^{60}Ni(α,pγ) 1976Da01,1980Ry03,1979Mu08

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Jun Chen	NDS 196,17 (2024)	30-Sep-2023

1976Da01: E=11.7 MeV α beam was produced from the 7.5-MV Van de Graaff accelerator at Universite Laval. Targets were 175-460 μg/cm^2 self-supporting 98% enriched ^{60}Ni. γ rays were detected with a Ge(Li) detector and protons were detected with an annular silicon detector. Measured Eγ, Iγ, pγ(θ). Deduced levels, J, π, γ-ray branching ratios, multipolarities, mixing ratios. Comparisons with available data.

1980Ry03: E=10 MeV α beam was produced from the University of Melbourne 5U Pelletron accelerator. Target was 164 μg/cm^2 99.6% enriched ^{60}Ni. γ rays were detected with a Ge(Li) detector and protons were detected with a surface-barrier detector. Measured Eγ, Iγ, pγ-coin, Doppler-shift attenuation. Deduced levels, $T_{1/2}$, transition strengths. Comparisons with available data.

1979Mu08 (also 1979Mu09): E=9.5-19 MeV α beams were produced at the Oliver Lodge Laboratory. Target was 1.2 mg/cm^2 >99.8% enriched ^{60}Ni on a gold backing. γ rays were detected with an escape-suppressed spectrometer for γ(θ) and a three-Ge(Li) Compton polarimeter for γ(lin pol). Measured Eγ, Iγ, γγ-coin, γ(θ), γ(lin pol), Doppler-shift attenuation. Deduced levels, J, π, $T_{1/2}$, γ-ray multipolarities, mixing ratios.

1973Ho21: E=10.0-12.3 MeV α beams were from the University of Pennsylvania Tandem Van de Graaff accelerator. γ rays were detected with a Ge(Li) detector. Measured Eγ, Doppler-shift attenuation. Known $T_{1/2}$ of 670 and 1547 levels are used for calibration.

^{63}Cu Levels

E(level)[†]	J^{π}[‡]	$T_{1/2}$[#]	Comments
0	$3/2^-$		
669.5 *3*	$1/2^-$	0.215 ps *22*	
962.08 *21*	$5/2^-$	0.57 ps *7*	
1326.37 *23*	$7/2^-$	0.61 ps *6*	
1411.9 *3*	$5/2^-$	2.0 ps *3*	
1546.8 *4*	$3/2^-$	0.122 ps *12*	
1860.72 *24*	$7/2^-$	1.14 ps *28*	
2011.0 *5*	$3/2^-$	0.035 ps *8*	
2062.6 *7*	$(1/2)^-$	0.15 ps *7*	
2081.6 *5*	$5/2^{(-)}$		
2091.5 *4*	$7/2^-$	0.24 ps *8*	
2208.2 *5*	$9/2^-$		
2336.5 *5*	$5/2^-$		
2404.1 *6*	$7/2^-$		
2505.7 *3*	$9/2^+$		J^{π}: from γ(θ) and linear polarization of the 645-keV decay γ.
2677.0 *5*	$11/2^-$	0.58[@] ps *15*	J^{π}: from γ(θ) and linear polarization.
3461.8 *6*	$11/2^+$	≤0.42[@] ps	J^{π}: 11/2 from γ(θ), linear polarization, and yield curve of the 956-keV decay γ. $11/2^-$ leads to unreasonably large B(M2)(W.u.).
4155.4 *7*	$13/2^+$	<0.56[@] ps	J^{π}: $13/2^+$ and $9/2^-$ from γ(θ) and linear polarization of decay data. $9/2^-$ is unfavored considering yield curve and M2 strength.
4496.3 *9*	$17/2^+$		J^{π}: $17/2^+$ and 13/2 from γ(θ) and linear polarization of the 341-keV γ ray. The yield curve of decay γ indicates a spin higher than 13/2.
4917.7 *10*	$13/2,15/2^+,19/2^+$		J^{π}: from γ(θ) and linear polarization data.

† From a least-squares fit to γ-ray energies, assuming ΔEγ=1 keV where not given.
‡ From γ(θ) in 1976Da01 up to 2404 level and from γ(θ) and γ(lin pol) in 1979Mu08 above that.
\# From DSAM in 1980Ry03, unless otherwise noted.
@ From DSAM in 1979Mu08.

γ(^{63}Cu)

E_i(level)	J^{π}_i	E_γ[†]	I_γ[†]	E_f	J^{π}_f	Mult.[‡]	δ[‡]	Comments
669.5	1/2$^-$	669.4 3	100	0	3/2$^-$			
962.08	5/2$^-$	961.8 3	100	0	3/2$^-$	M1+E2	−0.47 +4−9	
1326.37	7/2$^-$	361	17.2 11	962.08	5/2$^-$	M1+E2	−0.18 +8−10	
		1326.6 3	82.8 11	0	3/2$^-$	E2		
1411.9	5/2$^-$	450	20.2 12	962.08	5/2$^-$	D(+Q)	+0.11 +25−18	
		742	9.6 10	669.5	1/2$^-$	E2		
		1411.8 3	70.2 17	0	3/2$^-$	M1+E2	+0.61 +9−8	
1546.8	3/2$^-$	585	19.7 17	962.08	5/2$^-$	D(+Q)	+0.05 +14−15	
		877[&]	≤3.0	669.5	1/2$^-$			
		1546.6 4	80.3 17	0	3/2$^-$	M1+E2	+0.13 +5−4	
1860.72	7/2$^-$	535[&]	≤2.0	1326.37	7/2$^-$			
		898.7 3	43.4 18	962.08	5/2$^-$	D(+Q)	+0.05 5	
		1861.0 4	56.6 18	0	3/2$^-$	E2		
2011.0	3/2$^-$	688[&]	≤2.0	1326.37	7/2$^-$			
		1048.7 8	21.5 27	962.08	5/2$^-$	M1+E2		δ: +0.23 +15−9 or >+7.
		1341	33.3 31	669.5	1/2$^-$			
		2011.4 7	45.2 33	0	3/2$^-$	D+Q		δ: +0.06 +9−8 or +3.1 +13−8.
2062.6	(1/2)$^-$	516	53.0 35	1546.8	3/2$^-$			δ: −0.10 +8−10 or −3.2 +10−18 if J=3/2.
		1392.3 12	36.0 32	669.5	1/2$^-$			δ: +0.27 +16−15 or −3.7 +12−25 if J=3/2.
		2063	11.0 18	0	3/2$^-$			δ: −0.26 +16−18 or <−7 or >7 if J=3/2.
2081.6	5/2$^{(-)}$	534		1546.8	3/2$^-$			
		669[&]		1411.9	5/2$^-$			
		758		1326.37	7/2$^-$	D+Q		δ: +0.28 8 or +6.0 +54−23.
		1119		962.08	5/2$^-$			
		2081		0	3/2$^-$			
2091.5	7/2$^-$	680		1411.9	5/2$^-$			
		764.9 6		1326.37	7/2$^-$	D+Q		δ: −0.25 +17−24 or +1.3 +7−5.
		1130		962.08	5/2$^-$	D+Q	−1.06 +23−22	
		2092		0	3/2$^-$			
2208.2	9/2$^-$	885	59.0 18	1326.37	7/2$^-$	D+Q		δ: −0.28 5 (J=9/2); +0.56 +14−10 or +2.38 +23−22 (J=5/2).
		1246	41.0 18	962.08	5/2$^-$			δ: −0.05 5 (J=9/2); +2.0 +5−3 (J=5/2).
2336.5	5/2$^-$	474	≤3.0	1860.72	7/2$^-$			
		925	8.9 26	1411.9	5/2$^-$			
		1375	17.9 26	962.08	5/2$^-$	D+Q		δ: −0.58 +24−38 or >+3.
		1667	≤2.0	669.5	1/2$^-$			
		2337	73.2 41	0	3/2$^-$	D+Q		δ: +0.04 7 or −2.6 +8−12.
2404.1	7/2$^-$	991	21.2 31	1411.9	5/2$^-$	D+Q	−0.50 +12−20	
		1080	35.7 37	1326.37	7/2$^-$	D(+Q)	−0.12 21	
		1441	43.1 38	962.08	5/2$^-$	D+Q		δ: −0.26 +6−8 or −1.3 +6−4.
2505.7	9/2$^+$	414.3 4	33[#] 2	2091.5	7/2$^-$			

From ENSDF

$^{63}_{29}$Cu$_{34}$-2

γ(^{63}Cu) (continued)

E_i(level)	J^π_i	E_γ [†]	I_γ [†]	E_f	J^π_f	Mult. [‡]	δ [‡]
2505.7	9/2+	645.4 *3*	40[#] *2*	1860.72	7/2−	E1(+M2)[@]	−0.01[@] *2*
		1178.9 *3*	27[#] *1*	1326.37	7/2−	E1+M2[@]	
2677.0	11/2−	469.2 *4*	30 *2*	2208.2	9/2−	M1(+E2)[@]	+0.01[@] *3*
		1350.1 *4*	70 *2*	1326.37	7/2−	E2[@]	
3461.8	11/2+	956.1 *5*	100	2505.7	9/2+	M1+E2[@]	−0.42[@] *4*
4155.4	13/2+	1649.6 *6*	100	2505.7	9/2+	E2(+M3)[@]	−0.04[@] *5*
4496.3	17/2+	340.9 *5*	100	4155.4	13/2+	E2(+M3)[@]	−0.02[@] *2*
4917.7	13/2,15/2+,19/2+	421.4 *5*	100	4496.3	17/2+		

† From 1976Da01 up to 2404 level (Eγ with uncertainties from 1980Ry03) and from 1979Mu08 above that, unless otherwise noted. Intensities are % photon branching from each level.

‡ From γ(θ) in 1976Da01, with magnetic and electric character determined based on RUL and measured $T_{1/2}$ where available, unless otherwise noted.

Approximate branching deduced from γγ-coincidence experiment (1979Mu08).

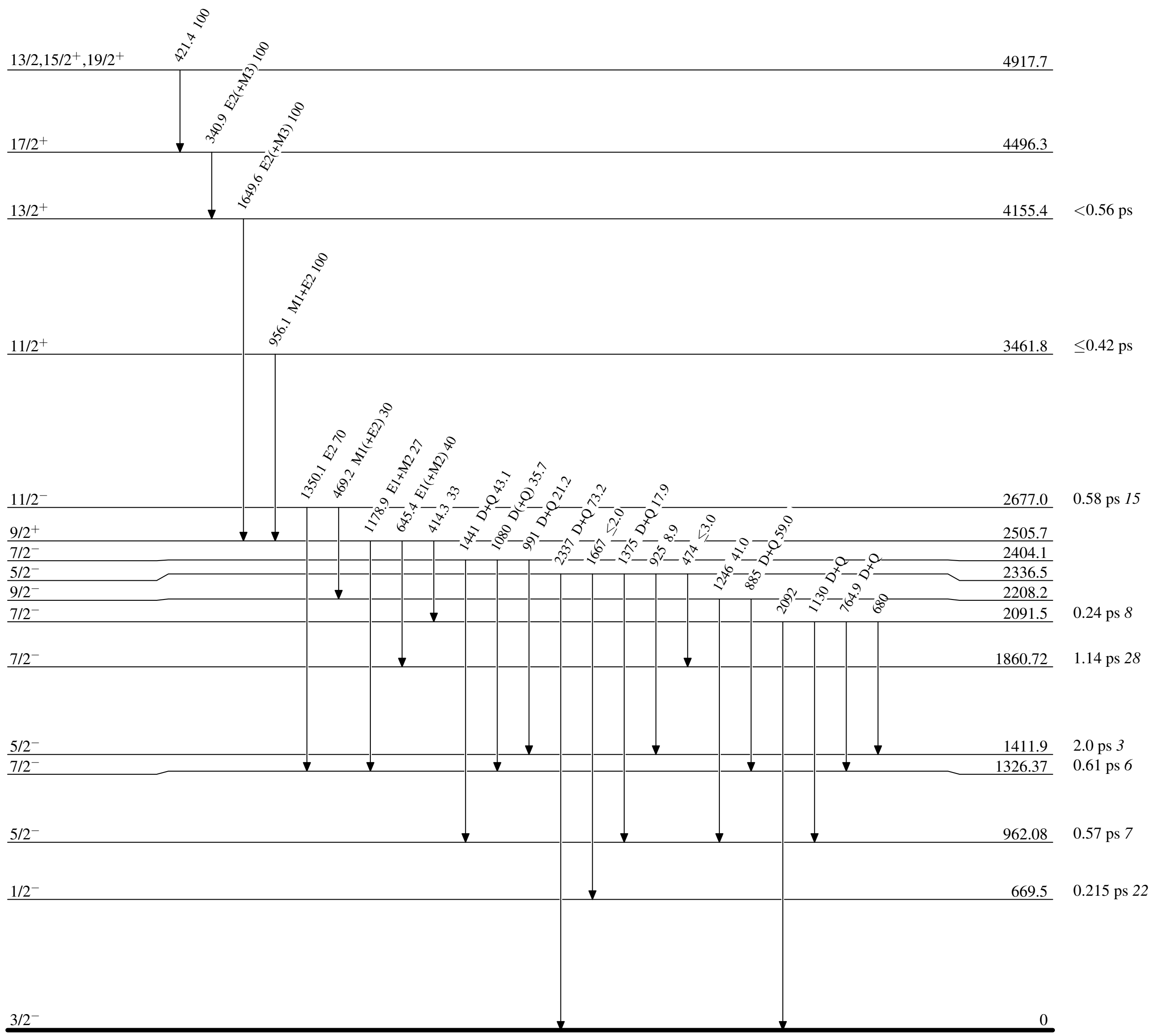
@ From γ(lin pol) in 1979Mu08.

& Placement of transition in the level scheme is uncertain.

^{60}Ni(α,pγ) 1976Da01,1980Ry03,1979Mu08

Level Scheme

Intensities: % photon branching from each level



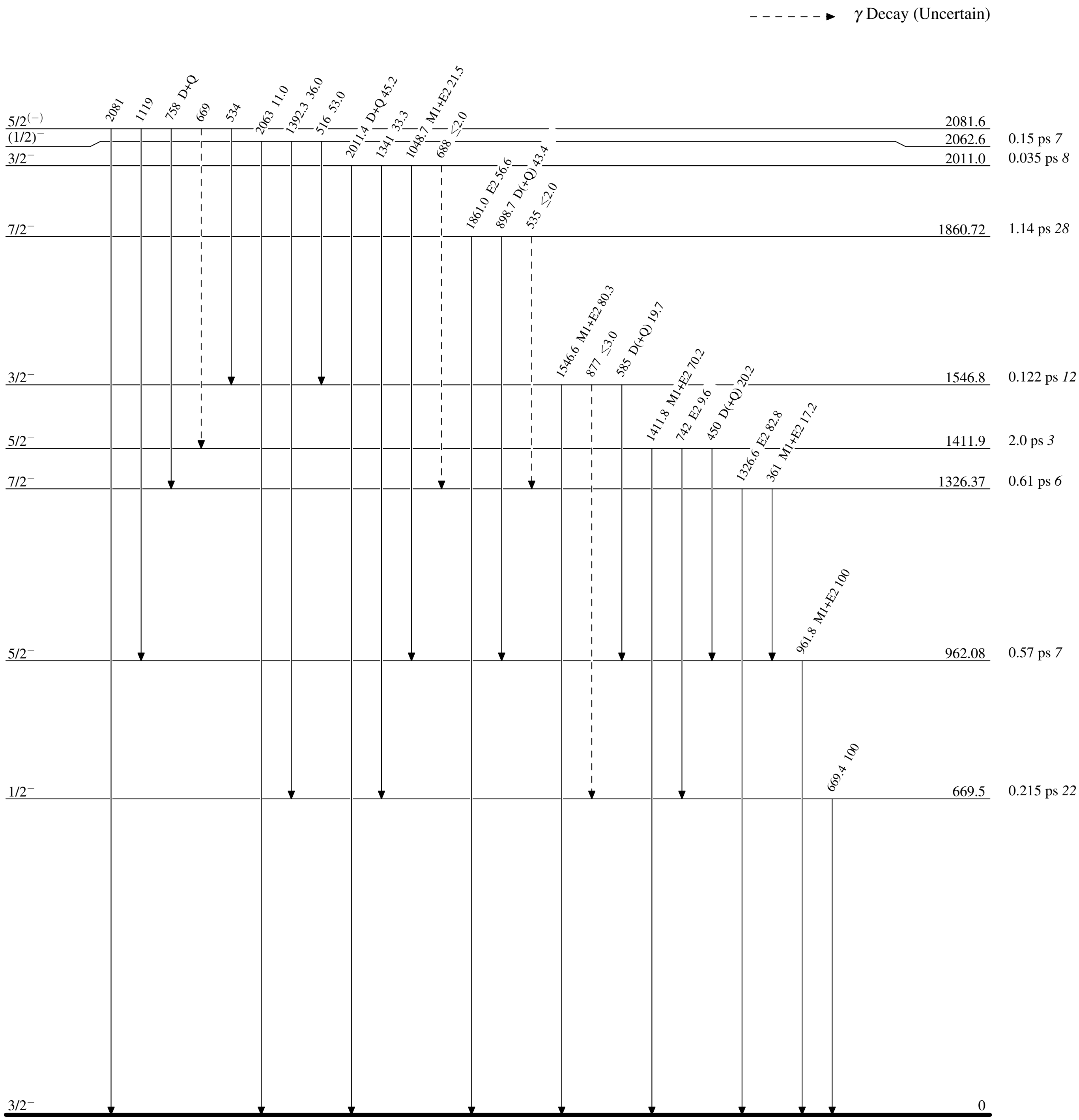
$^{63}_{29}Cu_{34}$

$^{60}Ni(\alpha,p\gamma)$ 1976Da01,1980Ry03,1979Mu08

Legend

Level Scheme (continued)

Intensities: % photon branching from each level



$^{63}_{29}Cu_{34}$