may be seen in figure 3. As we already had seen we may assume that the semFIS model gives the best results (closer to reality). Interesting is the even-odd staggering observed in both cases: for N < 184 (supposed to be magic neutron number) the semFIS model gives more pronounced variations than ASAF; for N > 186 the opposite is true.

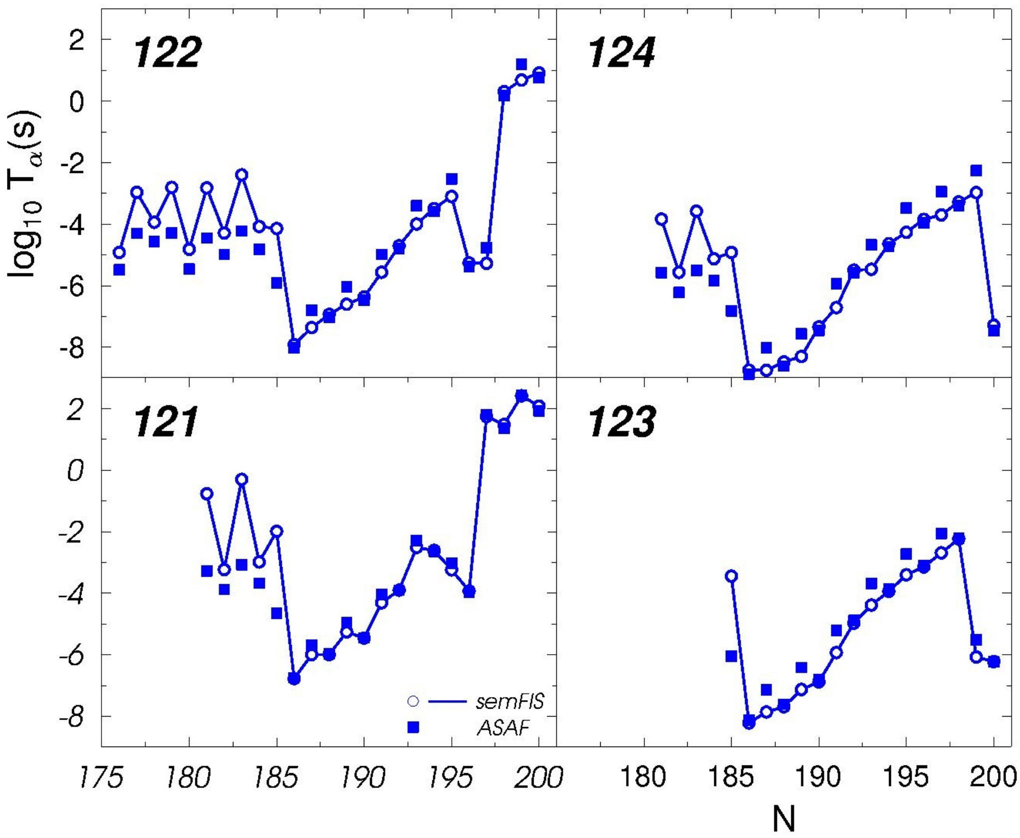

Figure 3 Comparison of half-lives for α decayofsuperheavieswithatomic a numbers Z = 121, 122, 123 and 124 calculated within ASAF model (full squares) and semFIS (open circles) versus the neutron numbers.

In conclusion the smallest errors may be obtained for α decay using the semFIS model, while for cluster decays the best model is UNIV. The ASAF model needs an optimization by changing the free parameters, so that both for α decay and cluster radioactivities the standard deviations will become smaller.

This year we published articles in *Physical Review C* [2], *Journal of Physics G: Nuclear and Particle Physics* [1], *International Journal of Modern Physics E* [3], *Romanian Reports in Physics* [5] *and Romanian Journal of Physics* [4]. In *Revista de Politica Stiintei si Scientometrie – Serie Noua,* we published a popularization article concerning the evaluation criteria of scientific researchers [6].

Also we have been invited to give invited talks at several International Scientific Meetings [7-9] and with an oral presentations [10]. At the International Conferences held in Kiev and Debrecen I have been Chairman of some parallel sessions; at the Conference in USA I have been member of the International Advisory Committee.

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