^{144}Sm(^{19}F,3nγ) 2012Wa17,2001Yi03,1995Su11

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	N. Nica	NDS 176, 1 (2021)	1-May-2021

2012Wa17 was compiled for XUNDL database by E. Thiagalingam and B. Singh, and 2001Yi03 by B. Singh (both compilers from McMaster).

2012Wa17, 2001Yi03, and 1995Su11 are from the same experimental group using the same reaction and similar experimnetal setups.

2012Wa17: E(^{19}F)=90 and 106 MeV delivered by the HI-13 tandem accelerator at CIAE in Beijing. Gamma rays detected by an array of eleven Compton-suppressed HPGe detectors. Measured reaction products, Eγ, Iγ, $\gamma\gamma$-coin, DCO. Deduced level energies, J, π, positive parity high-spin bands, isomeric state, configurations. Comparison with previous measurements.

2001Yi03: E(^{19}F)=90 MeV. Measured Eγ, Iγ, $\gamma\gamma$, and $\gamma\gamma(\theta)$(DCO) using the array of 11 Compton-suppressed HPGe detectors.

1995Su11: E(^{19}F)=90 MeV. Metallic ^{144}Sm target, 88.6% enrichment, rolled to a thickness of ≈2 mg/cm^2 with an evaporated Pb backing having a thickness of 1.0 mg/cm^2. Excitation functions and residual radioactivity were measured in the energy region from E(^{19}F)=85 MeV to 105 MeV. $\gamma\gamma$ coincidences measured using 5 HPGe BGO Compton-suppressed spectrometers and a 14-element ball of BGO detectors. Same reference as 1995Su07.

The results of all three refences are in essential agreement, with those of 2012Wa17 including those of 2001Yi03, which include those of 1995Su11. Basically 1995Su11 found bands A and a, extended by 2001Yi03 with bands B and b, and extended once more by 2012Wa17 with bands C, D and d. The level scheme is that of 2012Wa17.

Additional information 1.

^{160}Lu Levels

E(level)[†e]	J$^\pi$[‡]	Comments
0.0+x[c]	(6$^+$)	Additional information 2.
161.3+x[d] *10*	(7$^+$)	
323.4+x[c] *5*	(8$^+$)	
463.0+x[d] *8*	(9$^+$)	
558.5+x[@] *14*	(9$^-$)	
625.0+x[b] *10*	(8$^+$)	
669.5+x *14*	(10$^+$)	Possible isomeric state based on $\pi h_{11/2}\otimes\nu h_{9/2}$ configuration (2012Wa17).
705.7+x[c] *7*	(10$^+$)	
734.1+x[#] *14*	(10$^-$)	
810.6+x[@] *13*	(11$^-$)	
857.8+x[d] *8*	(11$^+$)	
933.2+x[b] *9*	(10$^+$)	
1058.6+x[#] *13*	(12$^-$)	
1160.6+x[c] *8*	(12$^+$)	
1217.8+x[@] *13*	(13$^-$)	
1264.3+x? *10*	(13$^+$)	
1337.8+x[d] *9*	(13$^+$)	
1360.7+x[b] *8*	(12$^+$)	
1522.4+x[#] *13*	(14$^-$)	
1661.1+x[c] *9*	(14$^+$)	
1730.8+x? *11*	(15$^+$)	
1754.8+x[@] *13*	(15$^-$)	
1854.4+x[b] *9*	(14$^+$)	
1898.3+x[d] *9*	(15$^+$)	
2085.4+x[#] *12*	(16$^-$)	
2371.7+x[@] *12*	(17$^-$)	
2422.4+x[b] *10*	(16$^+$)	

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^{144}Sm(^{19}F,3nγ) 2012Wa17,2001Yi03,1995Su11 (continued)

^{160}Lu Levels (continued)

E(level)[†e]	Jπ[‡]	E(level)[†e]	Jπ[‡]	E(level)[†e]	Jπ[‡]	E(level)[†e]	Jπ[‡]
2727.5+x[#] *12*	(18$^-$)	3426.7+x[#] *13*	(20$^-$)	4287.9+x[&] *12*	(22$^+$)	5311.7+x[a] *13*	(25$^+$)
2957.0+x[a] *12*	(17$^+$)	3657.0+x[b] *12*	(20$^+$)	4392.0+x[b] *13*	(22$^+$)	5379.8+x[@] *14*	(25$^-$)
3024.2+x[b] *11*	(18$^+$)	3682.9+x[&] *12*	(20$^+$)	4520.1+x[@] *13*	(23$^-$)	5695.0+x[&] *13*	(26$^+$)
3040.8+x[@] *13*	(19$^-$)	3752.2+x[@] *13*	(21$^-$)	4608.8+x[a] *12*	(23$^+$)		
3276.0+x[&] *12*	(18$^+$)	3975.0+x[a] *12*	(21$^+$)	4961.4+x[&] *13*	(24$^+$)		
3416.6+x[a] *12*	(19$^+$)	4175.5+x[#] *13*	(22$^-$)	5001.8+x[#] *14*	(24$^-$)		

[†] From least-squares fit to Eγ′s assuming 0.5 keV uncertainty for all Eγ′s.

[‡] From 2012Wa17 (in agrement with those previously established by 2001Yi03 and 1995Su11 for the common parts) based on DCO-based multipolarities and other specific arguments. For the negative parity yrast-band structure, J^π assignments were based on general considerations of rotational-band structure and systematics in neighboring isotopes and odd-odd nuclides. Analysis of the alignments and the associated sum rule (assuming that the proton and neutron contributions add linearly) led those authors to propose the listed values. For the positive-parity bands, the J^π values are based on the γ-decay patterns and considerations of rotational-band structure, including the expected increase in J^π values with increasing excitation energy.

[#] Band(A): $\pi h_{11/2}\otimes\nu i_{13/2}$,α=0.

[@] Band(a): $\pi h_{11/2}\otimes\nu i_{13/2}$,α=1.

[&] Band(B): $\pi 7/2[523]\otimes\nu(3/2[521]\otimes\nu i^2_{13/2})$,α=0. 7/2[523] from $h_{11/2}$ and 3/2[521] from $h_{9/2}$ orbitals.

[a] Band(b): $\pi 7/2[523]\otimes\nu(3/2[521]\otimes\nu i^2_{13/2})$,α=1. 7/2[523] from $h_{11/2}$ and 3/2[521] from $h_{9/2}$ orbitals.

[b] Band(C): $\pi 1/2[411]\otimes\nu 1/2[660]$,α=0. 1/2[411] from $d_{3/2}$ and 1/2[660] from $i_{13/2}$ orbitals.

[c] Band(D): $\pi 5/2[402]\otimes\nu 1/2[660]$,α=0. 5/2[402] from $d_{5/2}$ and 1/2[660] from $i_{13/2}$ orbitals.

[d] Band(d): $\pi 5/2[402]\otimes\nu 1/2[660]$,α=1. 5/2[402] from $d_{5/2}$ and 1/2[660] from $i_{13/2}$ orbitals.

[e] If ΔEγ not given, ±0.50 keV assumed for least-squares fitting.

γ(^{160}Lu)

The DCO ratio values given in the table are those reported by 2001Yi03 (the only exception of value reported by 2012Wa17 is noted separately). No multipolarities were explicitly adopted by authors (DCO ratios are ≈0.5 for pure dipole transitions and ≈1 for stretched quadrupole transitions). They use this information in assigning J^π values to the various proposed band members.

E_γ[†]	I_γ[‡]	E_i(level)	J^π_i	E_f	J^π_f	Mult.	Comments
75.7		810.6+x	(11$^-$)	734.1+x	(10$^-$)		
140.7		3416.6+x	(19$^+$)	3276.0+x	(18$^+$)		
141.1		810.6+x	(11$^-$)	669.5+x	(10$^+$)	D	DCO≈0.6 (2012Wa17).
152.5		857.8+x	(11$^+$)	705.7+x	(10$^+$)		
159.1	54.7	1217.8+x	(13$^-$)	1058.6+x	(12$^-$)	D	DCO=0.65 *5*.
175.7		734.1+x	(10$^-$)	558.5+x	(9$^-$)		
177.5		1337.8+x	(13$^+$)	1160.6+x	(12$^+$)		
192.7		1854.4+x	(14$^+$)	1661.1+x	(14$^+$)		
200.0		1360.7+x	(12$^+$)	1160.6+x	(12$^+$)		
227.5		933.2+x	(10$^+$)	705.7+x	(10$^+$)		
232.3	52.8	1754.8+x	(15$^-$)	1522.4+x	(14$^-$)	D	DCO=0.55 *4*.
243.1		705.7+x	(10$^+$)	463.0+x	(9$^+$)		
247.2	100	1058.6+x	(12$^-$)	810.6+x	(11$^-$)	D	DCO=0.81 *4*.
252.0	97.5	810.6+x	(11$^-$)	558.5+x	(9$^-$)	Q	DCO=0.96 *7*.
266.0	28.0	3682.9+x	(20$^+$)	3416.6+x	(19$^+$)	D	DCO=0.63 *8*.
286.0	47.3	2371.7+x	(17$^-$)	2085.4+x	(16$^-$)	D	DCO=0.54 *5*.
292.0	21.6	3975.0+x	(21$^+$)	3682.9+x	(20$^+$)	D	DCO=0.46 *6*.

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^{144}Sm(^{19}F,3nγ) 2012Wa17,2001Yi03,1995Su11 (continued)

γ(^{160}Lu) (continued)

E_γ †	I_γ ‡	E_i(level)	J_i^π	E_f	J_f^π	Mult.	Comments
301.7		463.0+x	(9^+)	161.3+x	(7^+)		
302.3		1160.6+x	(12^+)	857.8+x	(11^+)		
304.5	76.7	1522.4+x	(14^-)	1217.8+x	(13^-)	D	E_γ: from 2001Yi03; 2012Wa17 gives 304. DCO=0.78 *5*.
308.2		933.2+x	(10^+)	625.0+x	(8^+)		
312.9	20.0	4287.9+x	(22^+)	3975.0+x	(21^+)	D	DCO=0.47 *26*.
313.1	23.8	3040.8+x	(19^-)	2727.5+x	(18^-)	D	DCO=0.61 *6*.
318.0		3975.0+x	(21^+)	3657.0+x	(20^+)		
320.5	18.2	4608.8+x	(23^+)	4287.9+x	(22^+)	D	DCO=0.55 *10*.
323.4		323.4+x	(8^+)	0.0+x	(6^+)		
x324#							
325.4	8.2	1058.6+x	(12^-)	734.1+x	(10^-)	Q	DCO=1.3 *5*. $I\gamma(326)/I\gamma(248)$=0.08 *1*.
325.5	12.7	3752.2+x	(21^-)	3426.7+x	(20^-)	D	DCO=0.64 *8*.
330.1	59.8	2085.4+x	(16^-)	1754.8+x	(15^-)	D	DCO=0.74 *5*.
344.2	9.3	4520.1+x	(23^-)	4175.5+x	(22^-)	D	DCO=0.65 *15*.
349.8	12.5	5311.7+x	(25^+)	4961.4+x	(24^+)	D	DCO=0.67 *28*.
352.3	21.6	4961.4+x	(24^+)	4608.8+x	(23^+)	D	DCO=0.54 *11*.
355.5	37.2	2727.5+x	(18^-)	2371.7+x	(17^-)	D	DCO=0.71 *6*.
382.3		705.7+x	(10^+)	323.4+x	(8^+)		
382.5	8.5	5695.0+x	(26^+)	5311.7+x	(25^+)	D	DCO=0.65 *17*.
385.5	27.5	3426.7+x	(20^-)	3040.8+x	(19^-)	D	DCO=0.58 *7*.
392.4		3416.6+x	(19^+)	3024.2+x	(18^+)		
394.3		857.8+x	(11^+)	463.0+x	(9^+)		
407.0	50.0	1217.8+x	(13^-)	810.6+x	(11^-)	Q	DCO=1.25 *11*. $I\gamma(408)/I\gamma(160)$=0.91 *9*.
407.2		3682.9+x	(20^+)	3276.0+x	(18^+)		
423.1	12.8	4175.5+x	(22^-)	3752.2+x	(21^-)	D	DCO=0.71 *12*.
427.5		1360.7+x	(12^+)	933.2+x	(10^+)		
454.9		1160.6+x	(12^+)	705.7+x	(10^+)		
459.5		3416.6+x	(19^+)	2957.0+x	(17^+)		
463.9	21.0	1522.4+x	(14^-)	1058.6+x	(12^-)	Q	DCO=0.94 *36*. $I\gamma(464)/I\gamma(304)$=0.27 *3*.
480.3		1337.8+x	(13^+)	857.8+x	(11^+)		
481.7		5001.8+x	(24^-)	4520.1+x	(23^-)		
x484#							
493.9		1854.4+x	(14^+)	1360.7+x	(12^+)		
x494#							
499.8		1661.1+x	(14^+)	1160.6+x	(12^+)		
503.2		1360.7+x	(12^+)	857.8+x	(11^+)		
516.6		1854.4+x	(14^+)	1337.8+x	(13^+)		E_γ: 524.6 listed in Fig. 1 (Level scheme drawing of ^{160}Lu) of 2012Wa17 as decaying this level to 13^+, 1337.8+x level is likely to be a graphical error because it differs significantly from ΔE(levels)=516.6 and the exact 524.6γ is present twice for the similar interband transition from the upper level (16^+, 2522+x). Consequently the evaluator adopts the ΔE(levels) value.
x517#							
524.6		2422.4+x	(16^+)	1898.3+x	(15^+)		
537.1	63.9	1754.8+x	(15^-)	1217.8+x	(13^-)	Q	DCO=1.21 *9*. $I\gamma(537)/I\gamma(233)$=1.2 *2*.
558.3	11.0	3975.0+x	(21^+)	3416.6+x	(19^+)	Q	DCO=1.4 *3*. $I\gamma(559)/I\gamma(292)$=0.51 *10*.
561.0		1898.3+x	(15^+)	1337.8+x	(13^+)		
563.1	28.7	2085.4+x	(16^-)	1522.4+x	(14^-)	Q	DCO=1.36 *19*. $I\gamma(564)/I\gamma(331)$=0.48 *6*.

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^{144}Sm(^{19}F,3nγ) 2012Wa17,2001Yi03,1995Su11 (continued)

γ(^{160}Lu) (continued)

E_γ [†]	I_γ [‡]	E_i(level)	J_i^π	E_f	J_f^π	Mult.	Comments
567.5		2422.4+x	(16$^+$)	1854.4+x	(14$^+$)		
[x]568[#]							
590.1		1854.4+x	(14$^+$)	1264.3+x?	(13$^+$)		
601.8		3024.2+x	(18$^+$)	2422.4+x	(16$^+$)		
[x]602[#]							
605.3	11.8	4287.9+x	(22$^+$)	3682.9+x	(20$^+$)	Q	DCO=1.26 *27*. Iγ(606)/Iγ(313)=0.59 *14*.
617.1	54.2	2371.7+x	(17$^-$)	1754.8+x	(15$^-$)	Q	DCO=1.06 *9*. Iγ(617)/Iγ(286)=1.2 *2*.
632.8		3657.0+x	(20$^+$)	3024.2+x	(18$^+$)		
633.6	15.8	4608.8+x	(23$^+$)	3975.0+x	(21$^+$)	Q	DCO=1.4 *3*. Iγ(634)/Iγ(321)=0.87 *27*.
642.3	37.1	2727.5+x	(18$^-$)	2085.4+x	(16$^-$)	Q	DCO=1.12 *15*. Iγ(643)/Iγ(356)=1.1 *1*.
669.2	37.0	3040.8+x	(19$^-$)	2371.7+x	(17$^-$)	Q	DCO=1.16 *15*. Iγ(670)/Iγ(313)=1.6 *2*.
674.0	14.9	4961.4+x	(24$^+$)	4287.9+x	(22$^+$)	Q	DCO=1.22 *23*. Iγ(674)/Iγ(353)=0.69 *21*.
688.9	17.1	3416.6+x	(19$^+$)	2727.5+x	(18$^-$)	D	DCO=0.64 *16*. The DCO ratio indicates a dipole transition. From its competition with the intraband transitions, 2001Yi03 conclude that it is E1 and, thus, that the two bands involved have opposite parity.
691.6		2422.4+x	(16$^+$)	1730.8+x?	(15$^+$)		
699.3	24.0	3426.7+x	(20$^-$)	2727.5+x	(18$^-$)	Q	DCO=1.4 *3*. Iγ(700)/Iγ(385)=0.87 *11*.
702.6	11.7	5311.7+x	(25$^+$)	4608.8+x	(23$^+$)	Q	DCO=1.3 *3*. Iγ(703)/Iγ(351)=0.94 *19*.
711.7	19.6	3752.2+x	(21$^-$)	3040.8+x	(19$^-$)	Q	DCO=1.04 *17*. Iγ(712)/Iγ(326)=1.5 *2*.
734.4	7.4	5695.0+x	(26$^+$)	4961.4+x	(24$^+$)	Q	DCO=1.2 *5*. Iγ(733)/Iγ(383)=0.87 *26*.
735.0		4392.0+x	(22$^+$)	3657.0+x	(20$^+$)		
748.4	10.6	4175.5+x	(22$^-$)	3426.7+x	(20$^-$)	Q	DCO=1.20 *16*. Iγ(749)/Iγ(424)=0.83 *12*.
768.5	14.2	4520.1+x	(23$^-$)	3752.2+x	(21$^-$)	Q	DCO=1.20 *16*. Iγ(769)/Iγ(345)=1.5 *3*.
826.2		5001.8+x	(24$^-$)	4175.5+x	(22$^-$)		
859.7	7.1	5379.8+x	(25$^-$)	4520.1+x	(23$^-$)	Q	DCO=1.30 *23*.
871.6		2957.0+x	(17$^+$)	2085.4+x	(16$^-$)		
904.6	17.1	3276.0+x	(18$^+$)	2371.7+x	(17$^-$)	D	DCO=0.55 *12*. The DCO ratio indicates a dipole transition. From its competition with the intraband transitions, 2001Yi03 conclude that it is E1 and, thus, that the two bands involved have opposite parity.

[†] From 2012Wa17 (the most extensive and updated set).
[‡] From 2001Yi03 (2012Wa17 and 1995Su11 give no γ intensity data). The branching ratios given in comments are also from 2001Yi03.
[#] γ reported by 2001Yi03 to originate from the four-quasiparticle band, but was not otherwise placed by those authors.
[x] γ ray not placed in level scheme.

^{144}Sm(^{19}F,3nγ) 2012Wa17,2001Yi03,1995Su11

Level Scheme

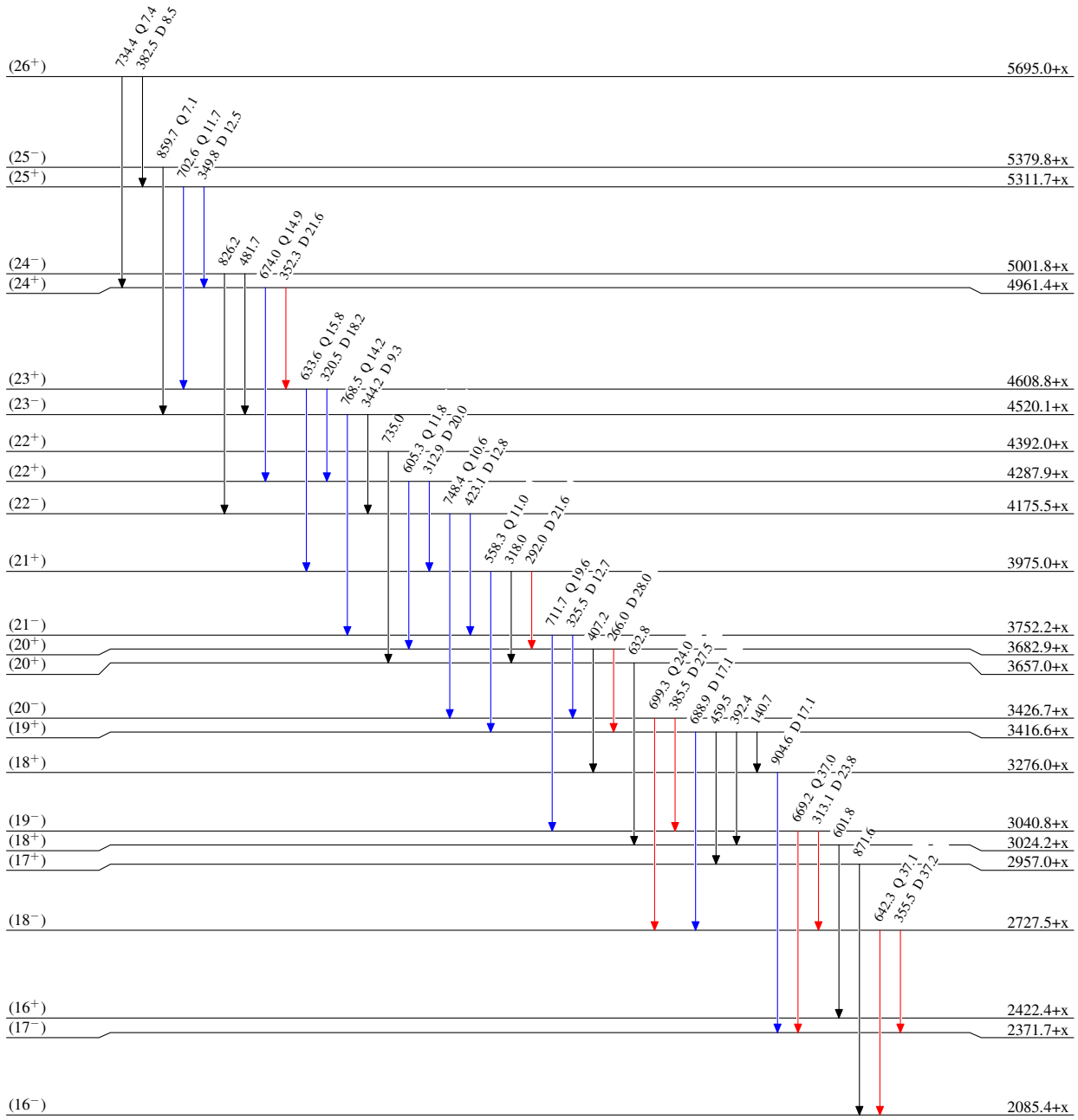
Intensities: Relative I_γ

Legend

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

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

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



$^{160}_{71}Lu_{89}$

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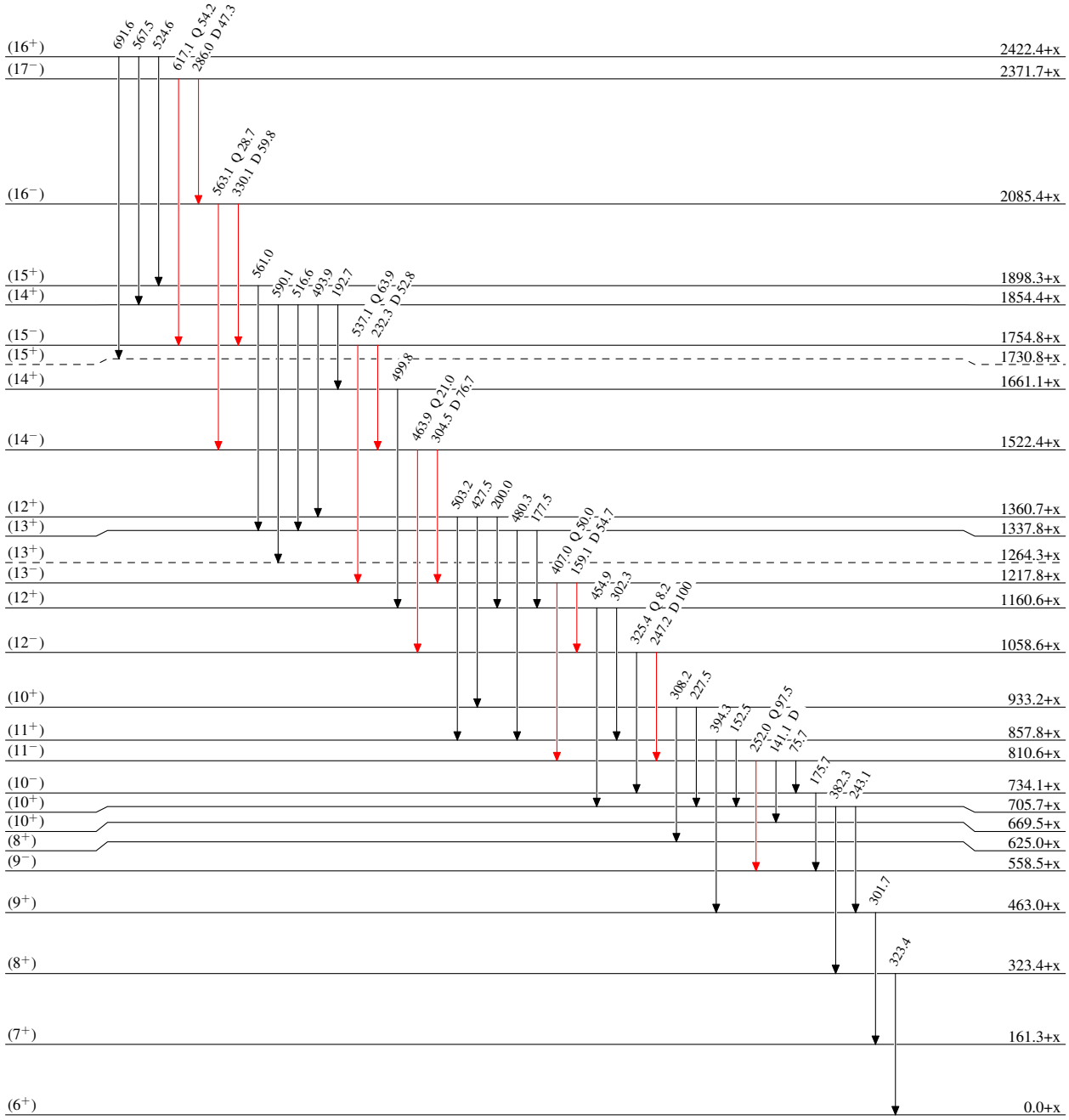
Level Scheme (continued)

Intensities: Relative I_γ

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



$^{160}_{71}Lu_{89}$

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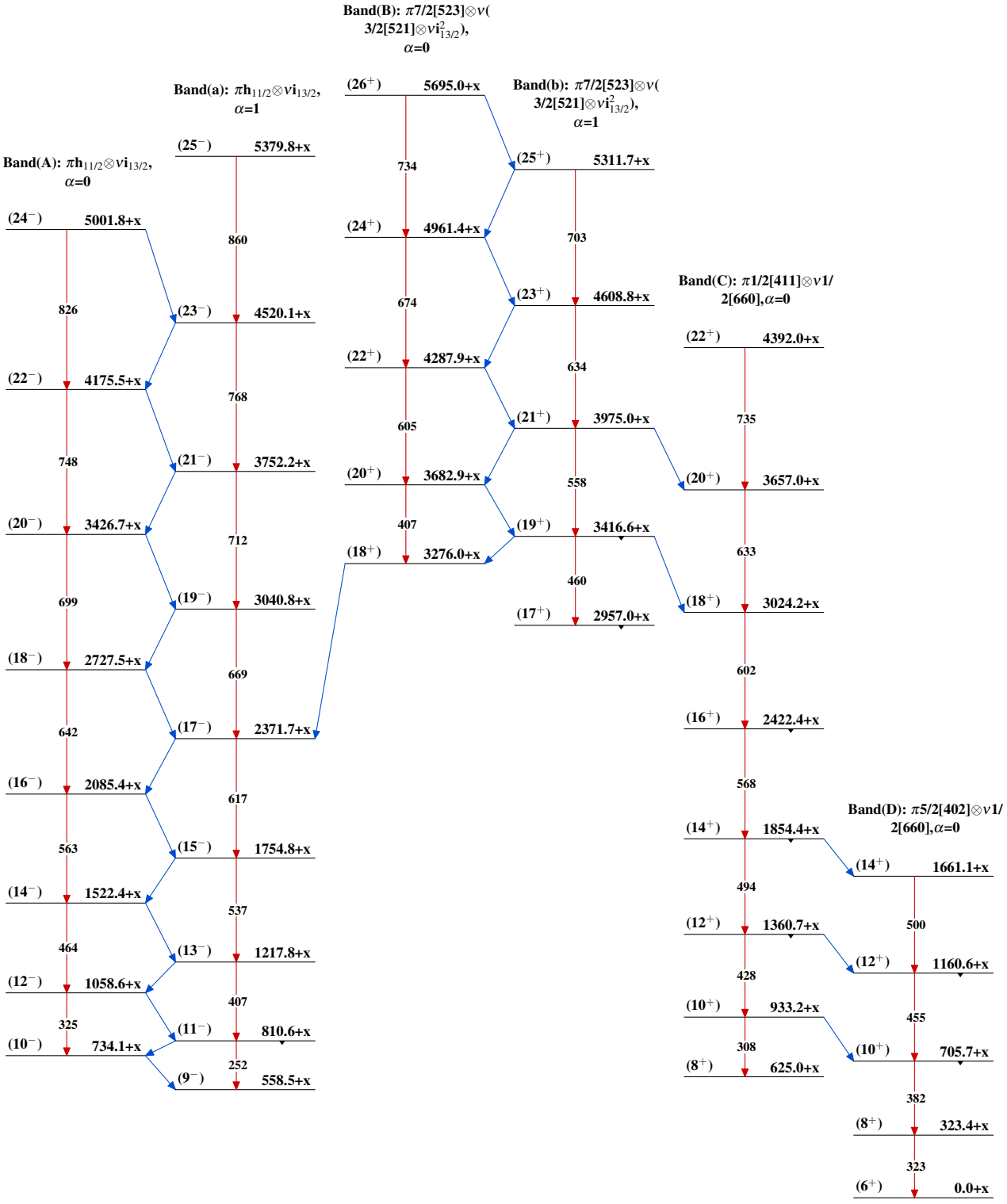
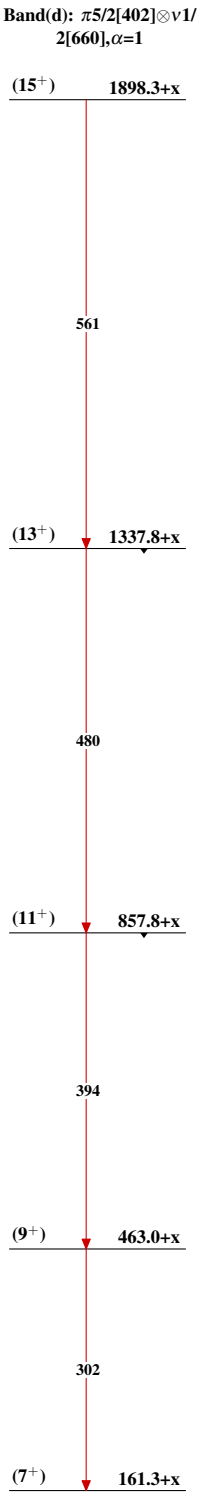


$^{160}_{71}Lu_{89}$

^{144}Sm(^{19}F,3nγ) 2012Wa17,2001Yi03,1995Su11 (continued)



$^{160}_{71}Lu_{89}$