^{146}Nd(α,nγ) 1989Si11

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh and Jun Chen	NDS 185, 2 (2022)	23-Aug-2022

1989Si11: ^{146}Nd(α,nγ),E=16-20.4 MeV. Measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma(\theta)$, ce, and excitation functions at the University of Jyvaskyla cyclotron facility using a Compton-suppressed HPGe detector and other HPGe detectors for γ-ray studies, and a swept-current magnetic-lens with a Si(Li) detector for conversion electrons.

Other:

1976SiZW: ^{146}Nd(α,nγ),E=15-22 MeV and ^{148}Nd(α,3nγ),E=20-35 MeV. Measured Eγ, Iγ, $\gamma\gamma$-coin, excitation functions, $\gamma(\theta)$ from 0° to 90° in steps of 15° and ce using Ge detectors for γ-rays and a 7-gap orange magnetic spectrometer at McMaster for conversion electrons. The (α,nγ) studies were carried out at McMaster tandem accelerator, while (α,3nγ) work was done at the Chalk River tandem accelerator lab. Main data reported at 18 MeV for (α,nγ), and at 33 MeV for (α,3nγ).

^{149}Sm Levels

E(level)†	Jπ‡	E(level)†	Jπ‡	E(level)†	Jπ‡
0.0	7/2$^-$	747.80 *10*	13/2$^-$	1343.54 *11*	(9/2$^-$,11/2)
22.50	5/2$^-$	789.54 *8*	11/2$^+$	1361.38 *13*	17/2$^-$
277.16 *6*	5/2$^-$	878.86 *9*	13/2$^+$	1362.66 *14*	17/2$^+$
285.90 *7*	9/2$^-$	925.56 *12*		1398.92 *10*	15/2$^-$
350.24 *6*	3/2$^-$	994.60 *12*		1412.63 *23*	(11/2,13/2,15/2)
398.86 *12*	(1/2 to 7/2)	1039.06 *12*	(3/2$^-$,5/2$^-$,7/2$^-$)	1574.78 *25*	13/2$^-$
528.60 *10*	3/2$^-$	1132.55 *23*	(9/2$^-$,11/2)	1670.66 *14*	19/2$^+$
558.53 *6*	5/2$^-$	1173.24 *13*	(≤11/2)	1684.82 *14*	
591.04 *6*	9/2$^-$	1192.85 *9*	(13/2$^+$)	1847.1 *3*	15/2$^-$
636.25 *7*	7/2$^-$	1237.91 *12*		1926.06 *17*	21/2$^-$
664.16 *7*	11/2$^-$	1240.53 *13*	15/2$^+$		
710.00 *9*	(3/2,5/2$^+$)	1308.68 *22*	11/2$^-$		

† From least-squares fit to Eγ data. Uncertainties of ten γ rays were increased from 0.1 to 0.3 keV for acceptable reduced χ^2=2.2 as compared to critical χ^2=1.8. Without this adjustment, reduced χ^2=11.

‡ As given in level-scheme Fig. 3 of 1989Si11.

^{146}Nd(α,nγ) 1989Si11 (continued)

$\gamma(^{149}Sm)$

A 296.1γ with Iγ=1.7 *2* seen only in singles, with no evidence in $\gamma\gamma$-coin data.
All data are from 1989Si11 unless otherwise stated.

E_γ	I_γ	E_i(level)	J_i^π	E_f	J_f^π	Mult.‡	δ‡	α#	Comments
22.50		22.50	$5/2^-$	0.0	$7/2^-$				E_γ: rounded value from the Adopted Gammas.
89.3 *1*	4.9 *2*	878.86	$13/2^+$	789.54	$11/2^+$	D			A_2=−0.39 *14*; A_4=−0.20 *29* δ(Q/D)=−0.12 *11* or −3.6 *+27−10* from $\gamma(\theta)$.
121.7 *1*	4.7 *2*	398.86	(1/2 to 7/2)	277.16	$5/2^-$				A_2=+0.19 *8*; A_4=+0.20 *13*
125.4 *1*	8.0 *3*	789.54	$11/2^+$	664.16	$11/2^-$				A_2=+0.40 *38*; A_4=+0.01 *5*
									A_2=+0.38 *7*; A_4=+0.13 *7* (1976SiZW)
x168.5 *1*	2.7 *2*								
x170.7 *1*	1.4 *2*								
198.6 *1*	53.6 *18*	789.54	$11/2^+$	591.04	$9/2^-$	E1		0.0431 *6*	α(K)exp=0.044 *7* (1976SiZW) α(K)=0.0366 *5*; α(L)=0.00508 *7*; α(M)=0.001085 *15* Mult.: from α(K)exp (1976SiZW).
208.4 *1*	1.0 *2*	558.53	$5/2^-$	350.24	$3/2^-$	M1+E2	−0.45 *15*	0.210 *4*	A_2=−0.29 *17*; A_4=−0.22 *13* α(K)exp=0.14 *3* (1976SiZW) α(K)=0.175 *5*; α(L)=0.0278 *13*; α(M)=0.00605 *32* Mult.: from α(K)exp (1976SiZW).
214.8 *1*	57.4 *20*	878.86	$13/2^+$	664.16	$11/2^-$	E1		0.0350 *5*	A_2=−0.20 *3*; A_4=−0.01 *4*; α(K)exp=0.023 *3* α(K)=0.0297 *4*; α(L)=0.00411 *6*; α(M)=0.000877 *12* δ(M2/E1)=+0.02 *2* from $\gamma(\theta)$.
x238.3 *1*	9.9 *4*								A_2=+0.25 *5*; A_4=+0.03 *8*
254.6 *1*	6.2 *2*	277.16	$5/2^-$	22.50	$5/2^-$	M1+E2	+0.20 *+8−6*	0.1241 *20*	A_2=+0.29 *2*; A_4=−0.04 *3*; α(K)exp=0.067 *12* α(K)=0.1051 *19*; α(L)=0.01493 *23*; α(M)=0.00321 *5*
266.1 *1*	10.1 *4*	1574.78	$13/2^-$	1308.68	$11/2^-$	M1+E2	−0.50 *5*	0.1054 *18*	A_2=−0.79 *3*; A_4=+0.04 *4*; α(K)exp=0.071 *7* α(K)exp=0.098 *12* (1976SiZW) α(K)=0.0882 *16*; α(L)=0.01354 *20*; α(M)=0.00293 *4*
272.3 *1*	4.2 *6*	1847.1	$15/2^-$	1574.78	$13/2^-$	(M1+E2)	−0.7 *2*	0.095 *4*	A_2=−0.30 *11*; A_4=−0.70 *20* A_2=−0.29 *4*; A_4=−0.04 *5* (1976SiZW) Complex peak.
x275.6 *1*	5.2 *7*					D+Q			A_2=−0.63 *12*; A_4=−0.34 *23*
277.2 *1*	36.8 *16*	277.16	$5/2^-$	0.0	$7/2^-$	D+Q	−0.08 *+1−2*		A_2=−0.01 *1*; A_4=0.00 *2* A_2=−0.060 *13*; A_4=−0.016 *17* (1976SiZW)
281.4 *1*	3.8 *4*	558.53	$5/2^-$	277.16	$5/2^-$	D(+Q)	−0.07 *+22−17*		A_2=+0.17 *17*; A_4=+0.04 *15*
285.9& *1*	191&	285.90	$9/2^-$	0.0	$7/2^-$	M1(+E2)	<0.11	0.0917 *13*	A_2=−0.11 *2*; A_4=−0.02 *4*; α(K)exp=0.067 *4* α(K)=0.0780 *11*; α(L)=0.01084 *15*; α(M)=0.002325 *33* 1989Si11 suggest a weak component of 285.9γ from a 1684 level.
285.9& *1*	32&	1684.82		1398.92	$15/2^-$				
x301.9 *1*	1.4 *2*								A_2=+0.43 *9*; A_4=+0.68 *14*
305.1 *1*	2.1 *2*	591.04	$9/2^-$	285.90	$9/2^-$	M1(+E2)	+0.15 *15*	0.0768 *18*	A_2=+0.60 *3*; A_4=+0.15 *5*; α(K)exp=0.079 *15*

From ENSDF

^{146}Nd(α,nγ) 1989Si11 (continued)

$\gamma(^{149}Sm)$ (continued)

E_γ	I_γ	E_i(level)	J_i^π	E_f	J_f^π	Mult.‡	δ‡	α#	Comments
									α(K)=0.0652 *17*; α(L)=0.00910 *13*; α(M)=0.001953 *28* δ: other: <0.6 from α(K)exp.
309.4 *1*	6.1 *3*	1670.66	19/2$^+$	1361.38	17/2$^-$	D(+Q)	+0.07 *+5−6*	0.014	A_2=−0.14 *11*; A_4=+0.09 *19*
314.0 *1*	6.5 *3*	1192.85	(13/2$^+$)	878.86	13/2$^+$	D(+Q)	+0.4 *5*		A_2=+0.40 *8*; A_4=−0.04 *12*
327.7 *1*	30.4 *11*	350.24	3/2$^-$	22.50	5/2$^-$	M1(+E2)	−0.03 *4*	0.0640 *9*	A_2=−0.02 *1*; A_4=−0.03 *2*; α(K)exp=0.0404 *35* α(K)=0.0545 *8*; α(L)=0.00752 *11*; α(M)=0.001613 *23* δ: other: 1.5 *5* from α(K)exp.
[x]339.5 *1*	12.0 *5*								
350.4 *1*	5.0 *7*	350.24	3/2$^-$	0.0	7/2$^-$				A_2=−0.12 *6*; A_4=−0.01 *8* (1976SiZW) Mult.: ΔJ=1, D from $\gamma(\theta)$ data inconsistent with expected ΔJ=2, E2.
351.1† *1*	3.7 *7*	636.25	7/2$^-$	285.90	9/2$^-$				Poor fit. Level-energy difference=350.4.
359.8 *1*	3.0 *2*	710.00	(3/2,5/2$^+$)	350.24	3/2$^-$				A_2=+0.18 *10*; A_4=+0.17 *16* δ(Q/D)=+0.14 *+38−28* or +2.5 *+38−14* from $\gamma(\theta)$.
378.3 *1*	5.9 *3*	664.16	11/2$^-$	285.90	9/2$^-$	D(+Q)	0.00 *+2−3*		A_2=−0.22 *3*; A_4=+0.01 *5*
383.7 *1*	4.1 *4*	1173.24	(≤11/2)	789.54	11/2$^+$				
385.2† *1*	2.2 *5*	1132.55	(9/2$^-$,11/2)	747.80	13/2$^-$				
403.4 *1*	4.9 *4*	1192.85	(13/2$^+$)	789.54	11/2$^+$	M1+E2	−1.1 *8*	0.030 *7*	A_2=−0.78 *8*; A_4=−0.21 *15* A_2=−0.68 *7*; A_4=+0.20 *8*; α(K)exp=0.016 *3* (1976SiZW) α(K)=0.025 *6*; α(L)=0.0039 *4*; α(M)=0.00085 *7* Mult.: from α(K)exp (1976SiZW).
430.0 *1*	5.6 *4*	1670.66	19/2$^+$	1240.53	15/2$^+$	E2		0.01937 *27*	A_2=+0.24 *6*; A_4=−0.09 *10* α(K)exp=0.021 *3* (1976SiZW) α(K)=0.01571 *22*; α(L)=0.00287 *4*; α(M)=0.000630 *9* Mult.: from α(K)exp (1976SiZW) and $\gamma(\theta)$ in 1989Si11.
432.8 *1*	8.9 *4*	710.00	(3/2,5/2$^+$)	277.16	5/2$^-$				Complex peak due to a line from ^{148}Sm.
[x]435.5 *1*	4.2 *3*								
461.9 *1*	100.0	747.80	13/2$^-$	285.90	9/2$^-$	E2		0.01589 *22*	A_2=+0.355 *10*; A_4=−0.112 *17*; α(K)exp=0.0132 *9* α(K)exp=0.014 *3* (1976SiZW) α(K)=0.01296 *18*; α(L)=0.002291 *32*; α(M)=0.000502 *7*
483.8 *1*	20.1 *8*	1362.66	17/2$^+$	878.86	13/2$^+$	E2		0.01401 *20*	A_2=+0.36 *16*; A_4=−0.09 *3*; α(K)exp=0.012 *2* α(K)exp=0.015 *3* (1976SiZW) α(K)=0.01147 *16*; α(L)=0.001989 *28*; α(M)=0.000435 *6*
492.6 *1*	24.6 *10*	1240.53	15/2$^+$	747.80	13/2$^-$	E1		0.00446 *6*	A_2=−0.23 *14*; A_4=+0.01 *2*; α(K)exp=0.0073 *9* α(K)=0.00382 *5*; α(L)=0.000506 *7*; α(M)=0.0001079 *15* δ(M2/E1)=0.00 *9* from $\gamma(\theta)$.
520.7† *1*	4.6 *3*	1398.92	15/2$^-$	878.86	13/2$^+$	D			A_2=−0.54 *30*; A_4=+0.3 *4* (1976SiZW) E_γ: level-energy difference=520.1. Mult.: from $\gamma(\theta)$ (1976SiZW).
528.6[@] *1*	15.5[@] *6*	528.60	3/2$^-$	0.0	7/2$^-$				
528.6[@] *1*	15.5[@] *6*	1192.85	(13/2$^+$)	664.16	11/2$^-$				
536.1 *1*	10.6 *5*	558.53	5/2$^-$	22.50	5/2$^-$	D			A_2=−0.09 *4*; A_4=+0.003 *4* (1976SiZW) Mult.: from $\gamma(\theta)$ (1976SiZW).

From ENSDF

$^{149}_{62}Sm_{87}$-3

^{146}Nd(α,nγ) 1989Si11 (continued)

γ(^{149}Sm) (continued)

E_γ	I_γ	E_i(level)	J_i^π	E_f	J_f^π	Mult.‡	δ‡	α#	Comments
538		1847.1	15/2$^-$	1308.68	11/2$^-$				
x539.9 *1*	6.0 *4*								
553.6† *1*	9.0 *15*	1343.54	(9/2$^-$,11/2)	789.54	11/2$^+$				Complex line.
558.3 *1*	12.1 *15*	558.53	5/2$^-$	0.0	7/2$^-$	(M1+E2)	+1.6 *11*	0.0115 *35*	A_2=−0.43 *8*; A_4=−0.07 *13*
563.4 *1*	4.5 *14*	1926.06	21/2$^-$	1362.66	17/2$^+$				
568.6 *1*	22.2 *20*	591.04	9/2$^-$	22.50	5/2$^-$	(Q)			A_2=+0.24 *2*; A_4=+0.04 *4*
x577.4 *1*	1.2 *4*								
x582.9 *1*	3.9 *6*								
591.1 *1*	92.6 *41*	591.04	9/2$^-$	0.0	7/2$^-$	E2+M1		0.0112 *29*	α(K)exp=0.0060 *9* (1989Si11); α(K)exp=0.0082 *15* (1976SiZW) α(K)=0.0095 *26*; α(L)=0.00137 *26*; α(M)=0.00030 *5*
596.1† *1*	12.0 *4*	1343.54	(9/2$^-$,11/2)	747.80	13/2$^-$				
613.7@ *1*	37.2@ *15*	636.25	7/2$^-$	22.50	5/2$^-$				
613.7@ *1*	37.2@ *15*	1361.38	17/2$^-$	747.80	13/2$^-$				
623.8† *1*	2.0 *5*	1412.63	(11/2,13/2,15/2)	789.54	11/2$^+$				A_2=+0.21 *33*; A_4=+0.31 *54*
636.2 *1*	16.3 *13*	636.25	7/2$^-$	0.0	7/2$^-$	M1+E2	−0.30 *+16−18*	0.0114 *5*	A_2=+0.14 *4*; A_4=−0.19 *7* α(K)exp=0.0095 *15* (1976SiZW) α(K)=0.0097 *5*; α(L)=0.00132 *5*; α(M)=0.000283 *11* Mult.: from α(K)exp (1976SiZW).
644.9† *1*	2.6 *4*	1308.68	11/2$^-$	664.16	11/2$^-$				
648.4 *1*	3.9 *5*	925.56		277.16	5/2$^-$				
651.1 *1*	2.3 *4*	1398.92	15/2$^-$	747.80	13/2$^-$				
x656.0 *1*	2.2 *7*								
664.1& *1*	120&	664.16	11/2$^-$	0.0	7/2$^-$	E2		0.00625 *9*	α(K)exp=0.0044 *9* α(K)=0.00522 *7*; α(L)=0.000809 *11*; α(M)=0.0001754 *25*
664.1&† *1*	15&	1412.63	(11/2,13/2,15/2)	747.80	13/2$^-$				
x668.5 *1*	4.5 *7*								
x673.4 *1*	3.1 *7*								
708.7 *1*	35.4 *19*	994.60		285.90	9/2$^-$				A_2=+0.13 *2*; A_4=+0.25 *3*
734.7 *1*	21.5 *10*	1398.92	15/2$^-$	664.16	11/2$^-$				
752.5 *1*	8.8 *12*	1343.54	(9/2$^-$,11/2)	591.04	9/2$^-$				A_2=+0.01 *6*; A_4=+0.06 *9*
761.9 *1*	5.0 *4*	1039.06	(3/2$^-$,5/2$^-$,7/2$^-$)	277.16	5/2$^-$	D+Q			A_2=−0.17 *7*; A_4=−0.26 *12*
846.2† *1*	20.4 *9*	1132.55	(9/2$^-$,11/2)	285.90	9/2$^-$				Complex γ, contaminated by a line in ^{56}Fe.
952.0 *1*	8.4 *4*	1237.91		285.90	9/2$^-$				A_2=+0.05 *6*; A_4=−0.01 *10*
x955.4 *1*	4.5 *3*								
1022.4† *1*	7.9 *6*	1308.68	11/2$^-$	285.90	9/2$^-$	(M1+E2)	−2.8 *+3−4*	0.00253 *5*	A_2=−0.47 *4*; A_4=+0.15 *7*

From ENSDF

$^{149}_{62}Sm_{87}$-4

^{146}Nd(α,nγ) 1989Si11 (continued)

$\gamma(^{149}Sm)$ (continued)

† Poor fit in the level scheme. Uncertainty increased to 0.3 keV for fitting purpose.
‡ From 1989Si11 based on their $\gamma(\theta)$ and ce data, unless otherwise stated. For large δ(Q/D) values, (M1+E2) is assigned when ce data are not available, based on no evidence of levels of long half-lives which could decay by transitions of mult=E1+M2.
# Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on γ-ray energies, assigned multipolarities, and mixing ratios, unless otherwise specified.
@ Multiply placed with undivided intensity.
& Multiply placed with intensity suitably divided.
x γ ray not placed in level scheme.

From ENSDF

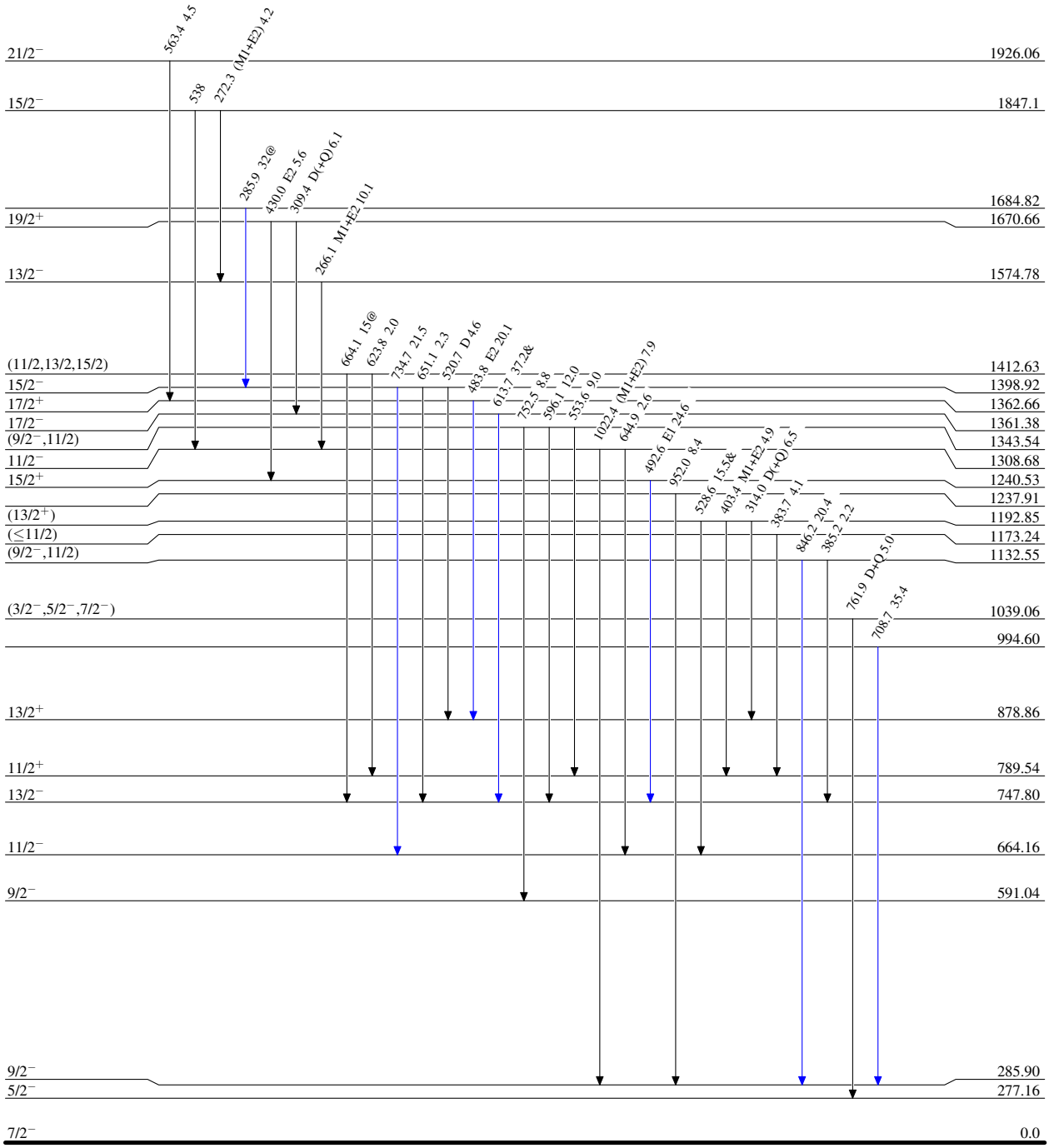
$^{149}_{62}Sm_{87}$-5

^{146}Nd(α,nγ) 1989Si11

Level Scheme

Intensities: Relative I_γ
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided

Legend
$I_\gamma < 2\% \times I_\gamma^{max}$
$I_\gamma < 10\% \times I_\gamma^{max}$
$I_\gamma > 10\% \times I_\gamma^{max}$



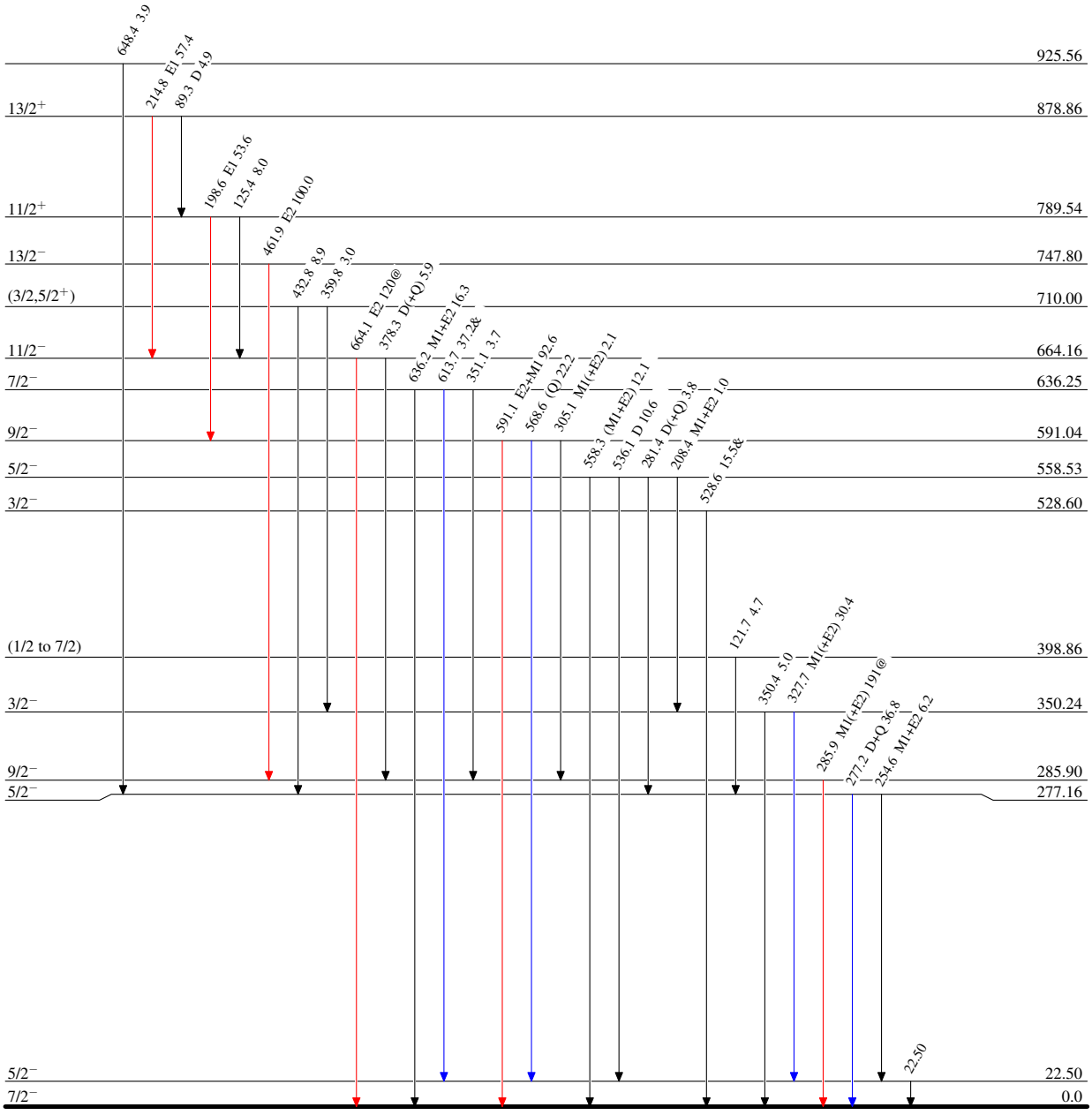
$^{149}_{62}Sm_{87}$

^{146}Nd(α,nγ) 1989Si11

Level Scheme (continued)

Intensities: Relative I_γ
& Multiply placed: undivided intensity given
@ Multiply placed: intensity suitably divided

Legend
$I_\gamma < 2\% \times I_\gamma^{max}$
$I_\gamma < 10\% \times I_\gamma^{max}$
$I_\gamma > 10\% \times I_\gamma^{max}$



$^{149}_{62}Sm_{87}$