Coulomb excitation 2002Ka05,1981Yo07,1972St23

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Coral M. Baglin	NDS 112, 1163 (2011)	15-Dec-2010

Others: 1968Ga24 (37 MeV ^{12}C, 38.1 MeV ^{14}N), 1970Ro03 (E(p)=2.6 MeV), 1972An16 (Eα=8.6, 9.4 MeV), 1972Kr02, 1974Le34, 1974Je04 (44 MeV ^{14}N).

2002Ka05: ^{93}Nb(p,p′γ), E=2.7-4.3 MeV; HPGe detector; measured Eγ, Iγ, reduced quadrupole transition probabilities At E(p)=3 MeV, $\gamma(\theta)$ (5 angles), excit.

1981Yo07: ^{93}Nb(^{16}O,^{16}O′), E=46,42,38,34 MeV, Ge(Li) detectors; measured total cross section, B(E2), Eγ, branching, ^{16}O-$\gamma(\theta)$; corrected for angular correlation and multiple Coulomb excitation.

1974Le34: ^{93}Nb(^{14}N,^{14}N′), E=44 MeV; measured $T_{1/2}$ using DSAM.

1972Kr02: ^{93}Nb(^{16}O,^{16}O′), E=25 MeV to 42 MeV, measured γ spectrum, B(E2).

1972St23: ^{93}Nb(^{16}O,^{16}O′), E=36 MeV; ^{93}Nb(α,α′), E=8.14 MeV. Measured Eγ, Iγ, $\gamma(\theta)$, B(E2), $T_{1/2}$ using DSAM.

^{93}Nb Levels

E(level)†	J$^\pi$‡	$T_{1/2}$#	Comments
0	$9/2^+$		J$^\pi$: adopted value.
743.92 *13*	$7/2^+$	0.57 ps *7*	B(E2)↑=0.0175 *5* J$^\pi$: D+Q γ to $9/2^+$; $\gamma(\theta)$ rules out J=9/2 and 11/2 (1972St23). $T_{1/2}$: weighted average of 0.61 ps *11* (1974Le34), 0.55 ps *14* (1972St23), 0.55 ps *10* (1974Je04). B(E2)↑: Weighted average of 0.0168 *10* (2002Ka05), 0.0188 *10* (1981Yo07), 0.0180 *13* (1972Kr02), and 0.0168 *8* (1972St23). Other: 0.023 ps *5* (1972An16).
808.57 *14*	$5/2^+$	6.16 ps *20*	B(E2)↑=0.0157 *5* J$^\pi$: from 1981Yo07; 7/2 and 9/2 (also allowed by $\gamma(\theta)$) are eliminated based on $T_{1/2}$, B(E2) and δ derived from $\gamma(\theta)$. $T_{1/2}$: weighted average of 5.5 ps *14* (1972St23) and 6.17 ps *20* calculated from B(E2) and the branching of the 809 transition assuming mult=M1 for the 65 transition. Other:≥1.4 ps (1974Je04). B(E2)↑: Weighted average of 0.0155 *10* (2002Ka05), 0.0153 *8* (1981Yo07), 0.0167 *12* (1972Kr02), 0.0157 *8* (1972St23). Others: 0.022 *5* (1972An16), 0.029 *6* (1968Ga24; 742 level included).
949.88 *18*	$13/2^+$	4.36 ps *15*	B(E2)↑=0.0241 *8* J$^\pi$: 13/2 or 7/2 from $\gamma(\theta)$; 7/2 inconsistent with $T_{1/2}$ for any δ. $T_{1/2}$: weighted average of 4.2 ps *14* (1972St23) and 4.36 ps *15* calculated from B(E2). Other:≥1.4 ps (1974Je04). B(E2)↑: Weighted average of 0.0265 *15* (2002Ka05), 0.0236 *13* (1981Yo07), 0.0247 *17* (1972Kr02), 0.0230 *11* (1972St23). Others: 0.031 *6* (1972An16), 0.019 *4* (1968Ga24).
979.04 *16*	$11/2^+$	0.251 ps *18*	B(E2)↑=0.0179 *6* J$^\pi$: $\gamma(\theta)$ allows 5/2, 7/2 or 11/2; only 11/2 is consistent with $T_{1/2}$ (1981Yo07). J=11/2 confirmed from 797$\gamma(\theta)$ (2002Ka05). $T_{1/2}$: weighted average of 0.236 ps *28* (1974Je04), 0.256 ps *26* (1974Le34), 0.31 ps *7* (1972St23), . B(E2)↑: Weighted average of 0.0175 *15* (2002Ka05), 0.019 *4* (1968Ga24), 0.0186 *10* (1981Yo07), 0.0172 *9* (1972St23), 0.023 *5* (1972An16). Other: 0.0127 *11* (1972Kr02).
1082.68 *15*	$9/2^+$	>2.8@ ps	B(E2)↑=0.00257 *23* J$^\pi$: 339$\gamma(\theta)$ limits J to 9/2 (1972St23); 1981Yo07 deduce 5/2, 7/2 or 9/2, but their $\gamma(\theta)$ differs from that of 1972St23. J=9/2 confirmed from 339$\gamma(\theta)$ (2002Ka05). B(E2)↑: weighted average of 0.0020 *3* (2002Ka05), 0.00306 *21* (1981Yo07), 0.00219 *26* (1972Kr02), 0.0026 *2* (table 1, 1972St23). Other: 0.0033 *7* (1972An16). $T_{1/2}$: other: >0.7 ps (1972St23).

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Coulomb excitation 2002Ka05,1981Yo07,1972St23 (continued)

^{93}Nb Levels (continued)

E(level)[†]	J$^{\pi}$[‡]	T$_{1/2}$[#]	Comments
1297.23 *18*	9/2$^+$,13/2$^+$	0.21[@] ps *+21−7*	B(E2)↑=0.00381 *24* J$^{\pi}$: 318$\gamma(\theta)$ allows J=9/2 or 13/2 (1981Yo07). B(E2)↑: Weighted average of 0.0040 *4* (1981Yo07) and 0.0037 *3* (table 1, 1972St23). Other: 0.0046 *9* (1972An16).

[†] From least-squares fit to Eγ.
[‡] Based on $\gamma(\theta)$ and T$_{1/2}$ and E2 Coulomb excitation of level.
[#] From DSAM, except as noted.
[@] From 1974Le34.

$\gamma(^{93}Nb)$

E$_i$(level)	J$_i^{\pi}$	E$_{\gamma}$[†]	I$_{\gamma}$[‡]	E$_f$	J$_f^{\pi}$	Mult.[@]	δ[#]	Comments
743.92	7/2$^+$	743.92 *16*	100	0	9/2$^+$	M1+E2	+0.236 *18*	Other Eγ: 744.7 *3* (1972Kr02). Mult.: pure E2 inconsistent with measured T$_{1/2}$. δ: abs(δ) from B(E2) and T$_{1/2}$ of the 744 level. From $\gamma(\theta)$, δ=+0.14 *12* (2002Ka05), +0.30 *+10−8* (1981Yo07), +0.21 *4* (1972St23).
808.57	5/2$^+$	64.6 *3*	1.25 *8*	743.92	7/2$^+$	D		E$_{\gamma}$,I$_{\gamma}$: from 1972St23. Mult.: D from RUL.
		808.58 *15*	100.00 *8*	0	9/2$^+$	E2		Other Eγ: 809.3 *3* (1972Kr02). δ: pure Q transition from $\gamma(\theta)$ (1981Yo07) if J=5/2.
949.88	13/2$^+$	949.87 *18*	100	0	9/2$^+$	E2		Other Eγ: 950.5 *3* (1972Kr02). δ: pure Q transition from $\gamma(\theta)$ (1981Yo07) if J=13/2.
979.04	11/2$^+$	979.01 *18*	100	0	9/2$^+$	M1+E2	−0.251 *11*	magnitude from T$_{1/2}$ and B(E2); sign from 2002Ka05. Other: abs(δ)≤0.5 from $\gamma(\theta)$ (1981Yo07); δ=−0.4 *3* or +2.1 *3* from $\gamma(\theta)$ (2002Ka05). Other Eγ: 979.0 *10* (1972Kr02).
1082.68	9/2$^+$	103.5[&b] *3*	10.9 *9*	979.04	11/2$^+$			E$_{\gamma}$,I$_{\gamma}$: from 1972St23.
		338.77 *9*	100 *3*	743.92	7/2$^+$	D+Q	−0.14[a] *7*	Other Eγ: 339.3 *10* (1972Kr02). Branching=100.0 *25* (2002Ka05), 100 *6* (1981Yo07), 100 *3* (1972St23).
		1082.6 *3*	33 *3*	0	9/2$^+$	E2+M1	>1.8	Other Eγ: 1084.0 *10* (1972Kr02). I$_{\gamma}$: average of 29 *4* (2002Ka05), 30.9 *15* (1981Yo07), 40.0 *23* (1972St23). δ: >1.8 from B(E2), T$_{1/2}$>2.8 ps, and adopted γ properties. Other δ: −0.21 or −2.47 (uncertainty unstated) from $\gamma(\theta)$ (2002Ka05), but first solution untenable if T$_{1/2}$>2.8 ps.
1297.23	9/2$^+$,13/2$^+$	318.16 *20*	47 *14*	979.04	11/2$^+$	D+Q	≥+0.07	unweighted average of Branching=61 *3* (1981Yo07), 32.1 *19* (1972St23).

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Coulomb excitation **2002Ka05,1981Yo07,1972St23 (continued)**

$\gamma(^{93}Nb)$ (continued)

E_i(level)	E_γ[†]	I_γ[‡]	E_f	J^π_f	Mult.[@]	δ[#]	Comments
							Possibly the 318γ is a multiplet As is observed In some other reaction studies.
							δ: if J=9/2.
1297.23	553.3 *4*	51 *4*	743.92	$7/2^+$			Branching=49 *4* (1981Yo07), 57 *6* (1972St23).
	1297.3 *3*	100 *4*	0	$9/2^+$	E2+M1	0.33 *+17−6*	Branching=100 *6* (1981Yo07), 100 *6* (1972St23). Mult.: D+Q transition; not E1+M2 from RUL. δ: from B(E2), $T_{1/2}$ and adopted branching.

[†] Weighted average from 1981Yo07 and 1972St23.

[‡] Relative photon branching normalized so Iγ=100 for strongest γ deexciting level; weighted average from 1972St23 and 1981Yo07, except as noted. Note that data do not agree within stated uncertainties for either the 1082γ or the 318γ and, for those, the unweighted average is adopted.

[#] From ^{16}O-$\gamma(\theta)$ (1981Yo07), except as noted.

[@] From $\gamma(\theta)$ and direct excitation of level in Coulomb excitation if $\Delta\pi$ given; from $\gamma(\theta)$ alone, otherwise.

[&] Excit for 104γ in 1981Yo07 does not agree with Coulomb excitation theory, and authors conclude that it is not a ^{93}Nb G. There is no evidence that the 104γ is a doublet in 1981Yo07. Authors estimate that, if a 104 keV ($9/2^+$ to $11/2^+$) transition exists, it constitutes <10% of 1083 level′s excitation cross section at E(^{16}O)=34 MeV. Consequently, evaluator indicates transition as tentative here and omits it from Adopted Gammas.

[a] A_2=+0.15 *3* in 1972St23, giving δ=−0.14 *7*. However, A_2=+0.02 *5* and A_4=+0.03 *8* in 1981Yo07, giving δ=+0.13 *11*. Source of discrepancy is not known, but positive sign is also inconsistent with δ(339γ) from (α,pγ) and, therefore, rejected.

[b] Placement of transition in the level scheme is uncertain.

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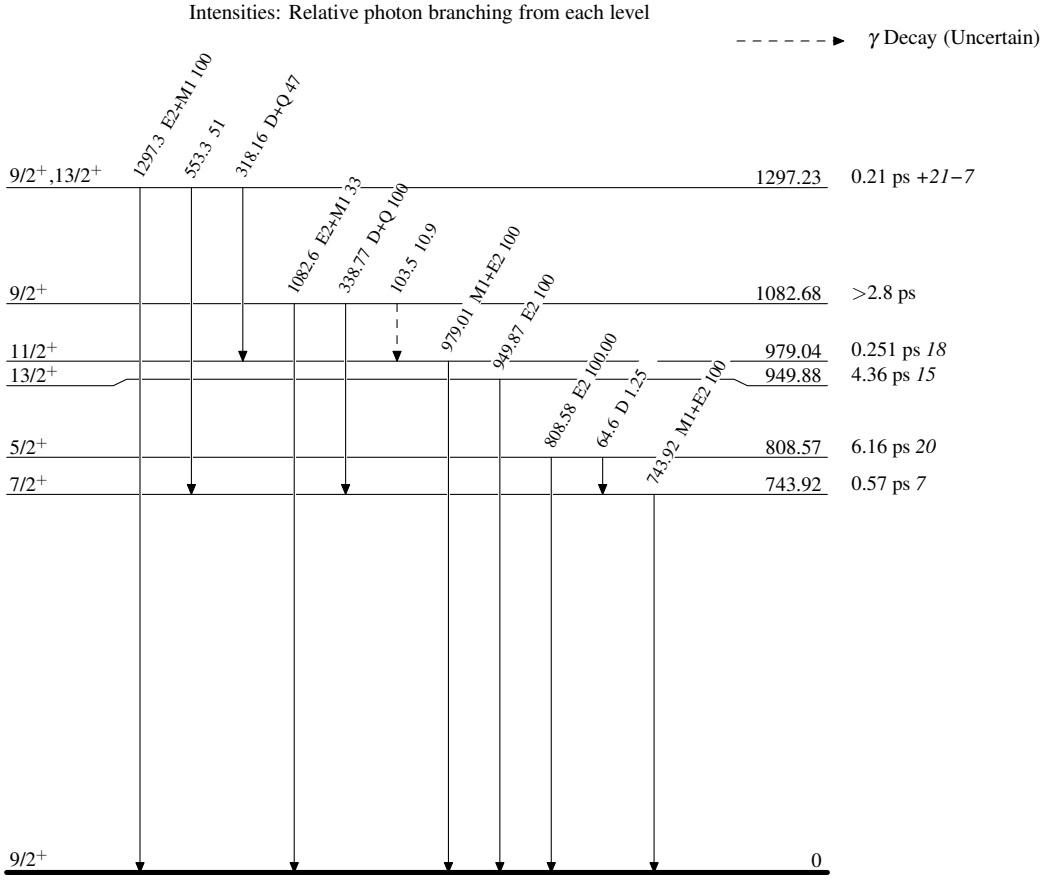
Legend

Level Scheme

Intensities: Relative photon branching from each level



$^{93}_{41}Nb_{52}$