^{65}Cu(γ,γ') 1976Sw01

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Jun Chen	NDS 202,59 (2025)	25-Feb-2025

1976Sw01: E=1.5-4.7 MeV photons were produced by bremsstrahlung with electron beam from the Bartol accelerator. Scattered γ rays were detected with a Ge(Li) detector. Measured $\gamma(\theta)$. Deduced levels, J, π, widths, γ-ray branching ratios, multipolarities, mixing ratios.

1975MoYT: photoexcitation of 7939 and 8484 resonances; measured Eγ, Iγ, $\gamma(\theta)$, γ-linear polarization; deduced widths, Ge(Li).

1967Gi15: resonant scattering. Measured $\gamma(\theta)$ with NaI. Deduced widths for levels at 6070 and 8499.

1974Wo05: photoexcitation of 6556 resonance. Measured Eγ, Iγ, $\gamma(\theta)$ with Ge(Li) and NaI detectors. Deduced branching ratios, widths.

1964Be21,1968Me09: resonant scattering and self-absorption. Measured $\gamma(\theta)$. Deduced widths, γ-ray mixing ratio.

1981Ca10: bremsstrahlung. Measured Eγ, Iγ, $\gamma(\theta)$ with a Ge(Li) detector. Deduced widths.

1971Be22: photoexcitation of 6070 and 8484 resonances, self-absorption. Measured $\gamma(\theta)$ with a NaI detector. Deduced widths.

1971Ol03: photoexcitation of 8484 resonance. Measured $\gamma(\theta)$ with a Ge(Li) and a NaI detector. Deduce γ ray mixing ratios.

1971ImZY: photoexcitation. Measured resonance fluorescence with a Ge(Li) detector. Deduced widths.

1972ArZD: bremsstrahlung. Measured resonance fluorescence. Deduced width.

1979DaZC: resonant scattering. Measured $\gamma(\theta)$. Deduced width.

Others (deduced widths): 1963Ka29, 1964Ar01, 1964Be21, 1969Ru01, 1970Ka34, 1972Wh08, 1973Ko31.

^{65}Cu Levels

g=(2J$_x$+1)/(2J$_0$+1), where J$_x$ is the spin of excited level and J$_0$=3/2 is the spin of ground state.

E(level)[†]	J$^\pi$[‡]	T$_{1/2}$[#]	Comments
0	3/2$^-$		J$^\pi$: From Adopted Levels.
770.8[@]	1/2$^-$	101 fs *6*	T$_{1/2}$: from Γ=4.53×10^{-3} eV *26*, weighted mean of 4.8×10^{-3} eV *6* (1971ImZY), 4.8×10^{-3} eV *4* (1972ArZD), 4.36×10^{-3} eV *26* (from gΓ(0)=2.18×10^{-3} eV 13, 1981Ca10), 4.6×10^{-3} eV *14* (1969Ru01), and 5.1×10^{-3} eV *24* (1972Wh08).
1115.5[@]	5/2$^-$	0.285 ps *11*	J$^\pi$: (5/2) from $\gamma(\theta)$ in 1964Be21, 1968Me09. T$_{1/2}$: from Γ=1.60×10^{-3} eV *6*, weighted average of 1.73×10^{-3} eV *10* (1968Me09), 1.63×10^{-3} eV *9* (1972ArZD), 1.54×10^{-3} eV *6* (1979DaZC) and 1.65×10^{-3} eV *19* (from gΓ(0)=2.47×10^{-3} eV *28*, 1981Ca10), 1.0×10^{-3} eV *3* (1963Ka29), 1.5×10^{-3} eV *4* (1964Be21), 1.8×10^{-3} eV *2* (1970Ka34), 1.0×10^{-3} eV *10* (1972Wh08), and 1.9×10^{-3} eV *7* (1973Ko31).
1481.7 *5*	7/2$^-$	0.41 ps *+15−9*	T$_{1/2}$: from Γ=1.12×10^{-3} eV *30*, unweighted mean of 1.412×10^{-3} eV *15* (from gΓ(0)^2/Γ=1.95×10^{-3} eV *2*, 1976Sw01) and 0.82×10^{-3} eV *14* (from gW(θ)Γ(0)^2/Γ=1.13×10^{-3} eV *19*, 1981Ca10), with adopted Γ(0)/Γ=0.831 *2* and W(θ)=1. Other: >0.11×10^{-3} eV (1972Wh08).
1624 *1*	5/2$^-$	0.86 ps *+31−20*	from gΓ(0)^2/Γ=0.24×10^{-3} eV *5* (1976Sw01), adopted Γ(0)/Γ=0.551 *19*.
1724.9 *5*	3/2$^-$	85 fs *+17−13*	J$^\pi$: 3/2 from $\gamma(\theta)$ in 1976Sw01. T$_{1/2}$: gΓ(0)^2/Γ=2.92×10^{-3} eV *30* (1976Sw01), adopted Γ(0)/Γ=0.739 *26*.
2094.3?[@]	7/2$^-$	>0.33 ps	T$_{1/2}$: gΓ(0)^2/Γ<0.24×10^{-3} eV (1976Sw01), adopted Γ(0)/Γ=0.293 *20*, if J(2094)=7/2.
2107.4[@]	(5/2)$^-$		
2212.84? *15*	(1/2)$^-$	>0.12 ps	T$_{1/2}$: gΓ(0)^2/Γ<0.24×10^{-3} eV (1976Sw01), adopted Γ(0)/Γ=0.36 *8*, if J(2213)=1/2.
2279.1?[@]	7/2$^-$	>5.9 fs	T$_{1/2}$: gΓ(0)^2/Γ<0.24×10^{-3} eV (1976Sw01), adopted Γ(0)/Γ=0.039 *18*.
2328.6 *10*	3/2$^-$	9 fs *+6−4*	J$^\pi$: 3/2 from $\gamma(\theta)$ in 1976Sw01. gΓ(0)^2/Γ=6.5×10^{-3} eV *7* (1976Sw01), adopted Γ(0)/Γ=0.36 *8*.
2862.1 *10*	(1/2$^-$)	19.3 fs *+22−18*	gΓ(0)^2/Γ=11.8×10^{-3} eV *12* (1976Sw01), adopted Γ(0)/Γ=1.0.
2875.1 *10*	(3/2$^-$)	13 fs *+5−4*	gΓ(0)^2/Γ=13.5×10^{-3} eV *14* (1976Sw01), adopted Γ(0)/Γ=0.61 *6*, if J(2875)=3/2.
2898 *2*		0.10 ps *+8−4*	E(level): corresponds to 2902 level in Adopted Levels; could also includes

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^{65}Cu(γ,γ') 1976Sw01 (continued)

^{65}Cu Levels (continued)

E(level)†	Jπ‡	$T_{1/2}$#	Comments
			contribution from 2894 level in Adopted Levels. $T_{1/2}$: $g\Gamma(0)^2/\Gamma=3.0\times10^{-3}$ eV *9* (1976Sw01), adopted $\Gamma(0)/\Gamma=0.67$ *8* for 2902 level if J(2902)=5/2.
3086 *2*	(3/2$^-$)	0.14 ps *+6–3*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=3.2\times10^{-3}$ eV *9* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$ if J(3086)=3/2.
3166.5 *10*		5.5& fs *+6–5*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=20.7\times10^{-3}$ eV *21* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$.
3265 *2*		27& fs *+16–8*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=3.6\times10^{-3}$ eV *12* (1976Sw01), adopted $\Gamma(0)/\Gamma=0.92$ *3*.
3326.0 *10*	(3/2,5/2)	5.5& fs *+6–5*	Jπ: (3/2,5/2) from $\gamma(\theta)$ data of 1976Sw01. $T_{1/2}$: $g\Gamma(0)^2/\Gamma=20.6\times10^{-3}$ eV *21* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$.
3356 *2*	5/2$^+$	1.4 fs *+51–12*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=2.3\times10^{-3}$ eV *8* (1976Sw01), adopted $\Gamma(0)/\Gamma=0.068$ *+51–38*.
3504 *2*		17& fs *+5–3*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=6.8\times10^{-3}$ eV *14* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$.
3631 *2*	(1/2$^+$,3/2$^+$)	16& fs *3*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=7.1\times10^{-3}$ eV *12* (1976Sw01), assuming $\Gamma(0)/\Gamma=1$.
3753 *2*		18& fs *+10–5*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=6.4\times10^{-3}$ eV *22* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$.
3825 *2*		18& fs *+6–4*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=6.3\times10^{-3}$ eV *16* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$.
3895 *2*	1/2$^+$	17.3 fs *+31–23*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=13.2\times10^{-3}$ eV *20* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$.
3926 *2*		5.9& fs *6*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=19.2\times10^{-3}$ eV *19* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$.
3958 *2*		3.8& fs *4*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=30\times10^{-3}$ eV *3* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$.
4006 *2*		11& fs *+8–3*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=10\times10^{-3}$ eV *4* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$.
4056 *2*		2.38& fs *+28–23*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=48\times10^{-3}$ eV *5* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$.
4099 *2*		2.9& fs *+44–17*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=18.2\times10^{-3}$ eV *24* (1976Sw01), adopted $\Gamma(0)/\Gamma=0.68$ *+30–22*.
4126 *2*	3/2$^+$	12.0 fs *+14–12*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=38\times10^{-3}$ eV *4* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$.
4141 *2*		2.7& fs *+4–3*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=42\times10^{-3}$ eV *5* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$.
4271 *2*		3.8& fs *+8–6*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=30\times10^{-3}$ eV *5* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$.
4356 *2*		5.4& fs *+13–9*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=21\times10^{-3}$ eV *4* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$.
4376 *2*		7.6& fs *+28–16*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=15\times10^{-3}$ eV *4* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$.
4397 *2*		1.68& fs *+23–18*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=68\times10^{-3}$ eV *8* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$.
4525 *2*		1.36& fs *+32–22*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=84\times10^{-3}$ eV *16* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$.
4533 *2*		2.7& fs *+7–5*	$T_{1/2}$: $g\Gamma(0)^2/\Gamma=43\times10^{-3}$ eV *10* (1976Sw01), adopted $\Gamma(0)/\Gamma=1$.
6070	(3/2)	0.7 fs *+5–2*	E(level): from 1967Gi15. Jπ: (3/2) from $\gamma(\theta)$ in 1967Gi15. $T_{1/2}$: from $\Gamma=0.63$ eV *24*, weighted average of 0.67 eV *35* (1967Gi15) and 0.59 eV *33* (1971Be22). Eγ-E(res)=9.3 eV *8* (1967Gi15).
6556	(1/2)	6.5 fs *+26–30*	E(level): from 1974Wo05. Jπ: (1/2) from $\gamma(\theta)$ in 1974Wo05. $T_{1/2}$: from $\Gamma=0.07$ eV *+6–2* (1974Wo05). Eγ-E(res)=11.2 eV *8* (1974Wo05).
7939 *5*	(5/2)		Jπ: (5/2) from $\gamma(\theta)$ in 1975MoYT.
8485 *2*	(1/2,5/2$^-$)	1.38 fs *13*	E(level): other: 8499 (1967Gi15). Jπ: (1/2) from $\gamma(\theta)$ in 1975MoYT and 1967Gi15, but J=(5/2) is from $\gamma(\theta)$ in 1971Ol03. $T_{1/2}$: from $\Gamma=0.33$ eV *3*, with $\Gamma(0)/\Gamma=0.90$ *5* (1975MoYT). Other widths (corrected for $\Gamma(0)/\Gamma=0.90$ *5*): 1.0 eV *4* (1967Gi15) with $\Gamma(0)=0.94$ eV *29*, 0.52 eV *12* (1971Be22). Note that 1967Gi15 report a $\Gamma=11.5$ eV *80* based on a branching of $\Gamma(0)/\Gamma=0.08$ *4*, which seems incorrect. Eγ-E(res)=9.4 eV *7* (1967Gi15).

† From Eγ data, unless otherwise noted.
‡ From Adopted Levels. Arguments from this dataset are given under comments where available.
# Deduced by the evaluator from $g\Gamma(0)^2/\Gamma$ in 1976Sw01 and adopted g.s. transition branching ratio of $\Gamma(0)/\Gamma$ from Adopted

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^{65}Cu(γ,γ') 1976Sw01 (continued)

^{65}Cu Levels (continued)

Gammas as given under comments, unless otherwise noted. Where there is no deexcitation transition or only a single transition in Adopted Gammas, $\Gamma(0)/\Gamma=1.0$ is assumed.

[@] Rounded values from Adopted Levels.

[&] Quoted values are for $T_{1/2}/(2J+1)$, since the level spin J is unknown.

$\gamma(^{65}Cu)$

Unplaced transitions probably correspond to primary transitions from the 7939 or 8484 resonance levels (1975MoYT).
A_2 and A_4 values under comments are from 1976Sw01, unless otherwise noted.

E_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	δ[‡]	Comments
770.7[@]	770.8	$1/2^-$	0	$3/2^-$			
1115.5[@]	1115.5	$5/2^-$	0	$3/2^-$	D+Q	−0.437 *15*	Mult.,δ: from $\gamma(\theta)$ in 1968Me09. Other: δ(Q/D)=−0.52 *7* or −1.09 *+9−12* from 1964Be21.
1481.7 *5*	1481.7	$7/2^-$	0	$3/2^-$			
1624 *1*	1624	$5/2^-$	0	$3/2^-$			
1724.9 *5*	1724.9	$3/2^-$	0	$3/2^-$	D+Q		δ: δ(Q/D)=0.15 *5* or 1.8 *8* (1976Sw01). A_2=+0.39 *7*.
2094.6[@]	2094.3?	$7/2^-$	0	$3/2^-$			
2212.6[@]	2212.84?	$(1/2)^-$	0	$3/2^-$			
2280.2[@]	2279.1?	$7/2^-$	0	$3/2^-$			
2328.6	2328.6	$3/2^-$	0	$3/2^-$	D+Q		δ: 0.15 *5* or 1.9 *9* (1976Sw01). A_2=+0.38 *8*.
2862.1 *10*	2862.1	$(1/2^-)$	0	$3/2^-$			A_2=+0.09 *28*.
2875.1 *10*	2875.1	$(3/2^-)$	0	$3/2^-$			A_2=+0.43 *24*.
2898 *2*	2898		0	$3/2^-$			
3086 *2*	3086	$(3/2^-)$	0	$3/2^-$			
3166.5 *10*	3166.5		0	$3/2^-$			A_2=−0.18 *16*.
3265 *2*	3265		0	$3/2^-$			
3326.0 *10*	3326.0	(3/2,5/2)	0	$3/2^-$	(D+Q)		δ: 0.9 *5* if J(3326)=3/2. A_2=+0.89 *17*.
3356 *2*	3356	$5/2^+$	0	$3/2^-$			
3504 *2*	3504		0	$3/2^-$			
3631 *2*	3631	$(1/2^+,3/2^+)$	0	$3/2^-$			
3753 *2*	3753		0	$3/2^-$			
3825 *2*	3825		0	$3/2^-$			
[x]3894[#] *3*							
3895 *2*	3895	$1/2^+$	0	$3/2^-$			
3926 *2*	3926		0	$3/2^-$			
[x]3934[#] *3*							
3958 *2*	3958		0	$3/2^-$			
4006 *2*	4006		0	$3/2^-$			
4056 *2*	4056		0	$3/2^-$			
4099 *2*	4099		0	$3/2^-$			
4126 *2*	4126	$3/2^+$	0	$3/2^-$			
4141 *2*	4141		0	$3/2^-$			
[x]4147[#] *3*							
[x]4186[#] *3*							
4271 *2*	4271		0	$3/2^-$			
4356 *2*	4356		0	$3/2^-$			
4376 *2*	4376		0	$3/2^-$			

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^{65}Cu(γ,γ') 1976Sw01 (continued)

$\gamma(^{65}Cu)$ (continued)

E_γ[†]	I_γ	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡]	Comments
4397 *2*		4397		0	$3/2^-$		
[x]4510[#] *3*							
[x]4525[#] *3*							
4525 *2*		4525		0	$3/2^-$		
4533 *2*		4533		0	$3/2^-$		
[x]4857[#] *3*							
[x]5345[#] *3*							
[x]5616[#] *3*	1.9						
5832[#] *3*	1.2[#]	7939	(5/2)	2107.4	$(5/2)^-$		
6070		6070	(3/2)	0	$3/2^-$		E_γ: from level-energy difference. A_2=+0.20 *4* (1967Gi15).
6214[#] *3*	0.7[#]	7939	(5/2)	1724.9	$3/2^-$		
6269[#] *3*	1.5[#]	8485	(1/2,5/2$^-$)	2212.84?	$(1/2)^-$		
6315[#] *3*	3[#]	7939	(5/2)	1624	$5/2^-$		
6457[#] *3*	2[#]	7939	(5/2)	1481.7	$7/2^-$		
6556		6556	(1/2)	0	$3/2^-$		E_γ: from level-energy difference.
6760[#] *3*	1.5[#]	8485	(1/2,5/2$^-$)	1724.9	$3/2^-$		
7714[#] *3*	4[#]	8485	(1/2,5/2$^-$)	770.8	$1/2^-$		
7939[#] *3*	12[#]	7939	(5/2)	0	$3/2^-$		
8484[#] *3*	100[#]	8485	(1/2,5/2$^-$)	0	$3/2^-$	D+Q	E_γ: other: 8499 (1967Gi15). Mult.: from $\gamma(\theta)$ in 1971Ol03 for J(8484)=5/2. A_2=0.00 *5* (1967Gi15). A_2=+0.38 *4*, A_4<+0.04 (1971Ol03).

[†] From 1976Sw01, unless otherwise noted.
[‡] From $\gamma(\theta)$ in 1976Sw01, unless otherwise noted.
[#] From 1975MoYT.
[@] Rounded values from Adopted Gammas.
[x] γ ray not placed in level scheme.

^{65}Cu(γ,γ′) 1976Sw01

Level Scheme

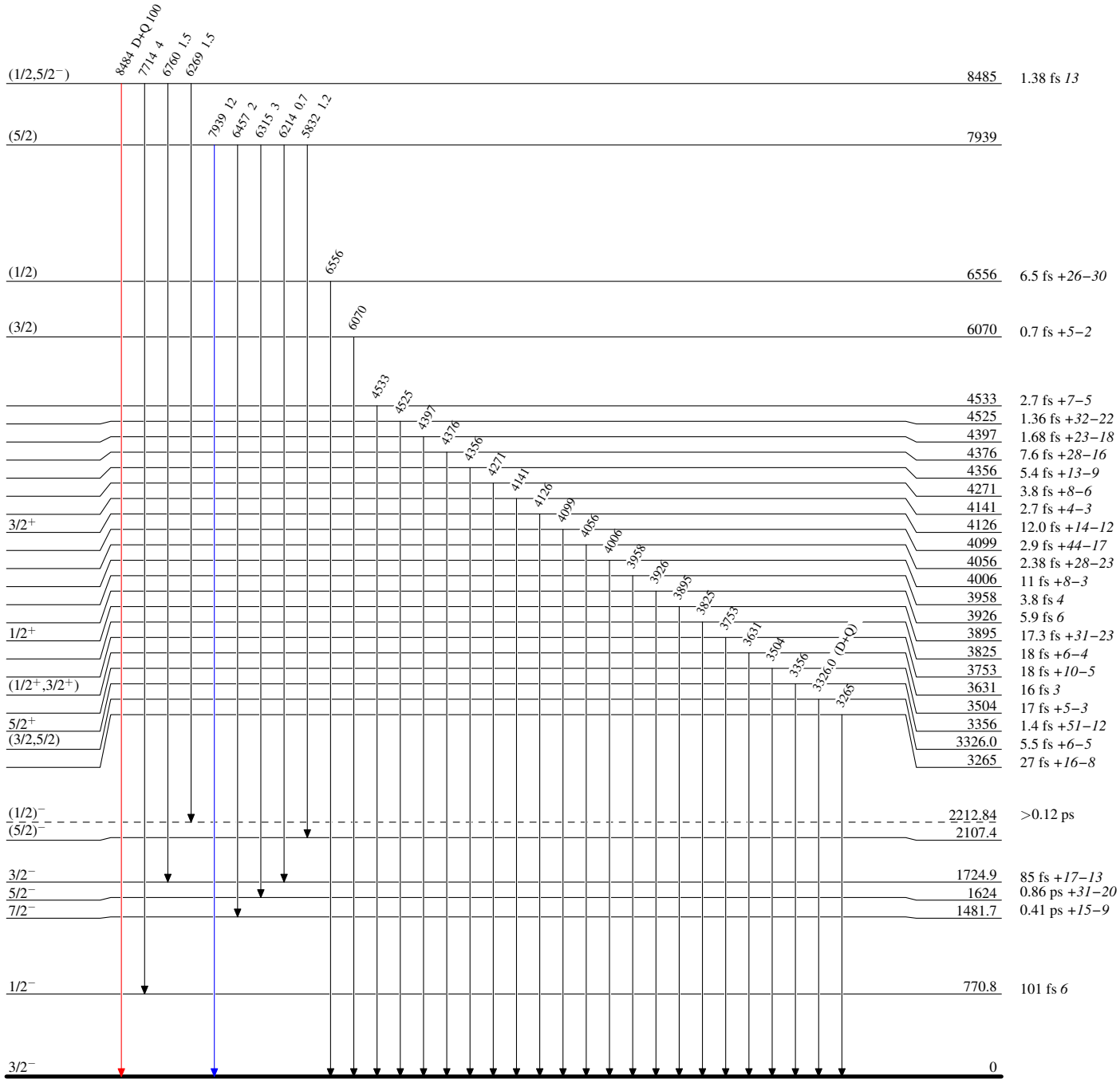
Intensities: Relative I_γ

Legend

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

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

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

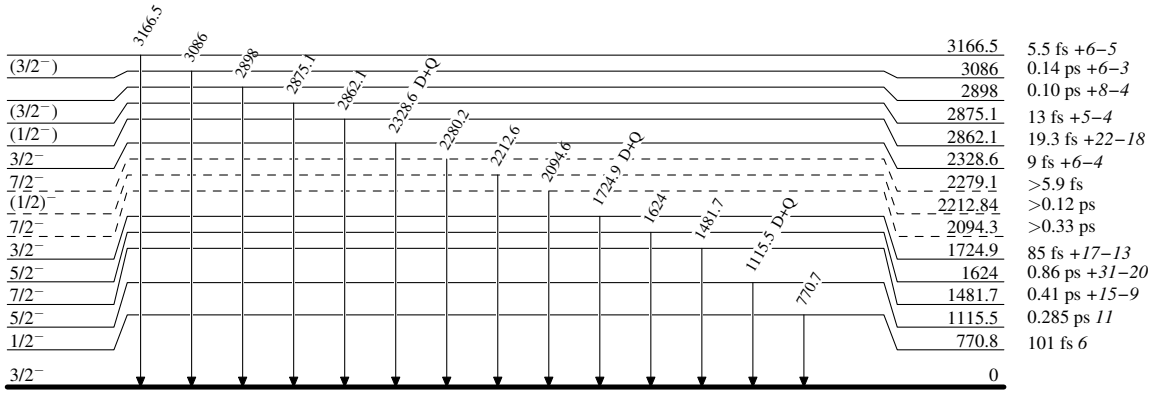


$^{65}_{29}Cu_{36}$

^{65}Cu(γ,γ′) 1976Sw01

Level Scheme (continued)

Intensities: Relative I_γ



$^{65}_{29}Cu_{36}$