Cerere FASCICUL la TANDEM

(Câmpurile cu * trebuie completate în mod obligatoriu pentru ca cererea de fascicul să fie înregistrată)

Titlu experiment	**Lifetime measurements in $^{74}_{33}As_{41}$**

Responsabil experiment:

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Scurtă prezentare a interesului ştiinţific

In ultimele trei decenii nucleele din zona de masa cu A≈60-80 au constituit si constituie obiectul unui interes deosebit, atit pentru experimentatori cit si pentru teoreticieni. Progresele realizate in domeniul spectroscopiei gama in fascicul au dus la acumularea rapida de date experimentale, accentul punindu-se pe nucleele neutronodeficitare cu N≈Z. Datele acumulate au aratat ca, pentru nucleele cu Z≥33 proprietatile nucleare se modifica drastic atunci cind se trece de la nucleele sferice cu numar magic de neutroni N=50 la nucleele neutronodeficitare cu N=36-40. Nucleele din zona de masa cu A≈60-80 prezinta o serie de particularitati de structura care le diferentiaza net de nucleele deformate mai grele. O caracteristica importanta a nucleelor din zona de masa cu A≈70 este prezenta coexistentei de forma la spini josi. Examinarea diagramei de nivele uniparticula releva prezenta mai multor intervale de paturi atit pentru deformare nula cit si pentru deformari oblate si prolate, practic pentru fiecare doi nucleoni adaugati intre 32 si 42. S-a sugerat si este destul de larg acceptat ca atit prezenta deformarii si a coexistentei de forma cit si rapiditatea evolutiei deformarii cu numarul de protoni si neutroni se datoresc intervalelor de paturi din spectrul uniparticula care apar la Z,N=40 pentru deformare β=0, la Z,N=38 pentru deformare prolate $\beta\approx0.4$, la Z,N=36 pentru deformare oblate $\beta\approx-0.4$ si la Z,N=34 atit pentru deformari prolate cit si oblate $|\beta|\approx0.24$. Spre deosebire de nucleele grele deformate, densitatea de nivele uniparticula in nucleele cu A≈70 este mai mica (numarul de stari uniparticula pe unitatea de energie este cu aproximativ un factor doi mai mic) astfel ca intervalele de paturi care apar in spectrul uniparticula au o importanta relativa mai mare. Adaugarea sau eliminarea a 2-3 nucleoni poate deci avea efecte dramatice asupra formei nucleare. Este de asteptat ca stari corespunzind unei forme sferice, unei deformari prolate si unei deformari oblate sa coexiste in acelasi nucleu. Aceasta este in particular adevarat pentru izotopii neutronodeficitari ai Se(Z=34) si Kr (Z=36) in care protonii prefera o deformare oblate pe cind neutronii pentru N=38-42 favorizeaza o deformare prolate mare ($\beta\approx0.4$). Intrucit pina in prezent nu exista o interpretare unica a aspectelor neobisnuite evidentiate in studiul structurii nucleelor din zona de masa cu A≈60-80, studiul sistematic al evolutiei deformarii nucleare ca functie de numarul de nucleoni, energie de excitatie si spin reprezinta, in acesta zona de masa, o problema de stringenta actualitate.

In ultimii ani au fost investigate in detaliu nucleele situate in vecinatatea intervalelor de paturi deformate corespunzind la numerele de nucleoni N=Z=36 si N=Z=38 pentru deformari mari ($\beta \approx 0.4$) oblate si prolate respectiv. Una din amprentele coexistentei de forma in nucleele par-pare este aparitia unor nivele $J^{\pi}=0^{+}$ de joasa excitare, care pot fi interpretate ca ,,stari fundamentale'' excitate cu deformare diferita de deformarea starii fundamentale. Recent au fost pusi in evidenta la initiativa si cu participarea unor membri ai laboratorului nostru izomeri de forma $J^{\pi}=0^{+}$ in ^{74}Kr si, pentru prima data intr-un nucleu cu N=Z, in ^{72}Kr. Descoperirea acestor izomeri de forma a adus un plus de evidenta in favoarea importantei celor doua intervale de paturi mentionate mai sus in determinarea structurii nucleeelor din aceasta zona de masa. In nucleul par-impar ^{73}Se s-a demonstrat recent prin masuratorile noastre ca deformarea in banda colectiva de paritate negativa bazata pe nivelul $5/2^{-}$ de la 151 keV este prolate cu $\beta \approx +0.45$ pe cind deformarea in starea fundamentala $9/2^{+}$ si in banda decuplata bazata pe starea fundamentala este oblate. In nucleul impar-impar ^{72}As, izoton cu ^{73}Se, s-a pus recent in evidenta prin masuratorile noastre in colaborare cu grupul de spectroscopie de la Vanderbilt University si cu grupul de la FSU si deasemenea prin masuratorile efectuate la FSU o banda colectiva de paritate pozitiva bazata pe nivelul $J^{\pi}=8^{+}$ de la 981.6 keV. Pe cind proprietatile nivelelor de spin jos si mediu de ambele paritati pina la nivelul $J^{\pi}=7^{-}$ de la 562.8 keV, inclusiv momentele magnetice, pot fi descrise in termeni de model in paturi sferic fara a implica deformare, nivelele benzii de paritate pozitiva si spin inalt bazate pe nivelul $J^{\pi}=8^{+}$ sint colective. Ipoteza avansata in literatura privind structura nivelului $J^{\pi}=8^{+}$ este ca acesta s-ar datora configuratiei $[\pi 1g_{9/2},\nu 1g_{9/2}]_{8}^{+}$. In acord cu acesta ipoteza factorul giromagnetic al starii 8^{+} ar trebui sa fie apropiat de valoarea g=+0.412. Aceasta valoare se obtine luind pentru factorii giromagnetici protonic si neutronic valorile empirice masurate pentru starile uniparticula $9/2^{+}$, $1g_{9/2}$ din nucleele impare in protoni si in neutroni vecine cu ^{72}As. Valoarea masurata de noi recent g=-0.534(35) este in dezacord cu valoarea teoretica, calculata in ipoteza unei configuratii $[\pi 1g_{9/2},\nu 1g_{9/2}]_{8}^{+}$ pentru nivelul 8^{+}. Experimentele propuse urmaresc efectuarea de masuratori de timpi de viata in nucleul impar-impar ^{74}As (N=41) studiat recent de noi utilizind reactiile ^{64}Ni(^{12}C,pnγ)^{74}As la 40 MeV si ^{64}Ni(^{13}C,p2nγ)^{74}As la 45 MeV. S-au atribuit la ^{74}As 21 de noi tranzitii, plasate intr-o schema de nivele care extinde considerabil schema de nivele stabilita in urma masuratorilor precedente. Pentru masuratorile de timpi de viata se va utiliza reactia ^{64}Ni(^{13}C,p2nγ)^{74}As la 45 MeV. Se continua astfel traditia investigarii coexistentei de forma in nucleele par-pare, impare si impar-impare din zona $A \approx 70$ prin experimente de spectroscopie gama si de electroni de conversie utilizind atit acceleratorul Tandem al IFIN-HH cit si facilitati experimentale performante din strainatate in cadrul unor colaborari internationale.

Relevanta exp. Propus pt. Realizarea unor faze cu ANSTI sau Granturi

Rezultatele vor fi utilizate la propunerea de noi contracte de ceetare (IDEI, PARTENERIAT). Deasemenea rezultatele vor servi la o teza de doctorat (George Drafta).

Timp de fascicul (unit=8ore)*	30	Perioada optimă*	19.10.2011-29.10.2011

Proprietatile fasciculelor cerute:

Tip*	^{13}C	Energie(MeV)*	45 MeV	Intensitate*(p/nA)	10 nA

Extensia experimentală solicitată*	Ext. 1	Cerinţe vid*	10^{-6} Torr

Cerinţe speciale legate de detectori, electronică, sistem achiziţie

Sistemul de achizitie multiparametric atasat sistemului multidetector instalat pe extensia nr. 1

Precizarea unor informaţii minimale necesare evaluării de risc radiologic:

a) Activitatea surselor folosite* : 2-5 μCi

b) Se folosesc surse deschise* : Nu

c) Estimarea activitaţii reziduale rezultate în urma iradierii* : 10-20 μCi

d) Modul de stocare/transport a tintelor iradiate* : Se vor depune in depozitul de surse radioactive al DFN-T pina la dezactivarea lor

Nota

Pentru utilizatorii din afara clădirii acceleratorului TANDEM este necesară autorizarea colectivului de radioprotecţie IFIN-HH pentru desfăşurarea activităţii în Unitatea Nucleară: TANDEM.

Lifetime measurements in ${}^{74}_{33}As_{41}$

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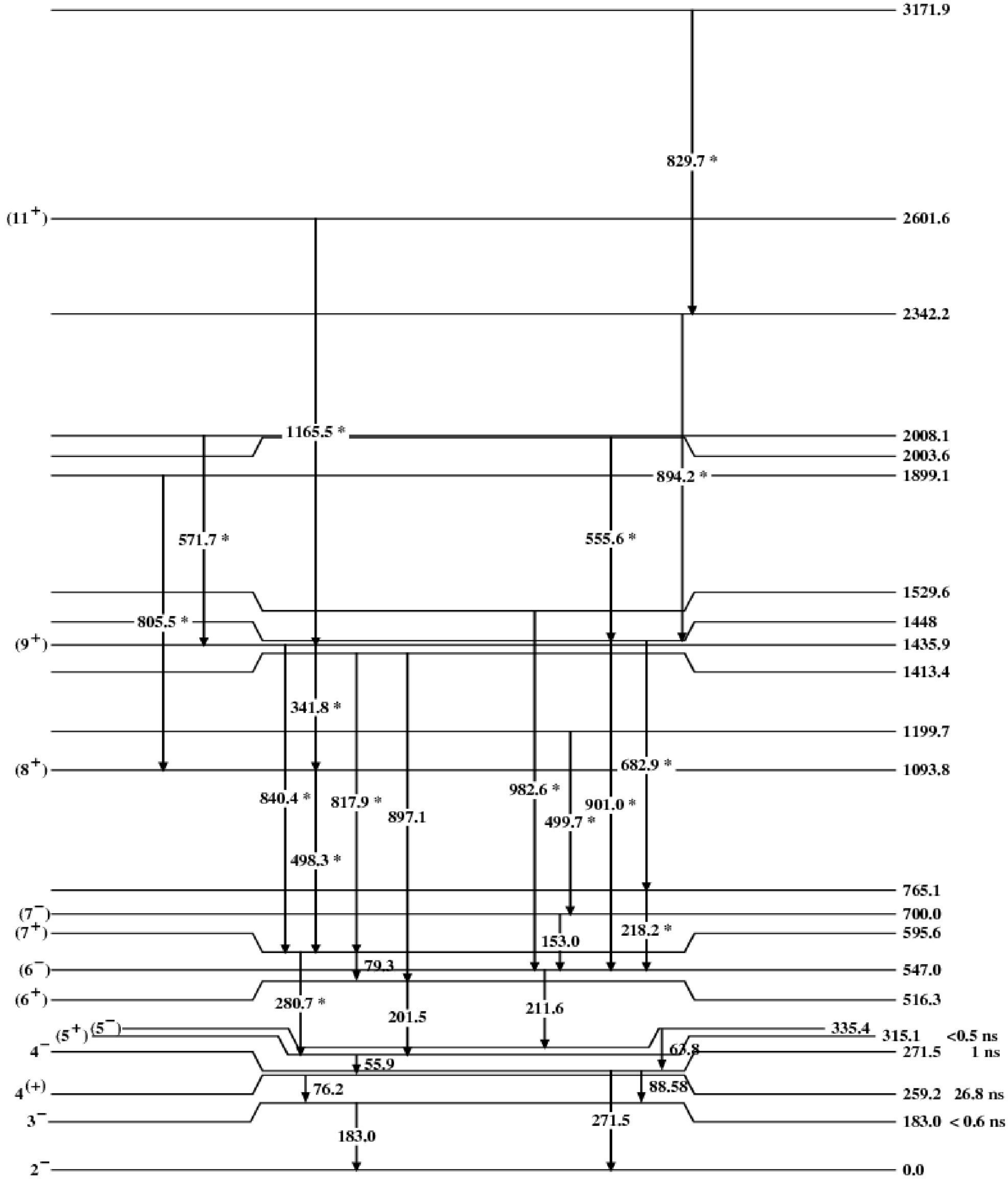
Extensive investigations of the structure of neutron deficient $A \approx 60-80$, $N \approx Z = 33-40$ nuclei has revealed many interesting features. Drastic changes of properties appear for nuclei with $Z \geq 33$ when going from nuclei with 50 neutrons to nuclei with 36-40 neutrons [1,2]. Large quadrupole deformations $\beta \approx 0.4$ and strong collectivity are seen. Furthermore, evidence for shape coexistence at low spins found for the first time in ^{72}Se [3] has generated a special interest in studies of the region. A striking feature is the strong variation of the shape as a function of particle number, excitation energy and spin. The microscopic structure of the nuclei from $A \approx 60-80$ mass region is essentially determined by the $2p_{1/2}$, $1f_{5/2}$, $2p_{3/2}$ and $1g_{9/2}$ orbitals. The strong shape variation and the shape coexistence effects may be interpreted as resulting from the competition of the stabilizing energy gaps of the deformed single-particle field at nucleon numbers 34, 36, 38 and 40. Calculations of the equilibrium configurations in this mass region have been performed within the configuration-dependent shell-correction approach with deformed Woods-Saxon potentials [4].

Calculations based on the generalized Woods-Saxon potential [4] (see Fig. 1., pag. 398) predict competing deformed gaps at nucleon numbers 34 and 36 for $\beta \approx -0.26$ and $\beta \approx -0.4$ respectively and at nucleon numbers 34 and 38 for $\beta \approx 0.26$ and $\beta \approx 0.4$ respectively. A pronounced shell gap also exists at a nucleon number 40 for a spherical shape. The single-particle level density in the $A \approx 60-80$ nuclei is lower by a factor of two than in deformed heavy nuclei; so, the single-particle deformed energy gaps which appear at similar nucleon numbers $(N, Z = 34-38)$ manifest themselves in a comparatively dramatic way. Hence, adding or removing a few nucleons can have a dramatic effect on the nuclear shape. Competing prolate, oblate and spherical shapes are even expected to coexist in the same nucleus. This is particularly true for the neutron-deficient selenium $(Z = 34)$ and krypton $(Z = 36)$ isotopes, where the protons appear to prefer an oblate shape but where neutron numbers of 38–42 favors a strongly deformed $\beta \approx 0.4$ prolate shape.

The shape coexistence in ^{72}Se has been explained as arising from the oblate polarizing influence of the shell gap at nucleon number 34 and the strong prolate driving influence of the gap at nucleon number 38. In recent years, nuclei near the strongly deformed shell gaps at $N = Z = 36$ and $N = Z = 38$ for large oblate and large prolate deformation, respectively, have been investigated in much detail. The recently discovered $J^{\pi} = 0^{+}$ shape isomers in ^{74}Kr and, for the first time, in the $N = Z$ nucleus ^{72}Kr reinforced the evidence of the importance of both shell gaps [5]. So, the detailed spectroscopy near the $N = 38$ deformed shell gap is still an interesting research subject. The study of the odd-odd $^{74}_{33}As_{41}$ is fairly interesting.

The excited levels of ^{74}As can be studied only from nuclear reactions, because the neighboring ^{74}Se and ^{74}Ge isobars and stable. Finckh et al. [6] have determined the energies of many ^{74}As levels from the (p, n) reactions using the neutron time-of-flight technique. The study of (p, nγ) reaction by Christianson et al. [7], Mordechai et al. [8], Kimura [9], Lal et al. [10] and Algora el al. [11] and the one–nucleon transfer reactions by Fournier et al. [12] and Rosner et al. [13] ex. extended our knowledge on the low spin part of the level scheme of ^{74}As considerably. In 1976 Garcia Bermudez et al.γ [14] reported the results of a study of the ^{72}Ge (α, pnγ) reaction at E_{α}= 30 to 55 MeV leading to levels of ^{74}As corresponding to spin values higher than those observed previously. The maximum spin observed was J=7. The decay pattern of these levels is rather simple and exhibit interesting features like the existence of two γ-ray cascades showing quite similar energy spacing and possible spin sequences J=7-6-5-4 which mainly feed the known 3^- state at 183.0 keV. However, the higher spin observed (J=7) is small compared to those usually obtained with (α, xn) reactions. Actually, it is to be noted that the possibility of observing higher spin levels was hampered in this experiment by the lack of statistics in the high-energy part of the coincidence spectra. A particularly interesting feature of the level scheme is the appearance of two groups of levels of very similar spacing and possibly equal spin sequence which decay into the ground and 3^-, 183 keV states. The fact that two sequences of levels with proposed spins J= 4, 5 and 6 lie at such similar excitations energies, is remarkable and suggests that they correspond to opposite parity. In the latest Nuclear Data Sheets evaluation [15] unambiguous spin and parity values have been assigned only to few low spin levels of ^{74}As. Also, only few lifetime limits and two lifetimes were measured for the low spin, low excitation energy levels. Recently, we studied high-spin levels of ^{74}As using two heavy-ion induced reactions: ^{64}Ni(^{12}C,pnγ)^{74}As and ^{64}Ni(^{13}C,p2nγ)^{74}As. The gamma rays were detected with an array of 8 HPGe detectors and 4 $LaBr_3$: Ce detectors. Detailed γ-γ coincidences were measured. 21 new transitions were assigned to the ^{74}As nucleus and were placed in a level scheme presented in Fig.1. From DCO ratio measurements spins were assigned to many levels. The level scheme extends considerably the previous level scheme presented in Fig.2. The ground state deformation for ^{74}As is predicted by Möller and Nix [16] to be β=-0.241. The neighbouring odd neutron N=41 nuclei show well developed rotational bands. Although the odd proton As nuclei do not show well developed bands they have been satisfactorily explained by Scholz and Malik (1968) on the basis of the strong Coriolis coupling. In the case of the odd–odd nucleus ^{74}As it has not been possible to identify levels that could be fitted into rotational bands. However, the significant l_n=2 spectroscopic factor found by Fourier et all. and the enhanced B(E2)=15±2 W.U. lend suport to the view that even in some low-lying states, we are dealing with substantial deformed state components.

We propose to determine the lifetimes of the low and high-spin states in ^{74}As by fast timing technique with the Bucharest mixed array of 9 HPGe and 8 LaBr:Ce detectors and by DSAM using HPGe detectors from the array. By using a special technique for the processing of timing information from the $LaBr_3$ detectors [17], and thus fully use the detector efficiency by adding up the contribution from all paires of such detectors, it is possible to measure in this way half lives down to 30-40 ps by the centroid shift method. In the same experiment the γ-γ coincidences measured with HPGe detectors will be used to measure the lifetimes by DSAM. The reaction used will be ^{64}Ni(^{13}C, p2nγ)^{74}As at 45 MeV. Estimation of the expected reaction cross-section was performed with the code CASCADE and is presented in Fig.3. Because the ^{64}Ni is thick, we have to integrate over energy. We need 10 days of beam time. This estimation is based also on the rate of triple Ge-LaBr-LaBr coincidences already measured in our previous experiment.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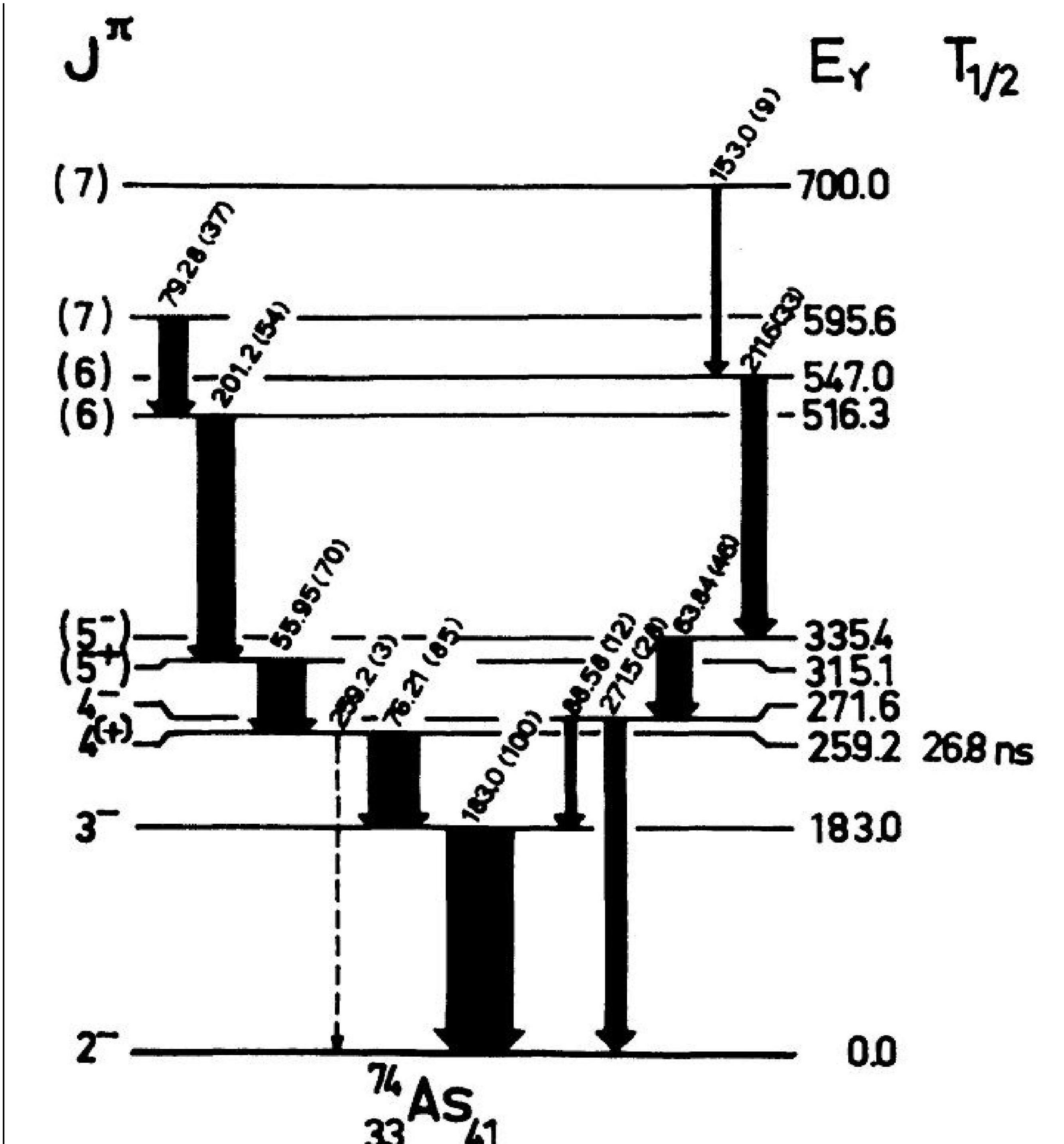
829.7 *
(11+)
2601.6
2342.2
1165.5 *
2008.1
2003.6
894.2 *
1899.1
571.7 *
555.6 *
1529.6
805.5 *
1448
(9+)
1435.9
1413.4
341.8 *
1199.7
(8+)
682.9 *
1093.8
840.4 *
817.9 *
897.1
982.6 *
499.7 *
901.0 *
498.3 *
765.1
(7−)
700.0
(7+)
153.0
218.2 *
595.6
(6−)
79.3
547.0
(6+)
516.3
280.7 *
201.5
211.6
(5+)
(5−)
335.4
315.1 <0.5 ns
4−
67.8
271.5 1 ns
55.9
4(+)
76.2
88.58
259.2 26.8 ns
3−
183.0 < 0.6 ns
183.0
271.5
2−
0.0

$^{74}_{33}As_{41}$

Fig. 1


Jπ
Eγ
T1/2
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(7)
700.0
79.28 (37)
(7)
595.6
211.6(33)
201.2 (54)
(6)
547.0
(6)
516.3
55.95 (70)
63.84 (46)
(5-)
335.4
(5+)
315.1
56.2 (3)
76.21 (85)
88.58 (12)
271.5 (28)
4-
271.6
4(+)
259.2
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3-
183.0
2-
0.0
74 33 As 41

Fig. 2

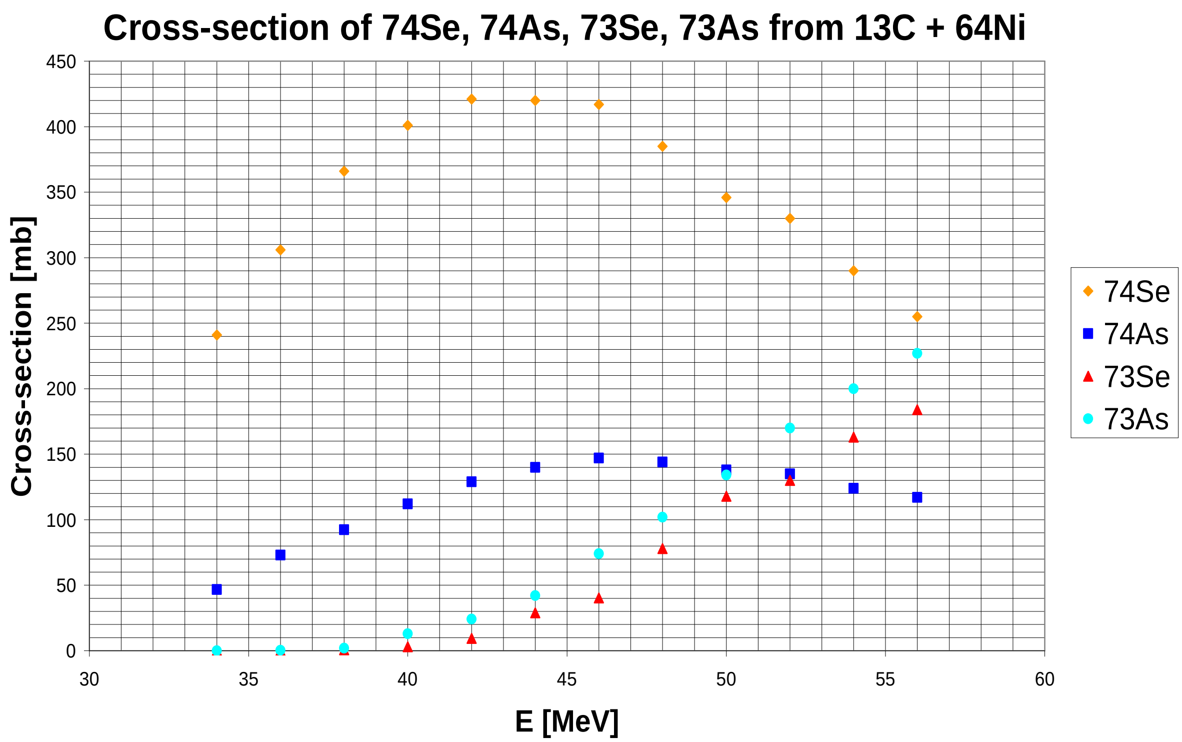

Fig. 3

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