

Софийски Университет
"Св. Климент Охридски"
Физически факултет



Структура на нисколежащи състояния в нечетните изотопи $^{99,101,103}\text{Ru}$

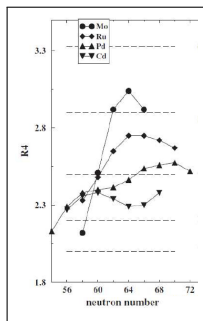
Станимир Кисьов

Съдържание

- 1 Експериментални резултати
- 2 Систематика на състоянията
- 3 Моделни изчисления

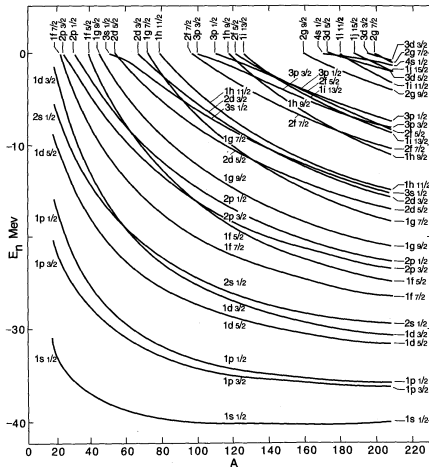
97,99,101,103Ru

99Pd 21.4 M ε: 100.00%	100Pd 3.63 D ε: 100.00%	101Pd 8.47 H ε: 100.00%	102Pd STABLE 1.02%	103Pd 16.991 D ε: 100.00%	104Pd STABLE 11.14%	105Pd STABLE 22.38%	106Pd STABLE 27.33%	107Pd 6.5E+6 Y β ⁻ : 100.00%
98Rh 8.72 M ε: 100.00%	99Rh 16.1 D ε: 100.00%	100Rh 20.8 H ε: 100.00%	101Rh 3.3 Y ε: 100.00%	102Rh 207.3 D ε: 78.00% β ⁻ : 22.00%	103Rh STABLE 100%	104Rh 42.3 S β ⁻ : 99.55% ε: 0.45%	105Rh 35.36 H β ⁻ : 100.00%	106Rh 30.07 S β ⁻ : 100.00%
97Ru 2.83 D ε: 100.00%	98Ru STABLE 1.87%	99Ru STABLE 12.76%	100Ru STABLE 12.60%	101Ru STABLE 17.06%	102Ru STABLE 31.55%	103Ru 39.247 D β ⁻ : 100.00%	104Ru STABLE 18.62%	105Ru 4.44 H β ⁻ : 100.00%
96Tc 4.28 D ε: 100.00%	97Tc 4.21E+6 Y ε: 100.00%	98Tc 4.2E+6 Y β ⁻ : 100.00%	99Tc 2.111E+5 Y β ⁻ : 100.00%	100Tc 15.46 S β ⁻ : 100.00% ε: 2.6E-3%	101Tc 14.02 M β ⁻ : 100.00%	102Tc 5.28 S β ⁻ : 100.00%	103Tc 54.2 S β ⁻ : 100.00%	104Tc 18.3 M β ⁻ : 100.00%
95Mo STABLE 15.84%	96Mo STABLE 16.67%	97Mo STABLE 9.60%	98Mo STABLE 24.39%	99Mo 65.976 H β ⁻ : 100.00%	100Mo 7.3E+18 Y 9.82% 2β ⁻ : 100.00%	101Mo 14.61 M β ⁻ : 100.00%	102Mo 11.3 M β ⁻ : 100.00%	103Mo 67.5 S β ⁻ : 100.00%
53	54	55	56	57	58	59	60	N



Excitation energy ratios $R_{4/2}$ in neutron-rich Mo, Ru, Pd and Cd

Масова зависимост на едночастичните орбитали



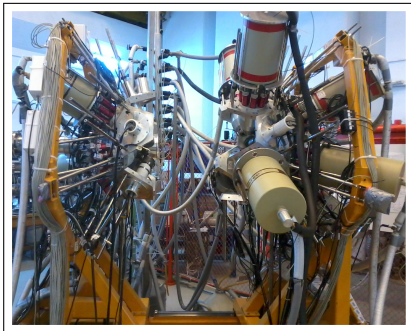
Зависимост на енергиите на неутронните едночастични орбитали от масовото число. В изследваната област орбиталите $d_{5/2}$ и $g_{7/2}$ се намират близко по енергия и могат да бъдат използвани за възпроизвеждане на нисколежащите състояния.

Bohr and Mottelson,

Nuclear Structure, vol. I (1969)

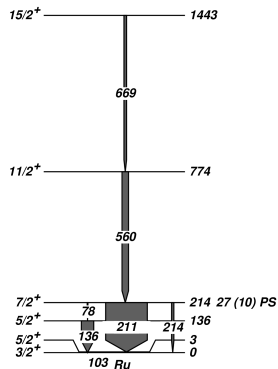
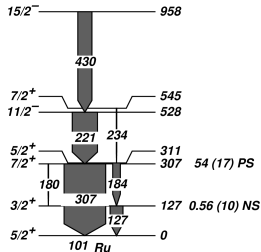
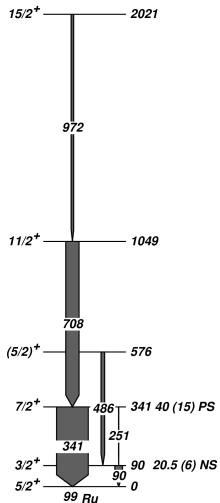
Експериментална постановка

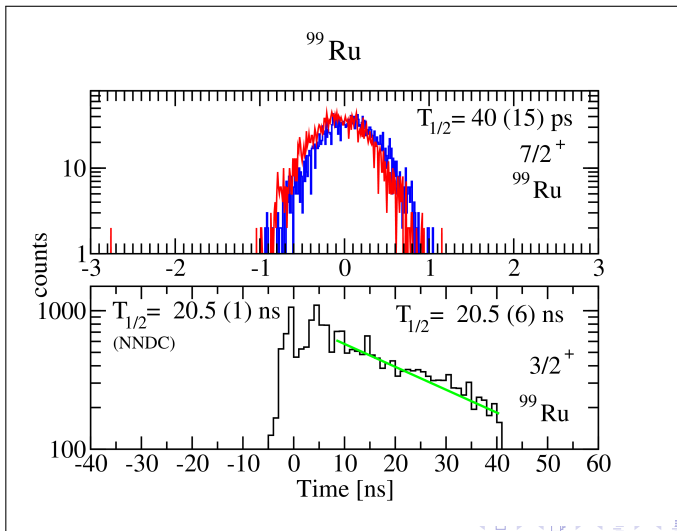
Смесена детекторна система от HPGe и LaBr_3 детектори за γ -спектроскопия (Букурещ, Румъния).

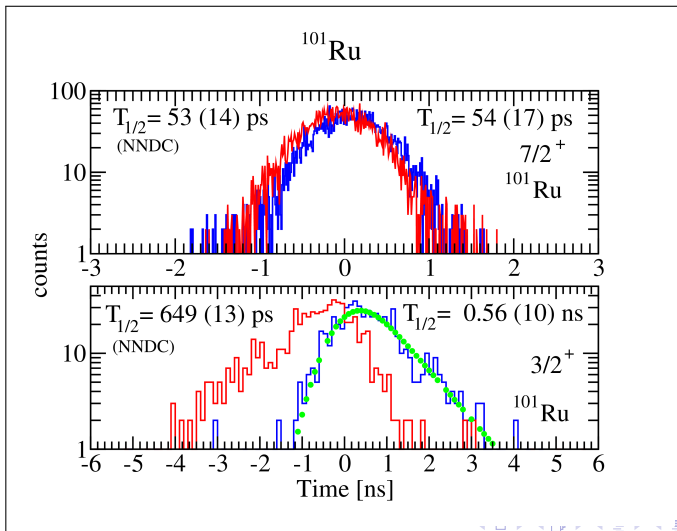


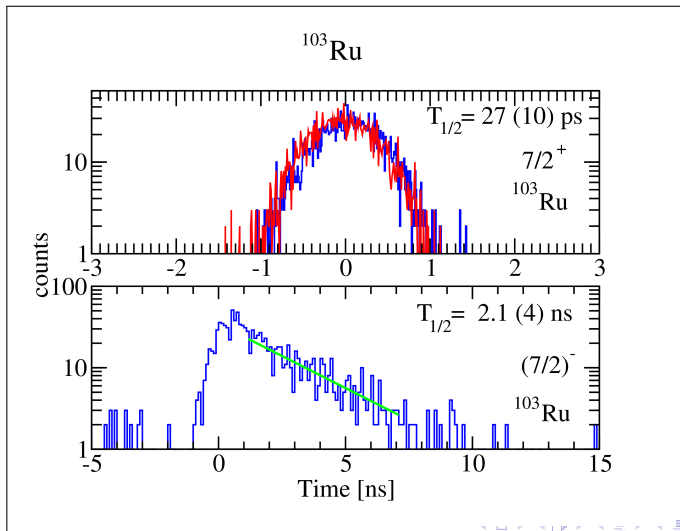
RoSphere

- 1 14 HPGe детектора
висока разделителна
способност по енергия
- 2 11 LaBr_3 детектора
висока разделителна
способност по време

Нисколежащи състояния в $^{99,101,103}\text{Ru}$ 

Периоди на полуразпад на $7/2^+$ и $3/2^+$ в ^{99}Ru 

Периоди на полуразпад на $7/2^+$ и $3/2^+$ в ^{101}Ru 

Периоди на полуразпад на $7/2^+$ и $(7/2)^-$ в ^{103}Ru 

Вероятности за преход

B(M1) и B(E2) стойности за $7/2^+ \rightarrow 5/2^+$ преходи в ^{97,99,101,103}Ru

Isotope	E_{level} [keV]	E_γ [keV]	$T_{1/2}$ [ps]	B(M1) [W.u.]	B(E2) [W.u.]
⁹⁷ Ru	422	422	25 (8)	0.012 (4)	–
⁹⁹ Ru	341	341	40 (15)	0.014 (6)	0.04 (3)
¹⁰¹ Ru	307	307	54 (17)	0.014 (5)	1.4 (14)
¹⁰³ Ru	214	211	27 (10)

B(M1) и B(E2) стойности за $3/2^+ \rightarrow 5/2^+$ преходи в ^{97,99,101}Ru

Isotope	E_{level} [keV]	E_γ [keV]	$T_{1/2}$ [ns]	B(M1) [W.u.]	B(E2) [W.u.]
⁹⁷ Ru	189	189	0.23 (2)	0.0122 (12)	30 (12)
⁹⁹ Ru	90	90	20.5 (6)	0.000180 (12)	52 (4)
¹⁰¹ Ru	127	127	0.56 (10)	0.019 (4)	23 (5)

Спектроскопски фактори от (d,p) реакции

 ^{97}Ru

E_{level}	J^{π}	L	S'
0.0	5/2+	2	3.43
189	3/2+		
421	7/2+	4	4.84
527	3/2+	2	0.84
770	3/2+	2	0.19
908	1/2+	0	1.15

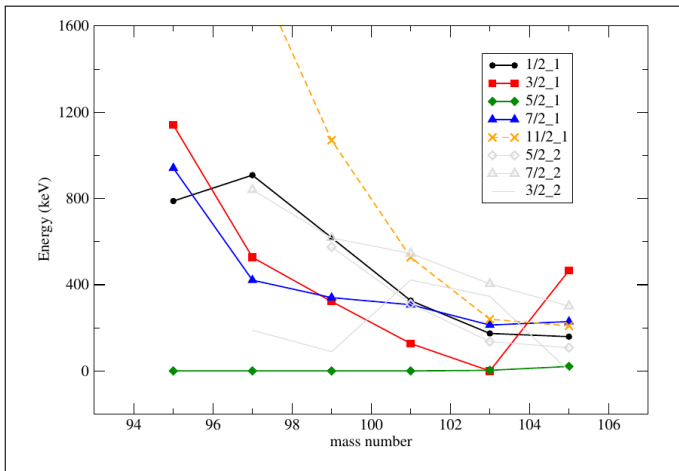
 ^{101}Ru

E_{level}	J^{π}	L	S'
0.0	5/2+	2	2.10
127	3/2+	2	0.067
307	7/2+	4	5.3
326	1/2+	0	0.96
421	3/2+	2	0.15
533	3/2+	2	0.72, 5.8
597	(5/2-)	3	0.60, 0.74
622	1/2+	0	0.063
685		2	0.17, 0.18
718	9/2+	1	0.017, 0.018
972	3/2+	2	0.63, 0.70

 ^{103}Ru

E_{level}	J^{π}	L	S'
0.0	3/2+	2	1.44
3.3	5/2+	2	1.35
136	5/2+	2	0.012
174	1/2+	0	0.75
215	7/2+	4	1.80
240	11/2-	5	3.2
298	(7/2)-	3	0.40
347	3/2+	2	0.060
405	(7/2)+	2	
433	1/2+	0	0.027
501	(5/2)+		
535	(3/2+, 5/2+)	(2)	0.03
553	(1/2+)		
591	(5/2)+	2	0.35
624	(5/2+)	(2)	(0.009)
661.2	(3/2)+	2	0.251
697.4	7/2+, 9/2+	4	0.71
736.1	1/2+	0	0.053

Систематика на нисколежащи състояния в Ru



Твърд триаксиален ротор плюс частица

Изследваните изотопи на Ru се намират в област, където се очаква появата на деформация. Съответно е възможна появата на триаксиалност под формата на твърд триаксиален ротор или γ -меко ядро. Моделни изчисления са направени в рамките на модела на твърд триаксиален ротор.

$$\kappa_4=0.070 \quad \mu_4=0.39$$

$$\kappa_5=0.062 \quad \mu_5=0.43$$

$$\gamma = (1/3) \arcsin \sqrt{(9/8) \left(1 - \frac{(X-1)^2}{(X+1)^2}\right)}$$

nucleus	ϵ_2	ϵ_4	γ	E_{2+}
^{99}Ru	+0.142	-0.002	28.0	0.54
^{101}Ru	+0.167	-0.065	26.0	0.42
^{103}Ru	+0.217	-0.007	20.0	0.25

Твърд триаксиален ротор плюс частица

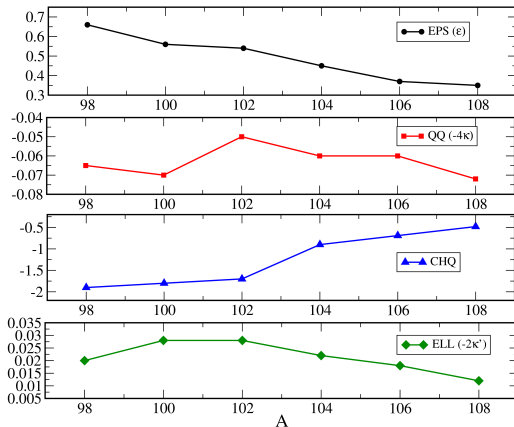
EXP		RTRPM		EXP		RTRPM		EXP		RTRPM	
			$15/2^+ \text{---} 2176$								
$15/2^+ \text{---} 2020$				$15/2^+ \text{---} 1862$	$15/2^+ \text{---} 1869$						
			$13/2^+ \text{---} 1744$								
$13/2^+ \text{---} 1497$				$13/2^+ \text{---} 1501$	$13/2^+ \text{---} 1507$	$15/2^+ \text{---} 1443$				$15/2^+ \text{---} 1368$	
$9/2^+ \text{---} 1278$						$13/2^+ \text{---} 1199$				$13/2^+ \text{---} 1225$	
$11/2^+ \text{---} 1049$	$11/2^+ \text{---} 1010$			$11/2^+ \text{---} 1001$	$11/2^+ \text{---} 952$						
				$9/2^+ \text{---} 929$							
$9/2^+ \text{---} 719$	$9/2^+ \text{---} 698$			$9/2^+ \text{---} 720$	$9/2^+ \text{---} 620$	$11/2^+ \text{---} 774$				$11/2^+ \text{---} 677$	
$7/2^+ \text{---} 617$				$7/2^+ \text{---} 545$	$9/2^+ \text{---} 620$	$9/2^+ \text{---} 557$				$9/2^+ \text{---} 540$	
$5/2^+ \text{---} 575$	$5/2^+ \text{---} 506$			$7/2^+ \text{---} 422$	$5/2^+ \text{---} 352$	$7/2^+ \text{---} 404$					
$3/2^+ \text{---} 321$				$5/2^+ \text{---} 422$	$5/2^+ \text{---} 352$	$3/2^+ \text{---} 346$					
$7/2^+ \text{---} 340$				$7/2^+ \text{---} 306$	$7/2^+ \text{---} 316$	$7/2^+ \text{---} 214$				$7/2^+ \text{---} 210$	
				$7/2^+ \text{---} 306$	$7/2^+ \text{---} 316$	$5/2^+ \text{---} 136$				$5/2^+ \text{---} 166$	
$3/2^+ \text{---} 89$	$3/2^+ \text{---} 89$			$3/2^+ \text{---} 127$	$3/2^+ \text{---} 124$	$5/2^+ \text{---} 0$				$5/2^+ \text{---} 111$	
$5/2^+ \text{---} 0$	$5/2^+ \text{---} 0$			$5/2^+ \text{---} 0$	$5/2^+ \text{---} 0$	$3/2^+ \text{---} 0$				$3/2^+ \text{---} 0$	
	99			101		103					
	Ru			Ru		Ru					

Твърд триаксиален ротор плюс частица

nucleus	J_i^π	E_i^{exp} (keV)	J_f^π	E_f^{exp} (keV)	$B(M1)^{exp}$ (W.u.)	$B(M1)^{th}$ (W.u.)	$B(E2)^{exp}$ (W.u.)	$B(E2)^{th}$ (W.u.)
$^{99}_{44}\text{Ru}_{55}$	5/2 ⁺	0	5/2 ⁺	0				
	3/2 ⁺	89	3/2 ⁺	89				
	3/2 ⁺	89	5/2 ⁺	0	0.000175 (4)	0.045	50.2 (10)	19.0
	7/2 ⁺	341	5/2 ⁺	0	0.014 (6)	0.00025	0.04	0.24
			3/2 ⁺	89			3.7 (14)	3.9
$^{101}_{44}\text{Ru}_{57}$	5/2 ⁺	0	5/2 ⁺	0				
	3/2 ⁺	127	3/2 ⁺	127				
	3/2 ⁺	127	5/2 ⁺	0	0.019 (4)	0.0076	17.21 (21)	0.49
	7/2 ⁺	306	5/2 ⁺	0	0.014 (4)	0.0003	1.4 (14)	0.05
			3/2 ⁺	127			13 (4)	19.9
$^{103}_{44}\text{Ru}_{59}$	3/2 ⁺	0	3/2 ⁺	0				
	7/2 ⁺	214	3/2 ⁺	0			70 (30)	13
			5/2 ⁺	3	0.08 (3)	0.004		
			5/2 ⁺	136	0.028 (13)	0.006		

IBM параметри за четни изотопи на Ru

$$H = \epsilon n_d + a_1 L^2 + a_2 Q^2$$



В моделните пресмятания е използван мултиполният вид на хамилтониана на IBM, с отчетени три члена.

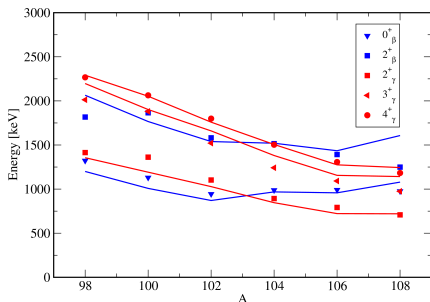
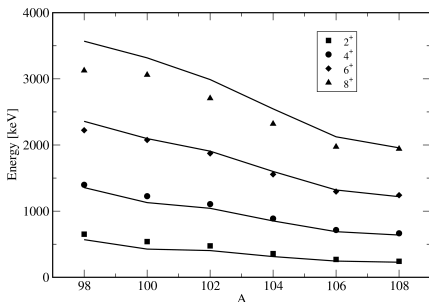
Зависимости между параметрите

- $\epsilon = \text{EPS}$
- $a_1 = 0.5 \text{ ELL}$
- $a_2 = 0.5 \text{ QQ}$

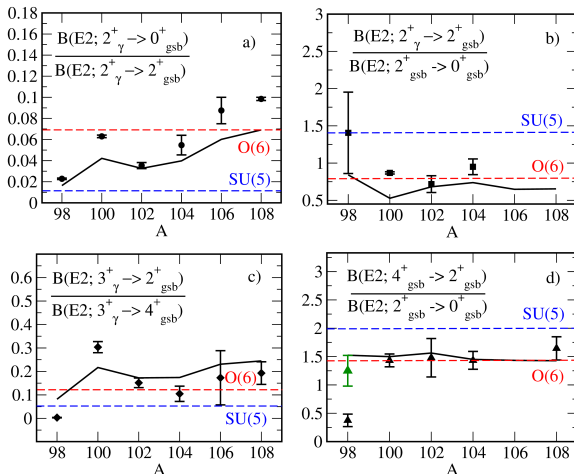
Енергии на пресметнатите състояния

IBM изчисления

В рамките на моделните изчисления се постига добор описание на енергиите на състоянията както в основната ивица, така и в β - и γ -ивиците в четните изотопи на Ru.

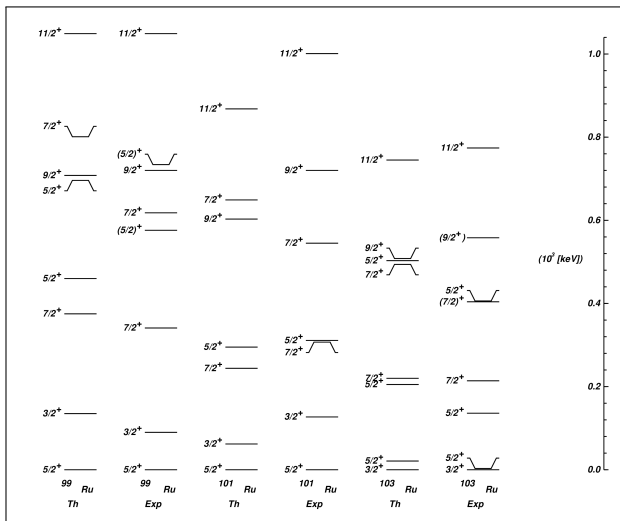


Вероятности за преход в рамките на пресмятанията



limit values from J. Stachel, P. Van Isacker and K. Heyde, PRC 25 650-657 (1982)

Енергии на пресметнатите състояния в рамките на IBFM



Structure of low-lying positive-parity states in $^{99,101,103}\text{Ru}$ from in-beam fast-timing measurements

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The neutron-deficient $^{99,101,103}\text{Ru}$ nuclei were studied from in-beam reaction data. Half-lives of excited states were measured with RoSphere and new results are presented. Rigid-Triaxial-Rotor-plus-Particle model calculations were performed and compared to the experimental data.

PACS numbers:

I. INTRODUCTION

In the last years a number of fast-timing experiments were performed at IFIN-HH (Romania) aiming to study the structure of the low-lying excited states in the medium-mass odd- A nuclei. These studies were motivated by the scarce lifetime data in this energy and time range.

of those low-lying states are having sub-nanosecond half-lives [6], which is an excellent opportunity to apply a recently developed in-beam fast-timing method.

II. EXPERIMENTAL SET UP AND DATA ANALYSIS

