Raport stiintific sintetic

privind implementarea proiectului in perioada octombrie 2011 – octombrie 2016

Fisiunea spontana a nucleelor supragrele

Nucleele supragrele (SG) produse pana in prezent prin reactii de fuziune se dezintegreaza prin emisie de particule alfa (Da) si fisiune spontana (FS). Pentru numere atomice mai mari de Z=121 radioactivitatea cluster (DC) [1] are o buna sansa de a intra in competitie.

In timp ce majoritatea perioadelor de injumatatire calculate pentru Da si DC sunt in acord cu datele experimentale (cu erori de cel mult 1-2 ordine de marime) [2], discrepanta dintre teorie si experiment poate intrece 10 ordine in cazul FS. De exemplu pentru $^{294}118$, valoarea minima prezisa este $\log_{10} T_f(s) = -0.66$ iar cea maxima $\log_{10} T_f(s) = 17.87$, adica o diferenta ce intrece 18 ordine de marime!! Noi am incercat la inceput [2] o dinamica bazata pe inertia nucleara de tip Werner-Wheeler (clasic), dar am constatat ca aceasta are valori prea mici. O solutie mai buna recurge la modelul microscopic "cranking" [3, 4, 5, 6].

In regiunea de nuclee grele cu Z=87-96, experientele privind DC de tipul ^{14}C, ^{20}O, ^{23}F, $^{22,24-26}$Ne, ^{28,30}Mg si ^{32,34}Si au confirmat previziunile noastre din 1980; DC este un fenomen rar intr-un fond imens de particule alfa. Calculele noastre [7] indica o tendinta catre un raport de ramificare $b = T_a/T_c > 1$ pentru nuclee SG cu $Z > 121$. In ciuda acordului dintre teorie si experiment pentru Da si DC, in regiunile hartii nucleelor la care experimentul inca nu a ajuns exista o incertitudine mare a calculelor timpilor de viata ca o consecinta a diferentelor dintre masele atomice calculate cu diferite modele.

Noi ne continuam studiul sistematic folosind 2 tabele de masa: experimental AME12 [8] disponibil pentru SG neutrondeficiente cu $Z < 119$ si teoretic WS-10 [9] extins pana la "neutron drip line".

In cele trei moduri de dezintegrare mentionate mai sus, dintr-un nucleu parinte ^{Z}A rezulta o particula emisa (sau un fragment usor) $^{Z_2}A_2$ si o fiica (fragment greu) $^{Z_1}A_1$. Consideram competitia FS efectuand calcule dinamice cu modelul microscopic cranking al tensorului inertiei nucleare si modelul original [10] in paturi cu doua centre pentru a obtine datele de intrare pentru corectiile microscopice de paturi si imperechere tip Strutinsky [11] la energia de deformare macroscopica de tip Yukawa-plus exponentiala [12, 13].

Intr-o prima etapa am cules cat mai multe date experimentale pentru a putea face comparatie cu teoria. Pentru Da, de exemplu, am reusit sa gasim 581 emitatori. Avem 27 date pentru DC; pana in prezent nu s-a detectat nici un parinte impar-impar.

Modurile de dezintegrare nucleare studiate sunt explicate prin tunelare cuantica a barierei de potential. Pentru Da s-a gasit [14] ca modelele noastre [15, 16] dau precizia cea mai buna. Folosim modelele noastre semFIS (modelul semiempiric bazat pe teoria fisiunii), ASAF (analytical superasymmetric fission) si UNIV (curba universala). Spre deosebire de majoritatea celorlalte modele care dau devieri mari de la valorile experimentale in vecinatatea numerelor magice de neutroni (de exemplu N=126) modelul semFIS se comporta bine si acolo. Pentru izotopii neutronodeficitari exista o limita tehnica: Da sau DC cu durate de viata sub o microsecunda nu pot fi detectate datorita timpului de zbor prin separatorul produsilor de recul. Detalii despre aceste rezultate bune au fost date in rapoartele anterioare.

Orice componenta a tensorului de inertie este data de

$$B_{ij} = 2\hbar^2 \sum_{\nu\mu} \frac{\langle \nu | \partial H / \partial \beta_i | \mu \rangle \langle \mu | \partial H / \partial \beta_j | \nu \rangle}{(E_\nu + E_\mu)^3} (u_\nu v_\mu + u_\mu v_\nu)^2 \tag{1}$$

unde H este hamiltonianul uni-particula utilizat pentru determinarea energiei nivelelor si functiilor de unda $|\nu\rangle$; u_ν^2 si v_ν^2 sunt probabilitatile de ocupare BCS, E_ν este energia unei cvasiparticule, iar β_i, β_j sunt parametrii independenti de deformare.

Studiem dinamica fisiunii reci [17, 18, 18]. Comparam in figura 1 valorile absolute ale corectiilor de paturi si imperechere pentru fisiunea simetrica a ^{282}Cn cu R_2 constant (linie intrerupta) si R_2 linear crescator (solid linia plina). Cum era de asteptat gapul pentru protoni, Δ_p, si neutroni, Δ_n, solutii ale sistemului BCS de doua ecuatii. Minime adanci in jurul $(R - R_i)/(R_t - R_i) = 0.82$ se vad clar. Rezultate similare se obtin si pentru nuclee grele cum ar fi ^{252}Cf sau ^{240}Pu. O prezentare

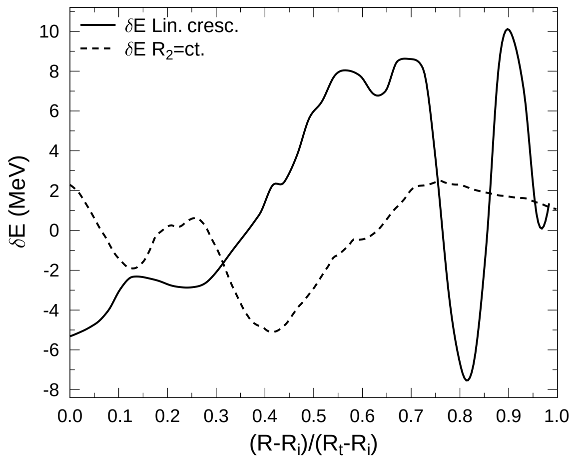

Figura 1: Comparatie dintre valorile absolute ale corectiilor de paturi si imperechere pentru fisiunea simetrica a ^{282}Cn cu R_2 constant (linie intrerupta) si R_2 care creste linear (linia solida).

pentru nespecialisti a marii diversitati de tipuri de dezintegrari nucleare se poate gasi in Ref. [20]. In concluzie, mentionam rezultatul cel mai important obtinut in acest an, privind intelegerea fenomenului de fisiune rece: *preformarea fragmentului usor la suprafata nucleului* [4, 5, 6] care poate fi astfel tratat in mod unificat impreuna cu Da si CD. Totodata subliniem necesitatea de a face calcule fiabile pentru perioade de injumatatire de FS ale nucleelor SG si necesitatea de a extinde aceste calcule pentru nuclee mai aproapiate de linia de stabilitate β si neutronoexcedentare. De asemenea, ne propunem sa studiem fisiunea ternara, atat in varianta de particula usoara care insoteste fisiunea cat si in cea de "fisiune ternara adevarata", cu 3 fragmente de mase comparabile.

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3. Journal of Physics G: Nucl Part Phys
4. Physical Review C
5. European Physical Journal A
6. Nuclear Physics A
7. Physica Scripta
8. International J. Mod. Phys. E
9. Mod. Phys. Letters A
10. Canadian Journal of Physics

11. Annalen der Physik (Berlin)

Expert evaluator

1. Comisia Europeana pentru proiecte FP6 si INTAS
2. New Eurasia Foundation in 2011 si 2013.

Onoruri

A. Membru al Editorial Advisory Board of International Journals

1. The International Review of PHYSICS (IREPHY) published by Praise Worthy Prize Publishers.
2. Journal of Nuclear and Particle Physics http://www.sapub.org/journal/editorialboard.aspx?JournalID=1029
3. Journal of Nuclear Physics, Material Sciences, Radiation and Applications (JNPMSRA) http://jnp.chitkara.edu.in

B. 2011 - Invited Talk at the Symposium dedicated to the discovery of atomic nucleus by Ernest Rutherford in 1911 and 55th Anniversary of JINR Dubna.

2011 - Short biography in Romanian, by Prof. P. T. Frangopol, published in Evrika Nr 1 (245) XXI (January 2011) 5-7, journal dedicated to High School Physics in Romania.

2012 - Diploma of Honour and the Institute of Atomic Physics Medal for contributions in the field of cluster radioactivity as a token of high appreciation of outstanding merit in the field of nuclear decay by cluster emission and the whole scientific and leadership activity in research.

2012 - Excaellence in Reviewing, Nuclear Physics A.

2013 - Excellence in Reviewing, Nuclear Physics A.

2013 - Grigore Moisil prize nominee, Bucharest.

2014 - Outstanding Contribution in Reviewing: Nuclear Physics A

2016 - 40 GBP pentru a cumpara carti la Amazon.uk acordati de Editorii revistei Nuclear Physics A in semn de apreciere pentru referatele din 2015

C. Membru in Comisii Internationale de Doctorat

2011 - Bharatiar University, Coimbatore, Tamilandu, India

2012 - Thapar University, Patiala, India

2014 - Bharatiar University, Coimbatore, Tamilandu, India

2016 - Cairo University, Egypt

Citari, indice Hirsch, indice i10, factor G

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Citari in 2011: 140, Citari in 2012: 199, Citari in 2013: 187, Citari in 2014: 193, Citari in 2015: 183, Citari in 2016 (pana in Sept): 90.

Pana in prezent stiu ca exista 53 teze de doctorat in care sunt citat.

Profilul Google Scholar http://scholar.google.com/citations?hl=ro&user=SH1MaoIAAAAJ

Studiul sistematic al celor 18 formule destinate calculului perioadelor de injumatatire in dezintegrarea alfa, publicat in Decembrie 2015, Y.Z. Wang, S.J. Wang, Z.Y. Hou, J.Z. Gu, Systematic study of alpha-decay energies and half-lives of superheavy nuclei, Phys. Rev. C 92 (2015) 064301. arata ca "formula SemFIS2 este cea mai buna sa prezica duratele de viata in dezintegrarea alfa ... In plus formula UNIV2 cu mai putini parametri si formulele VSS, SP si NRDX ... functioneaza bine pentru prezicerea duratelor de viata in dezintegrarea alfa."

Atat SemFIS2 (formula semi-empirica bazata pe teoria fisiunii) cat si UNIV2 (curba universala) au fost dezvoltate de catre noi (D.N. Poenaru, R.A. Gherghescu, W. Greiner si N. Carjan).

In 2016 am mai gasit o teza de doctorat care ma citeaza astfel ca pana in prezent cunosc 52 astfel de teze.

Legatura la Profilul meu Google Scholar http://scholar.google.com/citations?hl=ro&user=SH1MaoIAAAAJ

La fel pentru Radu A Gherghescu http://scholar.google.ro/citations?user=4ckbd0gAAAAJ&hl=en

Director de Proiect: Dr. Dorin N. Poenaru