^{28}Si(^{36}Ar,αpnγ) 1999Ru01,1998Ru01,2001Ru02

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Caroline D. Nesaraja, Scott D. Geraedts and Balraj Singh	NDS 111, 897 (2010)	12-Jan-2010

Includes ^{40}Ca(^{24}Mg,αpnγ) from 2001Ru02 (also 1999Ru02).

1999Ru01, 1998Ru01 (also 1999Ru02,2000Ru06): E=143 MeV. Measured Eγ, Iγ, $\gamma\gamma\gamma$, n$\gamma\gamma$, $\gamma\gamma(\theta)$(DCO), $T_{1/2}$ by residual Doppler-shift method using GAMMASPHERE array of 82 Compton-suppressed Ge detectors, charged-particle array (Microball) of CsI detectors and 15 neutron detectors. A highly-deformed band is reported in the second minimum which is found to decay by γ-emission to spherical states in the first minimum and by prompt proton emission to low-lying levels in ^{57}Ni. Self-consistent Hartree-Fock calculations were used to predict large collectivity of the highly-deformed band and general trend of dynamic moment of inertia.

2001Ru02, 2001Ru11: ^{40}Ca(^{24}Mg,αpnγ) E=96 MeV. Measured γ, $\gamma\gamma$, lifetimes by Doppler-shifted attenuated γ-ray lineshapes using EUROBALL array of 26 CLOVER detectors and 15 CLUSTER detectors. Neutrons were measured in coin with γ rays using an array of 50 liquid scintillators of the EUROBALL neutron wall. In 2001Ru11, γ-proton correlations were measured to deduce lifetime of proton decaying state.

2002Ru09: E=148 MeV. Measured Eγ, Iγ, $\gamma\gamma(\theta)$(DCO), prompt protons, (proton)γ coin using GAMMASPHERE array of 86 Compton-suppressed Ge detectors, MICROBALL and a wall of four ΔE-E silicon-strip telescopes. Neutrons were detected by 20 liquid scintillators.

A tentative 6585 level with 1396γ and 3073γ proposed earlier is not confirmed by 2002Ru09. DCO values are for 97°−150° geometry.

2007JoZW (conference paper): describes experimental arrangement to measure energies and angular distributions of prompt proton from high-spin states in ^{58}Cu and ^{58}Ni. The (proton)γ coin were detected using Gammasphere array of 77 HPGe detectors, LuWuSiA array or Microball for charged particles and neutron shell of 30 detectors for neutrons. The residual nuclei were separated using Fragment Mass Analyzer (FMA) at Argonne. Through Eγ-Eπ coin matrix, earlier results for proton decay from 8915 level were confirmed. However, the plan of this experiment was to study prompt proton decay of high-spin states in ^{58}Ni.

^{58}Cu Levels

E(level)[†]	J$^\pi$[‡]	$T_{1/2}$[#]	Comments
0.0	1^+		
443.5 *2*	$3^{(+)}$		
1548.8 *3*	(4^+)		
1646.7 *7*	(3^+)		
2064.4 *3*	(5^+)		
2919.6 *5*	(5^+)		
3420.1 *5*	(7^+)		
3511.6? *7*			
4064.7 *6*	(7^+)		
4440.4 *6*	(8^+)		
5189 *2*	(7^+)		J$^\pi$: from 2002Ru09.
5346.9 *8*	(9^+)		
5574.0 *7*	(9^+)		
6386.2 *9*	(10^+)		
6793 *1*	(9)		
7391 *1*	(11^+)		
8126 *1*	(11)		
8227? *1*	(9^+)		
8486 *2*	(12^+)		
8880 *2*			
8915[@] *1*	(9^+)	0.22 ps *18*	%p=96 *4* %p: from author's estimation of %γ<3 in 1998Ru01 and conservative lower limit of 93% in 2002Ru09. $T_{1/2}$: 0.042-0.40 ps (2001Ru11). J$^\pi$: from 2001Ru02. Main decay is through prompt proton transition of angular momentum 3 to 5 and E(p)(c.m.

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^{28}Si(^{36}Ar,αpnγ) 1999Ru01,1998Ru01,2001Ru02 (continued)

^{58}Cu Levels (continued)

E(level)[†]	J$^\pi$[‡]	T$_{1/2}$[#]	Comments
			system)= 2290 *20* (2002Ru09) to 3701, 9/2$^+$ level in ^{57}Ni. Weak proton transition to 3864, 11/2$^-$ level in ^{57}Ni is not confirmed by 2002Ru09. A 2330γ from this level proposed earlier is not confirmed by 2002Ru09. Proton decay is identified from the observation of following γ transitions in ^{57}Ni in coincidence experiments: 769 (from 769 level), 2577 (from 2577 level), 1124 and 2932 (from 3701 level). DCO(1124γ)=0.47 *13* (2001Ru02).
9679 *3*			
9745[@] *1*	(11$^+$)	0.38 ps *4*	T$_{1/2}$: from 2001Ru02. Q(transition)=2.75 *+27−24* (2001Ru02). Weak (≈8%) proton decay from this level, originally proposed, is not confirmed by 2002Ru09.
9803 *1*	(12)		
10775 *3*			
10942[@] *1*	(13$^+$)	0.104 ps *14*	T$_{1/2}$: from 2001Ru02. Q(transition)=2.55 *+19−15* (2001Ru02).
11552 *3*			
11841 *3*			
12519[@] *1*	(15$^+$)	0.035 ps *7*	T$_{1/2}$: from 2001Ru02. Q(transition)=2.21 *+26−19* (2001Ru02).
13128 *4*			
14474[@] *2*	(17$^+$)		
14880 *4*			
16816[@] *3*	(19$^+$)		
19564[@] *4*	(21$^+$)		
22745[@] *5*	(23$^+$)		

[†] From least-squares fit to Eγ's.
[‡] From 1999Ru01 and 2001Ru02 based on $\gamma\gamma(\theta)$ data, band structures and decay pattern of yrast type states. The parentheses have been added by the evaluators due to lack of strong arguments.
[#] From Doppler-attenuated line shape analysis (2001Ru02).
[@] Band(A): $\nu 4^1\pi 4^1$ intruder band (1998Ru01,1999Ru01,2001Ru02). Average Q(transition)= 2.0 *2* (1998Ru01), β_2=0.37. Interpreted (1998Ru01) as well-deformed rotational band in the second minimum. This band is also discussed by 1999Ru02.

γ(^{58}Cu)

DCO values are from 1999Ru01 (30°−83° geometry), unless otherwise stated. Angular distribution data are also given by 1999Ru01 in terms of R(asymmetry) for 30°−83° geometry. These values are given under document records. Other DCO values for selected transitions are from 2001Ru02 and 2002Ru09.

E$_\gamma$[†]	I$_\gamma$[†]	E$_i$(level)	J$_i^\pi$	E$_f$	J$_f^\pi$	Mult.[‡]	Comments
418 *1*	8 *1*	2064.4	(5$^+$)	1646.7	(3$^+$)		
443.5 *2*	100 *3*	443.5	3$^{(+)}$	0.0	1$^+$	Q	DCO=1.16 *10* (2001Ru02). Additional information 1.
500.5 *3*	6 *1*	3420.1	(7$^+$)	2919.6	(5$^+$)	Q	DCO= 1.01 *20*.
515.4 *3*	26 *1*	2064.4	(5$^+$)	1548.8	(4$^+$)	D	DCO= 0.54 *7*. Additional information 3.
592.0 *5*	3 *1*	3511.6?		2919.6	(5$^+$)		
830.2 *3*	22 *1*	9745	(11$^+$)	8915	(9$^+$)	E2	DCO=0.96 *18* (2002Ru09). Additional information 15.

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^{28}Si(^{36}Ar,αpnγ) 1999Ru01,1998Ru01,2001Ru02 (continued)

γ(^{58}Cu) (continued)

E_γ †	I_γ †	E_i(level)	J_i^π	E_f	J_f^π	Mult. ‡	Comments
906 *1*	8 *1*	5346.9	(9^+)	4440.4	(8^+)	D	R(asymmetry)=0.70 *17* (1999Ru01).
1020.4 *4*	42 *2*	4440.4	(8^+)	3420.1	(7^+)	D	DCO= 0.77 *12*. Additional information 9.
1039 *1*	5 *1*	6386.2	(10^+)	5346.9	(9^+)	D	R(asymmetry)=0.86 *17* (1999Ru01).
1105.0 *3*	29 *1*	1548.8	(4^+)	443.5	$3^{(+)}$	D	DCO= 0.55 *10*. Additional information 2.
1145.2 *5*	9 *1*	4064.7	(7^+)	2919.6	(5^+)		DCO= 0.95 *30*. Additional information 7.
1197.3 *5*	30 *2*	10942	(13^+)	9745	(11^+)	E2	DCO=1.07 *22* (2001Ru02). Additional information 19.
1317 *1*	4 *1*	9803	(12)	8486	(12^+)		
1355.6 *4*	75 *2*	3420.1	(7^+)	2064.4	(5^+)	Q	DCO= 1.09 *10*. Additional information 6.
1446 *1*	6 *1*	6793	(9)	5346.9	(9^+)		R(asymmetry)=1.7 *3* (1999Ru01); possibly ΔJ=0 transition.
1489 *1*	5 *1*	8880		7391	(11^+)		
1509.3 *5*	16 *1*	5574.0	(9^+)	4064.7	(7^+)	Q	DCO=1.02 *17* for 1509+1519 (2001Ru02); R(asymmetry)=1.21 *12* (1999Ru01). Additional information 11.
1519 *1*	5 *1*	9745	(11^+)	8227?	(9^+)	E2	DCO=1.02 *17* for 1509+1519 (2001Ru02); $ R(asymmetry)=1.2 *3* (1999Ru01). Additional information 16.
1576.4 *4*	28 *1*	12519	(15^+)	10942	(13^+)	E2	DCO=1.23 *21* (2002Ru09); R(asymmetry)=1.41 *14* (1999Ru01). Additional information 20.
1621.2 *4*	60 *2*	2064.4	(5^+)	443.5	$3^{(+)}$	Q	Additional information 4. DCO=1.08 *8*.
1647 *1*	10 *1*	1646.7	(3^+)	0.0	1^+		
1677 *1*	8 *1*	9803	(12)	8126	(11)		DCO= 1.2 *3*. Additional information 18.
1740 *1*	12 *1*	8126	(11)	6386.2	(10^+)	(D)	DCO= 0.78 *20*. Additional information 14.
1818@	3@ *1*	7391	(11^+)	5574.0	(9^+)		
1895 *1*	6 *1*	10775		8880			
1927 *1*	33 *2*	5346.9	(9^+)	3420.1	(7^+)	Q	DCO= 1.05 *15*. Additional information 10.
1946 *1*	24 *2*	6386.2	(10^+)	4440.4	(8^+)	Q	DCO= 1.10 *16*. Additional information 12.
1955 *1*	24 *1*	14474	(17^+)	12519	(15^+)	Q	DCO=1.08 *16* (2001Ru02). Additional information 21.
2000 *1*	15 *1*	4064.7	(7^+)	2064.4	(5^+)	Q	DCO=1.2 *3* (2001Ru02). Additional information 8.
2038 *2*	6 *1*	11841		9803	(12)		R(asymmetry)=1.35 *17* (1999Ru01) for a doublet.
2044 *2*	19 *2*	7391	(11^+)	5346.9	(9^+)	Q	DCO= 1.22 *25*. Additional information 13.
2087 *2*	4 *1*	8880		6793	(9)		
2100 *2*	9 *1*	8486	(12^+)	6386.2	(10^+)	(Q)	DCO= 1.3 *5*, $\hat{R}$(asymmetry)=1.25 16 (1999Ru01).
2288 *2*	7 *1*	9679		7391	(11^+)		
2342 *2*	16 *1*	16816	(19^+)	14474	(17^+)	Q	DCO=1.16 *20* (2002Ru09). Additional information 22.
2353 *2*	3 *1*	13128		10775			
2476.4 *8*	14 *1*	2919.6	(5^+)	443.5	$3^{(+)}$	Q	DCO= 1.17 *16*. Additional information 5.
2654# *2*	4 *1*	8227?	(9^+)	5574.0	(9^+)		
2748 *2*	8 *1*	19564	(21^+)	16816	(19^+)	Q	R(asymmetry)=1.43 *23* (1999Ru01).
3037# *3*	2 *1*	8227?	(9^+)	5189	(7^+)		

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^{28}Si(^{36}Ar,αpnγ) 1999Ru01,1998Ru01,2001Ru02 (continued)

γ(^{58}Cu) (continued)

E_γ[†]	I_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	Comments
3039 *3*	3 *1*	14880		11841			
3066 *3*	3 *1*	11552		8486	(12^+)		
3125 *3*	2 *1*	5189	(7^+)	2064.4	(5^+)		
3181 *3*	2 *1*	22745	(23^+)	19564	(21^+)		
4171 *3*	6 *1*	9745	(11^+)	5574.0	(9^+)	E2	DCO=1.1 *3* (2002Ru09); R(asymmetry)=1.46 *25* (1999Ru01). Additional information 17.
4399[@&]	1[@] *1*	9745	(11^+)	5346.9	(9^+)		

[†] From 1999Ru01 unless otherwise stated.
[‡] From DCO ratios, mult=D corresponds to ΔJ=1 and mult=Q to ΔJ=2, quadrupole transition. RUL used to restrict mult to E2 when level lifetimes are known.
[#] From 2002Ru09. Uncertainty is assigned as in 1999Ru01 for 2652 *2* and 3035 *3* transitions.
[@] From 2002Ru09, intensity is quoted in text of 2002Ru09.
[&] Placement of transition in the level scheme is uncertain.

^{28}Si(^{36}Ar,αpnγ) 1999Ru01,1998Ru01,2001Ru02

Level Scheme

Intensities: Relative I_γ

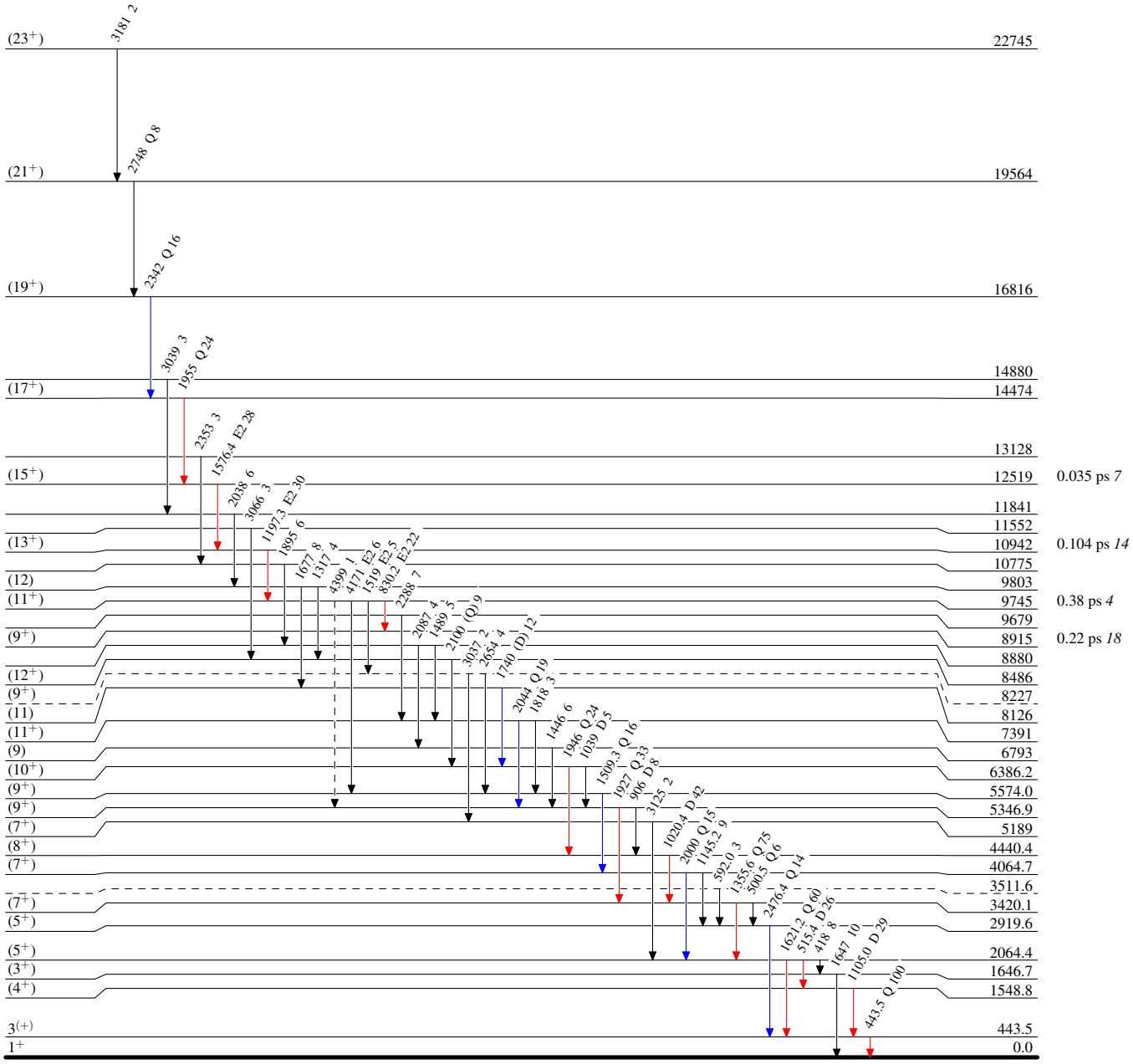
Legend

$I_\gamma < 2\% \times I_\gamma^{max}$

$I_\gamma < 10\% \times I_\gamma^{max}$

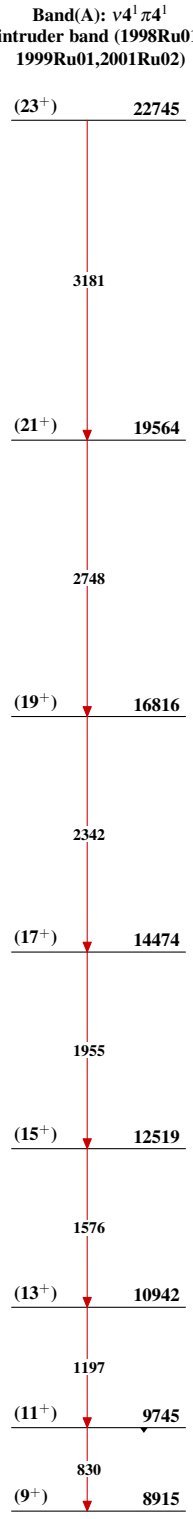
$I_\gamma > 10\% \times I_\gamma^{max}$

γ Decay (Uncertain)



$^{58}_{29}Cu_{29}$

^{28}Si(^{36}Ar,αpnγ) 1999Ru01,1998Ru01,2001Ru02



$^{58}_{29}Cu_{29}$