Izomer $K^{\pi} = 8^{-}$ w ^{132}Ce.
Wpływ nieosiowego kształtu jadra na osłabienie czystości liczby kwantowej K.
Dowód eksperymentalny?

Julian Srebrny (ŚLCJ UW) Seminarium Środowiskowe Fizyki Jądrowej 24 marca 2010

Plan prezentacji

1. Dlaczego lubimy badać izomery?
2. Przypomnienie naszych prac o **^{132}Ce** z 2009 i 2001,
   kontynuacja Seminarium J. Perkowskiego z zeszłego roku.
3. Określenie liczby kwantowej K. Jak rozumieć czystość liczby kwantowej?
4. Trójosiowy rotor, model D-F - zmieszanie K, w tym K=4.
   Czy to tłumaczy **B(E3;8- → 5+) i B(E3;8- → 6+)** ?
5. Przejścia E1 jako miara domieszek S-band do GSB w **^{132}Ce**
6. Wzbudzenia kulombowskie z K=0 do K=16 w ^{178}Hf,
   ten sam mechanizm jak dla E1 w **^{132}Ce**
7. Podsumowanie: różne mechanizmy rozpadu izomeru K

Dlaczego lubimy badać izomery ?

1. **Wyróżnione przez czas życia i prostsze schematy rozpadu w doświadczeniu**

   standardowe(E1, M1, E2) *pikosekundy,*

   izomery *ns, µs, ms, s, min., godz., lat***a**

2. **Długi czas życia oznacza jakieś wzbronienia.**
   - *niskie energie przejść gamma lub wysokie multipolowości*
   - *reguły wyboru wynikające z istnienia (ew. nowych) liczb kwantowych*

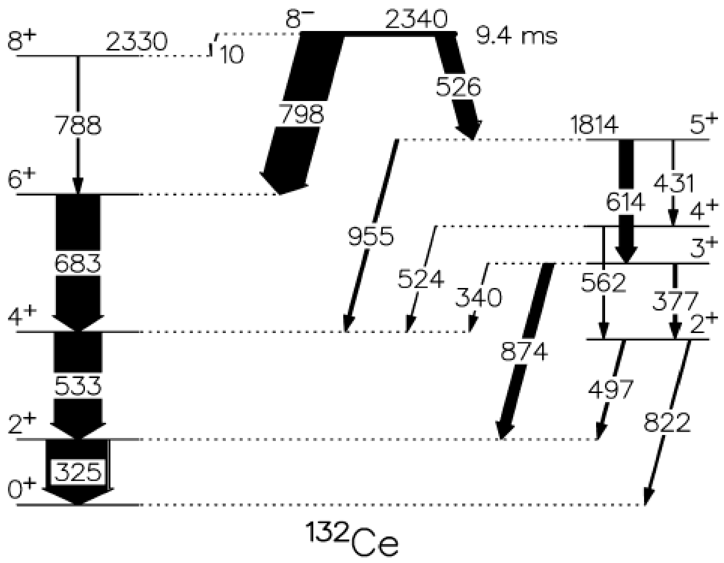
3. **Izomery K i czystość tej liczby kwantowej**

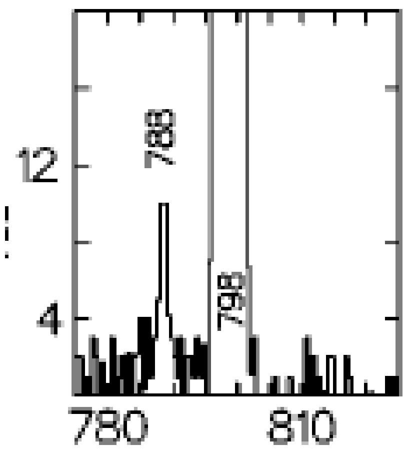
   ścisłe reguły wyboru - *nie powinno być przejść gamma*

   obserwacja przejść gamma(mimo silnego spowolnienia) -

   naruszenie reguł wyboru, tzn. naruszenie czystości danej liczby kwantowej.

4. **Szukamy dodatkowych składowych funkcji falowych o innym K**





Ge – Ge

PHYSICAL REVIEW C, VOLUME 63, 034302

Investigation of the $K^{\pi}=8^{-}$ isomer in ^{132}Ce

T. Morek, J. Srebrny, Ch. Droste, M. Kowalczyk, T. Rząca-Urban, K. Starosta, and W. Urban
Institute of Experimental Physics, Warsaw University, Hoża 69, 00-681 Warszawa, Poland

R. Kaczarowski and E. Ruchowska
The Andrzej Sołtan Institute for Nuclear Studies, 05-400 Świerk, Poland

M. Kisieliński, A. Kordyasz, J. Kownacki, M. Palacz, and E. Wesołowski
Heavy Ion Laboratory, Warsaw University, 02-093 Warszawa, Poland

W. Gast and R. M. Lieder
Institut für Kernphysik, Forschungszentrum Jülich, D-52425 Jülich, Germany

P. Bednarczyk, W. Męczyński, and J. Styczeń
The Niewodniczański Institute of Nuclear Physics, 31-342, Kraków, Poland
(Received 6 July 2000; published 31 January 2001)

Z = 54……. 64

N = 74 prolate(od Xe…… Dy)

$$\frac{7}{2}^{+}[404] \otimes \frac{9}{2}^{-}[514]$$

R.Moore et al. ***moment magnetyczny*** ^{130}***Ba***

Physics Letters B 547 (2002) 200–204

THE EUROPEAN
PHYSICAL JOURNAL A

***Eur. Phys. J.* A 42, 379–382 (2009)**

Regular Article – Experimental Physics

Absolute E3 and M2 transition probabilities for the electromagnetic decay of the $I^{\pi} = K^{\pi} = 8-$ isomeric state in ^{132}Ce

J. Perkowski[1,a], J. Andrzejewski[1], J. Srebrny[2], A.M. Bruce[7], Ch. Droste[3], E. Grodner[3], M. Kisielinski[2,4], A. Korman[4], M. Kowalczyk [2,3], J. Kownacki[2], A. Król[1], J. Marganiec[1,9], J. Mierzejewski[2,3], T.Morek[3], K. Sobczak[1,8], H. Trzaska[5,6], and M. Zielinska[2]

1 Faculty of Physics and Applied Informatics, University of Lodz,, Poland
2 Heavy Ion Laboratory, University of Warsaw,, Poland
3 Nuclear Physics Division, IEP, University of Warsaw, Poland
4 The Andrzej Soltan Institute for Nuclear Studies, Poland
5 Department of Physics, University of Jyvaskyla, Finland
6 Helsinki Institute of Physics, Finland
7 School of Environment and Technology, University of Brighton, UK
8 Institute of Physics Polish Academy of Sciences, Poland
9 Reactions and Nuclear Astrophysics Division, GSI, Germany

"Workshop on Nuclear Isomers: Structure and Applications"
19 - 21 May 2010 at the University of Surrey, Guildford, UK

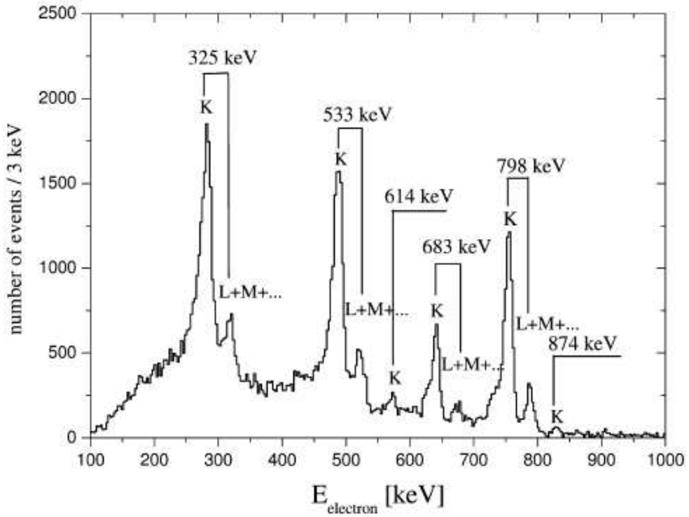


Fig. 3. Summed electron spectrum observed in coincidence with the 325, 533 and 683 keV gamma-ray transitions.

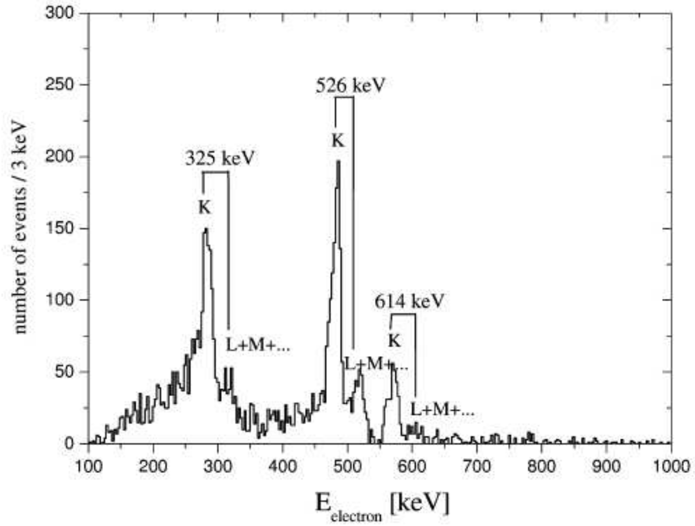
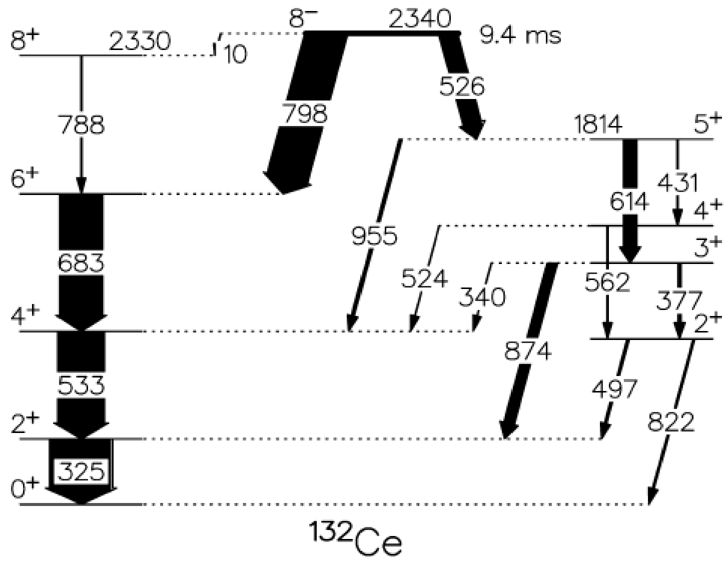
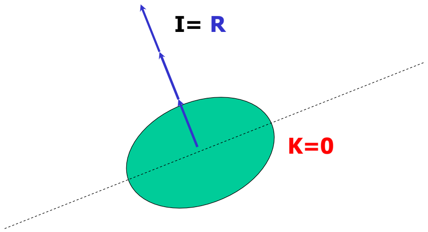


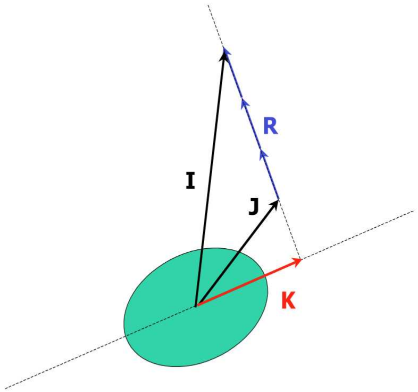
Fig. 4. Electron spectrum observed in coincidence with the 874 keV gamma-ray transition.

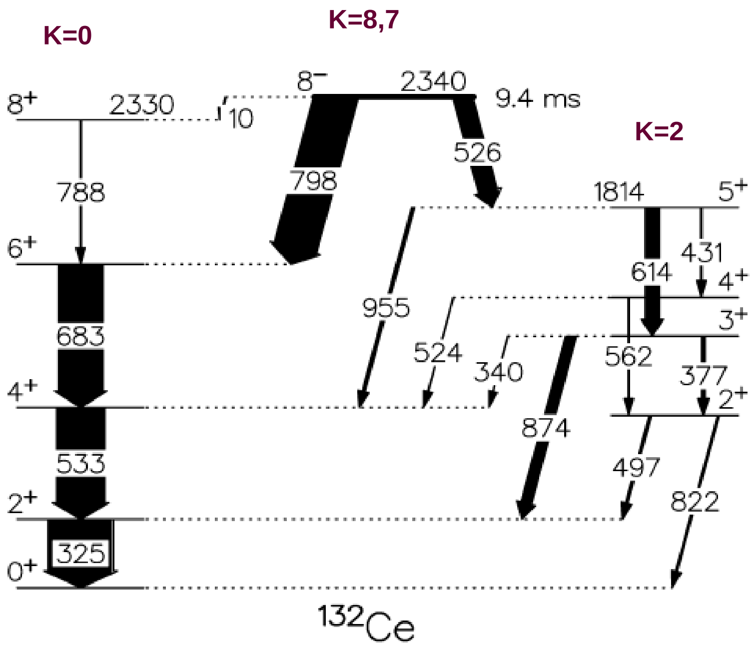


Określenie multipolowości 614 keV(E2), 526 keV(E3) i 798 keV(65% E3 + 35% M2)

Określenie spinów i parzystości **5^+** i **8^-**







Wzbronienie K

Stopień wzbronienia: $\nu = \Delta K - \lambda$

osłabienie przejść ΔK>λ o rzędy wielkości

$$F = T^{p}_{1/2} / T^{W}_{1/2},$$

$$f_{\nu} = F^{1/\nu}$$

http://www.slcj.uw.edu.pl/~pjn/DF/DF.htm

DF

trójosiowy sztywny rotor (najprostszy model z γ)

Davydov-Filippov Code.

The DF code is designed to calculate energies of collective states (up to spin 30) and reduced matrix elements of E2 transitions in even-even nuclei.
Calculations based of the Davidov-Filippov model of rigid asymmetric rotor [1] can be performed with the E2 operator :

$$M_{E2}(\beta, \cos(\gamma))$$

or

$$M_{E2}(\beta, \cos(\gamma), \beta^2, \cos(2\gamma))$$

An input file for the FAUST code can be created as an option.

History of versions:

1992 – ver.1.
2007 – ver. 2. Variable moment of inertia [2] was added.

Downloads:

kdf2.pas	the source code written in Borland Turbo-Pascal
kdf2.exe	the executable file working under control of DOS or Microsoft Windows operating systems
df_manual.pdf	the manual.

References:

[1] A.S. Davydov and G.F. Filippov, *Nucl. Phys.* **8** (1958) 237.
[2] M. A. J. Mariscotti, G. Scharff-Goldhaber, and B. Buck, *Phys.Rev*. **178** (1969) 1864.

Last update: 15/05/2008
Paweł J. Napiorkowski

PROGRAM DAVYDOV-FILIPOV

==

Z = 58 A = 132 EN(2, 1) = 300.0 keV beta= 0.2500 gamma = 25.00 [deg]

==

Level Energy [keV]

==

0(1) 0.00 0.0000

[0] 1.00000

2(1) 300.00 1.0000

[0] 0.97396 [2] 0.22670

2(2) 722.33 2.4078

[0]-0.22670 [2] 0.97396

3(1) 1022.33 3.4078

[2] 1.00000

4(1) 850.82 2.8361

[0] 0.85163 [2] 0.52239 [4] 0.04283

4(2) 1653.85 5.5128

[0]-0.52323 [2] 0.84246 [4] 0.12846

4(3) 2606.97 8.6899

[0] 0.03102 [2]-0.13181 [4] 0.99079

5(1) 1922.33 6.4078

[2] 0.97396 [4] 0.22670

5(2) 3189.31 10.6310

[2]-0.22670 [4] 0.97396

6(1) 1602.59 5.3420

[0] 0.76204 [2] 0.63424 [4] 0.13029 [6] 0.00702

6(2) 3077.22 10.2574

[0]-0.61930 [2] 0.65509 [4] 0.43127 [6] 0.03649

6(3) 3944.77 13.1492

[0] 0.18905 [2]-0.41020 [4] 0.88504 [6] 0.11270

7(1) 3091.74 10.3058

[2] 0.90763 [4] 0.41658 [6] 0.05165

8(1) 2565.78 8.5526

[0] 0.70567 [2] 0.67610 [4] 0.21006 [6] 0.02815 [8] 0.00113

Gamma=27.5

I=5+

K= [2] 88%,   K= [4] 12.3%

I=6+

K= [0] 51%,   K= [2] 45%,   K= [4] 3.6%,   K= [6] 0.02%

---

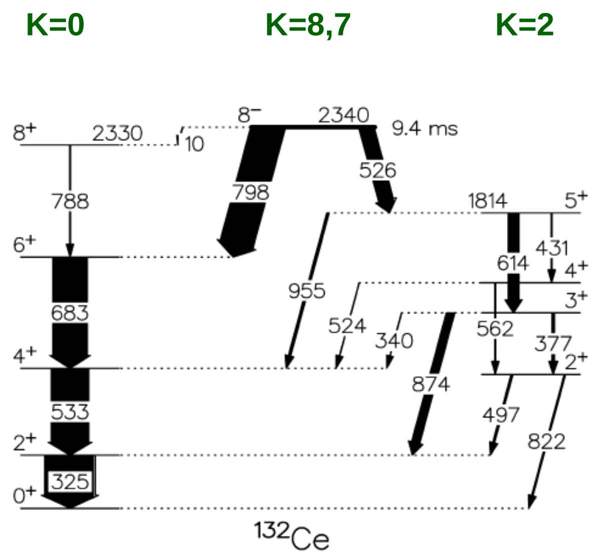
gamma=24

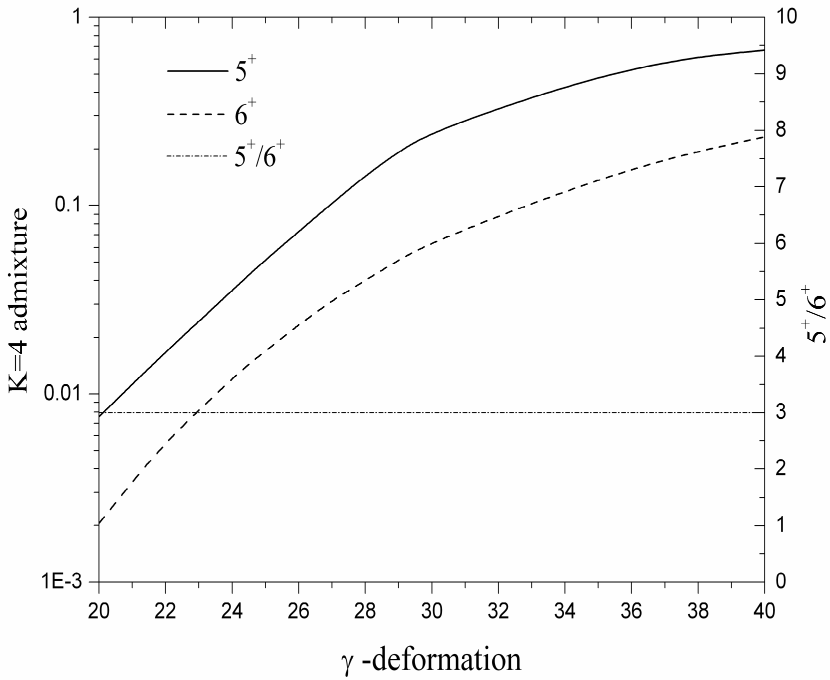
I=5+

K= [2] 96%,   K= [4] 3.6%

I=6+

K= [0] 61%,   K= [2] 37%,   K= [4] 1.20%,   K=[6] 0.003%





$B(E3;8^- \longrightarrow 5^+) / B(E3;8- \longrightarrow 6+) = 12(2)$

miara domieszki K=4 w obu stanach

$$\nu = \Delta K - \lambda$$

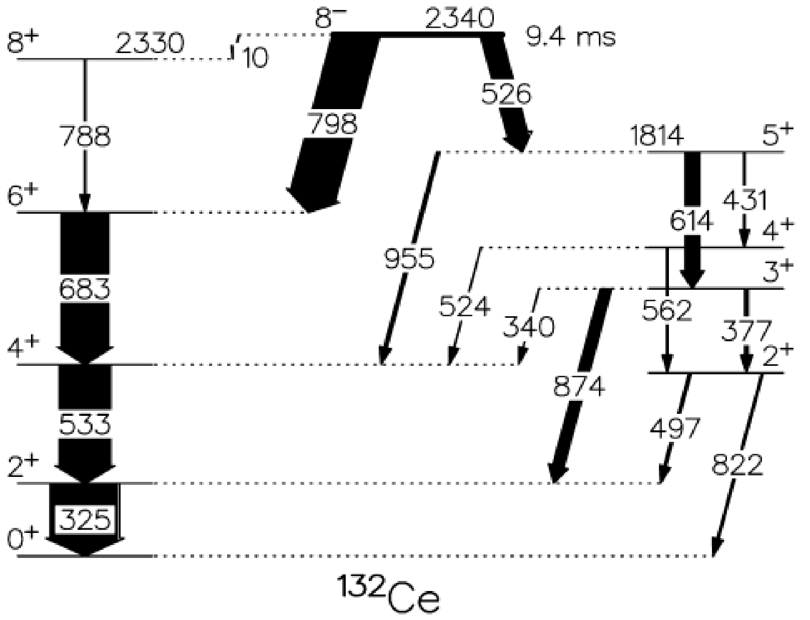
$\nu = (7 - 4) - 3 = 0$ brak wzbronienia

B (E3; 8- → 5+) / B(E3;8- → 6+) =

$[\langle 8\ 7\ 3\ -3 \mid 5\ 4\rangle / \langle 8\ 7\ 3\ -3 \mid 6\ 4\rangle]^2 \times [a(5+)/a(6+)]$

Exp.:   a(5+)/a(6+) = 12(2) / 1.15 = 10(2)

D-F theory: a(5+; γ =27.5) / a(6+; γ =24) = 10.2



Exp.: **a(5+)/a(6+) = 12(2) / 1.15 = 10(2)**

D-F theory: a(5+; γ =27.5) / a(6+; γ =24) = 10.2

Δγ= 3.5 ± 1.0°

B(E1; 8- → 8+) f_7

A.M. Bruce, A.P. Byrne, G.D. Dracoulis, W. Gelletly, T. Kibedi, F.G. Kondev, C.S. Purry, P.H. Regan, C. Thwaites, and P.M. Walker, Phys. Rev. C 55, 620 (1997).

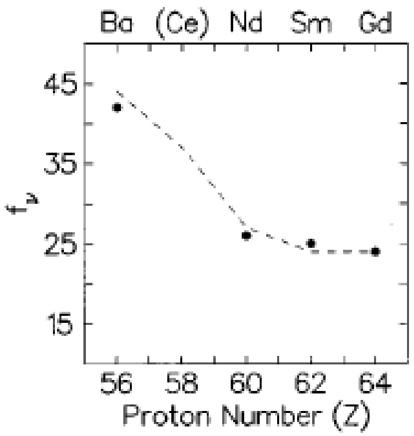


FIG. 3. Systematics of f_ν values for observed $E1$ decays from the $K^\pi = 8^-$ isomers in the $N=74$ isotones. The line depicts the f_ν values which are predicted using the band-mixing calculation outlined in Sec. III A.

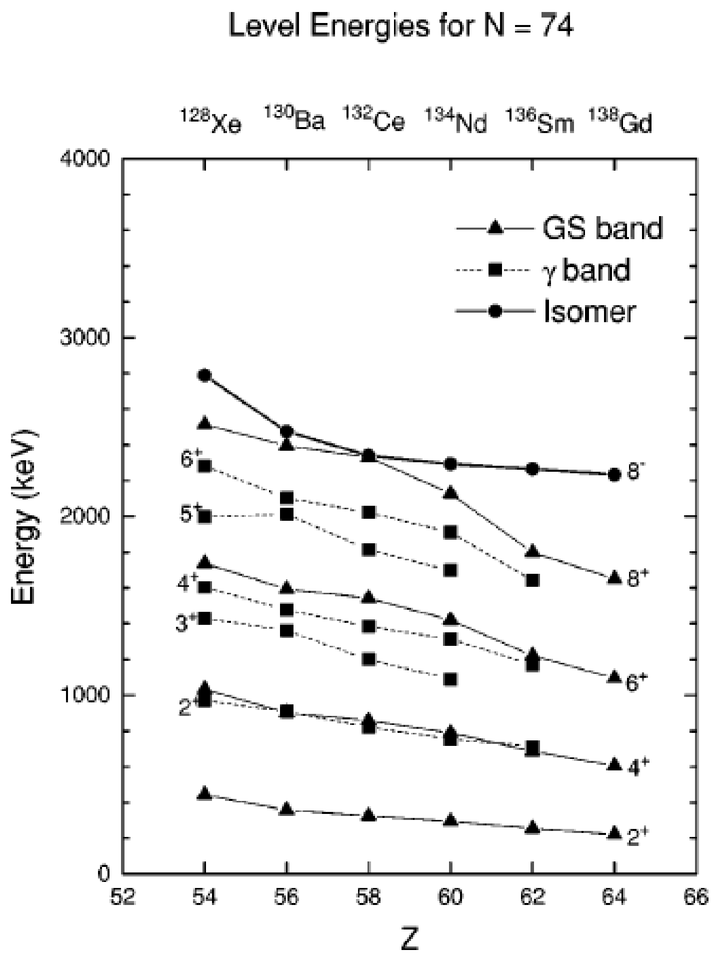


FIG. 5. Systematics of the excited levels with $I \leqslant 8$ relevant for the discussion of the even-even $N=74$ isotones.

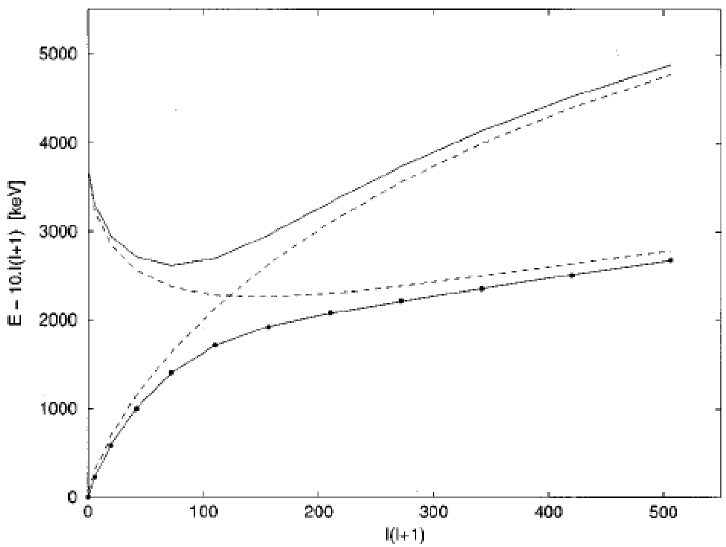


FIG. 5. The results of the two-band mixing calculation for ^{134}Nd. The unperturbed bands are shown as dashed lines and the perturbed bands as solid lines. The dots represent the measured excitation energies of the states in the yrast band.

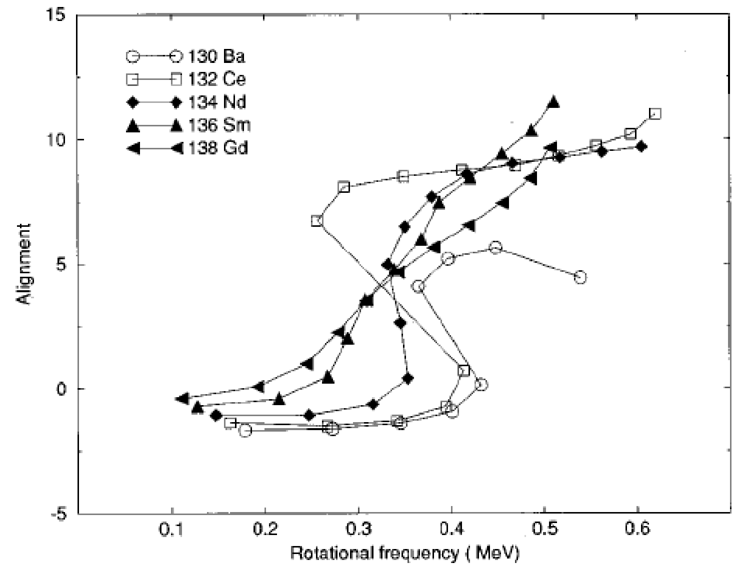


FIG. 4. Experimental alignments for ^{130}Ba, ^{132}Ce, ^{134}Nd, ^{136}Sm, and ^{138}Gd. Harris reference parameters of $\mathcal{I}_0 = 17.0$ $\hbar^2$ MeV^{-1} and $\mathcal{I}_1 = 25.0$ $\hbar^4$ MeV^{-3} have been used for all five nuclei.

A.M. Bruce, A.P. Byrne, G.D. Dracoulis, W. Gelletly, T. Kibedi, F.G. Kondev, C.S. Purry, P.H. Regan, C. Thwaites, and P.M. Walker,
Phys. Rev. C **55**, 620 (1997)

PHYSICAL REVIEW C 75, 034308 (2007)

Spin dependence of K mixing, strong configuration mixing, and electromagnetic properties of ^{178}H

A. B. Hayes,[1] D. Cline,[1] C. Y. Wu,[1,2] H. Ai,[3] H. Amro,[3] C. Beausang,[4] R. F. Casten,[3] J. Gerl,[5] A. A. Hecht,[3] A. Heinz,[3] H. Hua,[1,*] R. Hughes,[3] R. V. F. Janssens,[6] C. J. Lister,[6] A. O. Macchiavelli,[7] D. A. Meyer,[3,†] E. F. Moore,[6] P. Napiorkowski,[8] R. C. Pardo,[6] Ch. Schlegel,[5] D. Seweryniak,[6] M. W. Simon,[1] J. Srebrny,[8,9] R. Teng,[1] K. Vetter,[7] and H. J. Wollersheim[5]

[1]*Department of Physics and Astronomy, University of Rochester, Rochester, New York 14627, USA*
[2]*Lawrence Livermore National Laboratory, Livermore, California 94550, USA*
[3]*Wright Nuclear Structure Laboratory, Yale University, New Haven, Connecticut 06520, USA*
[4]*Physics Department, University of Richmond, Richmond, Virginia 23173, USA*
[5]*GSI, Gesellschaft für Schwerionenforschung, Planckstrasse 1, D-64291 Darmstadt, Germany*
[6]*Physics Division, Argonne National Laboratory, Argonne, Illinois 60439, USA*
[7]*Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA*
[8]*Heavy Ion Laboratory, Warsaw University, Warszawa, Poland*
[9]*Institute of Experimental Physics, Warsaw University, Warszawa, Poland*

(Received 16 October 2006; published 16 March 2007)

^{178}Hf(^{136}Xe,^{136}Xe)^{178}Hf coulomb excitation

Z=74

Ta (^{178}Hf, ^{178}Hf) Ta **Coulomb excitation, activation experiment**

Ten sam mechanizm powstawania domieszek wysokich K dla pasma o niskich K,

jak dla przejść E1 w N=74

^{178}Hf Z=74 COULEX z 0^+

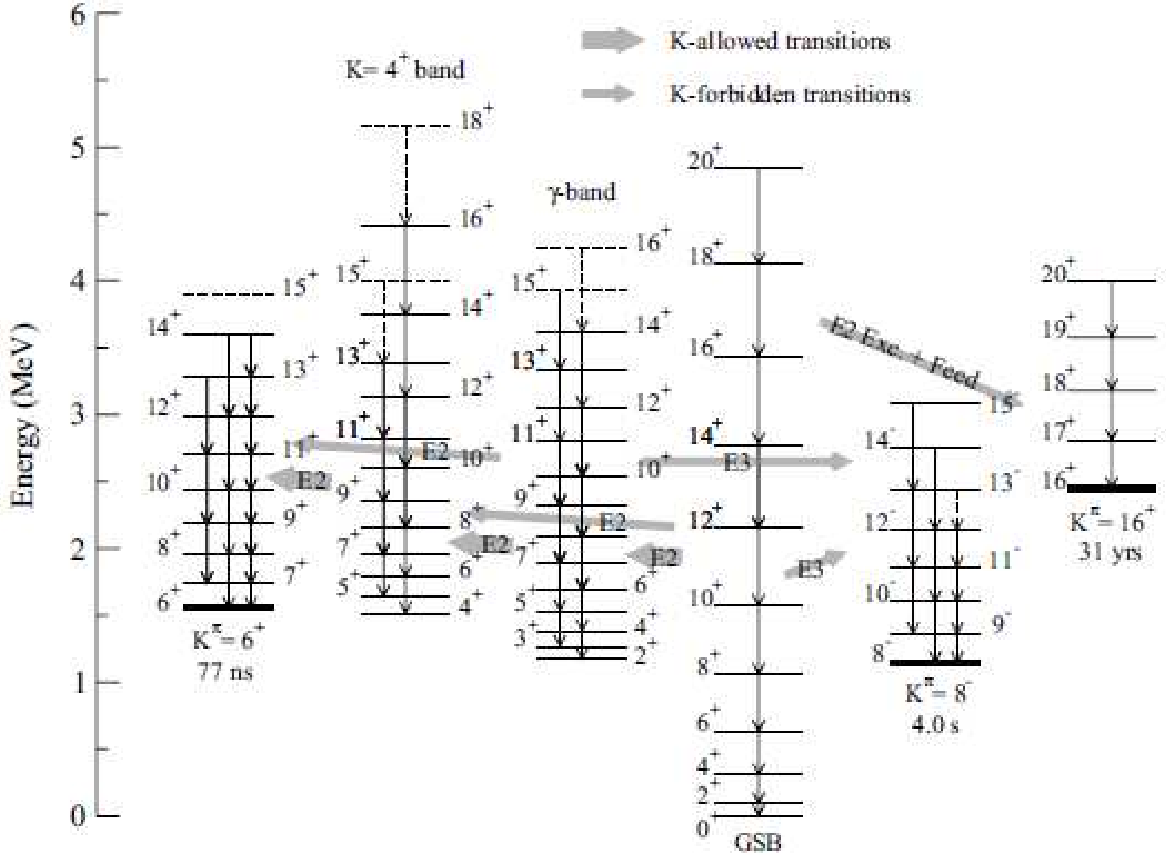


FIG. 18. A schematic representation of the population paths to the three isomer bands. The narrow and wide arrows represent band → band transitions.

PHYSICAL REVIEW C 75, 034308 (2007)

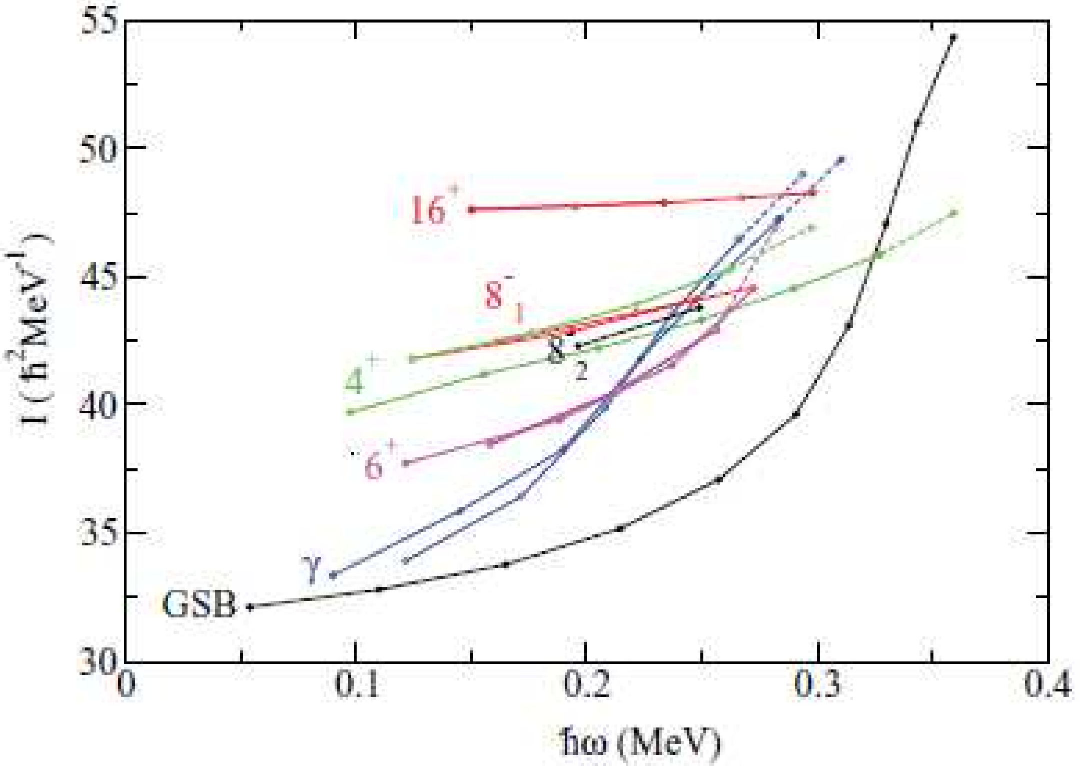


FIG. 35. (Color online) Measured moments of inertia of [178]Hf rotational bands. Dashed lines connect to tentatively assigned

szybka zmiana momentu bezwładności dla pasm o niskim K - *GSB, γ*

dla coraz większej rotacji stopniowe rozerwanie jednej pary, potem drugiej pary protonów

stałość momentu bezwładności dla pasm o wysokim K - 16^+, 8^-

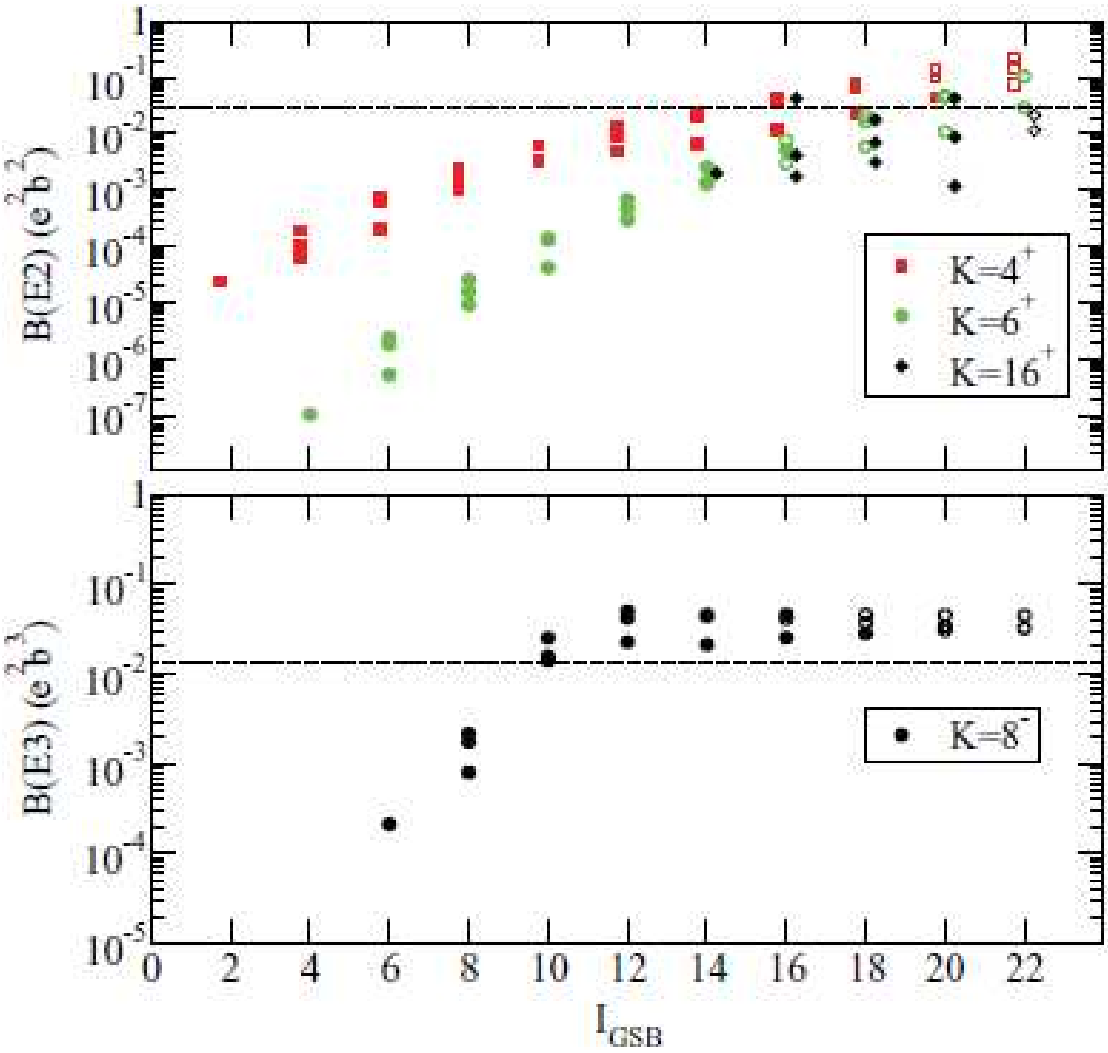


FIG. 33. (Color online) The three strongest reduced transition probabilities from each GSB level for GSB→ K^{π} transitions. GSB→

^{178}Hf Z=74 COULEX z 0^{+}

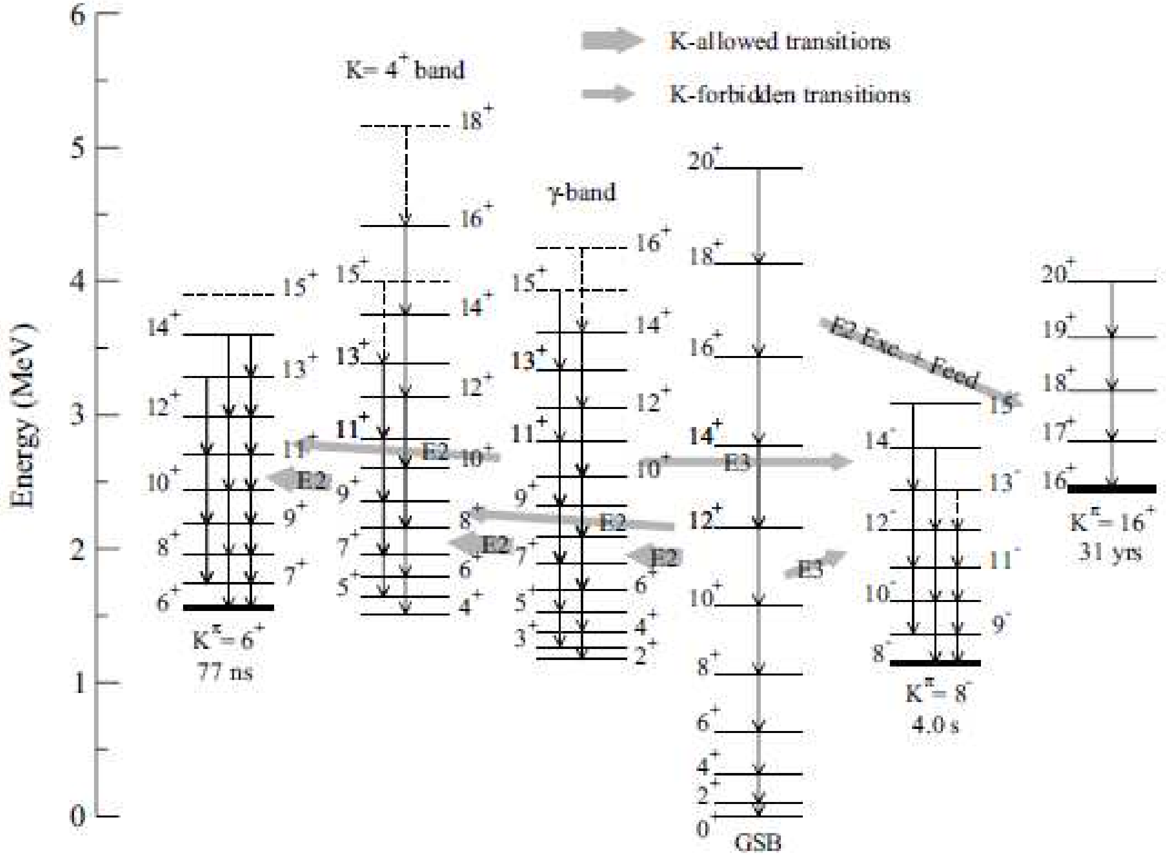


FIG. 18. A schematic representation of the population paths to the three isomer bands. The narrow and wide arrows represent band → band transitions.

SUMMARY

1. Stosunki B(E3; 8- →5+, 6+) miarą domieszek a(K=4).

   Zaś a(K=4) miarą deformacji trójosiowej.

   Wyniki pomiarów konsystentne z $\boldsymbol{\Delta\gamma = 3.5 \pm 1.0}$

2. Dla B(E1; 8- → 8+) mechanizm naruszenia czystości liczby kwantowej K taki sam w **^{178}Hf i ^{132}Ce.:** symetria osiowa i domieszki wysokich K do pasma o niskim K: Coriolis alignment.

3. Wagi obu mechanizmów możliwe przez porównanie rozkładów K f. falowych poszczególnych stanów.

Assuming K=0 for the ground state band,
and 99.46% ground and 0.53% S - for the 6+ in 132Ce,
we get the following distribution:

GSB - S	K	D-F(gamma=25)	D-F/yours
99.55%	0	58%	0.58
0.17	1		
0.13	2	40	313
0.08	3		
0.04	4	1.7	43
0.016	5		
0.005	6	0.005	1
0.0012			
0.0002			
2.03E-05			
1.02E-06			

which does add up to 100% in both cases.