^{252}Cf SF decay 2016Hu10,1997Ha64

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	N. Nica	NDS 154, 1 (2018)	20-Nov-2018

Parent: ^{252}Cf: E=0.0; $J^\pi=0^+$; $T_{1/2}$=2.645 y *8*; %SF decay=3.092 *8*

^{252}Cf-E,J^π,$T_{1/2}$,Q(SF): From 2005Ni22.

2016Hu10 and 2017Na15 compiled for XUNDL compilation by J. Chen (NSCL, MSU).

2017Na15: A ^{252}Cf source of 100 μCi activity and 3 μCi fission activity was sandwiched between two 15 mg/cm^2 Fe foils and placed at the center of the Gammasphere array of 101 Compton suppressed Ge detectors for γ-ray detection. Measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma\gamma\gamma$-coin, $\gamma\gamma(\theta)$. Deduced γ-ray multipolarities, mixing ratios.

2016Hu10: The experiment was carried out at LBNL using a ^{252}Cf source sandwiched between two Fe foils of thickness of 10 mg/cm^2. γ rays were detected with the Gammasphere array of 101 Compton-suppressed Ge detectors. Measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma\gamma\gamma$-coin, $\gamma\gamma(\theta)$. Deduced levels, J, π, bands, γ-ray mixing ratios. Systematics of neighboring nuclei. Comparisons with theoretical calculations.

2010SmZZ: measured ^{140}Xe-γ angular correlations for low-lying states using Gammasphere array (and Euroball for other nuclides).

2009Go09: measured g factor of the first 2$^+$ state by the method of correlation attenuations in randomly oriented magnetic fields (IPAC) using the Gammasphere array.

2005Ja12: measured angular momenta of ternary ^{252}Cf fission fragments.

1997Ha64: measured $\gamma\gamma\gamma$, x$\gamma\gamma$. Studied correlated pairs with no n emission and in ternary fission. Level scheme given in 1997Ha64 apparently based on earlier results (1993Bu12,1992Zh42).

1993Bu12,1992Zh42: measured γ, $\gamma\gamma$.

1980ChZM: measured γ, γ(t).

1976Wo04: measured ^{140}Xe-γ angular correlations for low-lying states using Ge(Li) detector.

1971Ch44: measured γ.

^{140}Xe Levels

Disagreement comment: Although there is a general good agreement in between the experimental work of 2016Ur01 (see ^{248}Cm SF decay), 2016Hu10, and 2017Na15 (same group of authors as 2016Ur01) there is disagreement as concern the parity of band D leading to quite different theoretical interpretations. Thus while 2016Ur01 argue for the γ collectivity of band C and D (with π=+ assigned for band C and no parity assigned for band D), 2016Hu10 later argue for s=±1 doublet octupole bands based essentially on assigned π=− for band D. This indeed is based on tentative (E1) assignments for all five ΔJ=1 transitions linking band D to C. However 2017Na15 based on the relatively high quadrupole mixing ratio of 821γ, one of these ΔJ=1 transitions, concluded that this is rather a (M1+E2) transition which qualifies band D as π=+, which contradicts the interpretation of 2016Hu10 and sustains that of 2016Ur01. However 2017Na15 did not report measurement on any of the other four (E1) linking transitions. Based on these experimental findings the evaluator adopts no parity for band D and no E1 or M1 character for the linking transitions before more extensive and precise measurements are going to be published.

E(level)[†]	J^π[‡]	$T_{1/2}$	Comments
0.0[@]	0$^+$		
376.7[@] *10*	2$^+$	70.5[#] ps *22*	g=0.56 *19* g factor measured by 2009Go09 based on $T_{1/2}$=0.113 ns *5* (1980ChZM) is g=0.35 *12* (2009Go09). If the adopted $T_{1/2}$=70.5 ps *22* is used one obtains the g=0.56 *19* which is adopted here.
834.4[@] *13*	4$^+$		
1304.4[a] *13*	3$^+$		
1416.9[@] *14*	6$^+$		
1513.1[&] *13*	3$^-$		
1573.1[a] *13*	5$^+$		
1725.7[c] *14*	6$^+$		
1771.7[&] *13*	5$^-$		

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^{252}Cf SF decay 2016Hu10,1997Ha64 (continued)

^{140}Xe Levels (continued)

E(level)[†]	Jπ[‡]	E(level)[†]	Jπ[‡]	E(level)[†]	Jπ[‡]	E(level)[†]	Jπ[‡]
1954.6[a] *14*	7+	2589.1[a] *15*	9+	3159.7[b] *16*	(10)	3997.9[@] *21*	14+
1983.5[@] *15*	8+	2590.7[@] *16*	10+	3246.6[&] *16*	11−	4125.6[a] *18*	(13+)
2184.7[&] *14*	7−	2736.3[&] *15*	9−	3269.8[@] *18*	12+	4433.4[&] *21*	(15−)
2256.6[c] *14*	8+	2775.3[b] *16*	(8)	3283.2[a] *16*	(11+)	4744.7[@] *23*	(16+)
2282.2[b] *14*	(4)	2933.2 *16*		3730.2[b] *17*	(12)	5166.2[&] *23*	(17−)
2489.2[b] *15*	(6)	2965.5[c] *15*	(10+)	3812.9[&] *19*	(13−)	5504.4[@] *25*	(18+)

[†] From a least-squares fit to γ-ray energies.
[‡] As given in 2016Hu10 from deduced γ-ray multipolarities and assignments in 2016Ur01.
[#] From 1999Li18 (adopted value).
[@] Band(A): Yrast band.
[&] Band(B): 2, 3− octupole band.
[a] Band(C): Positive band based on 3+.
[b] Band(D): Band based on J=(4). Parity not assigned (see the disagreement comment).
[c] Band(E): Based on 6+.

γ(^{140}Xe)

The data from ^{252}Cf SF allow normalization of the relative Iγ′s to per 100 parent decays.
Normalization multiplier: 0.00046 *7*, from %I(377γ)=1.5 *15%* (1971Ch44) multiplied by %SF(^{252}Cf)=3.092 *8* (2005Ni22).

E_γ	I_γ[#]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[†]	δ[‡]	Comments
156.1	0.48 *4*	1573.1	5+	1416.9	6+	(M1+E2)		
206.7[@]	<0.1	2489.2	(6)	2282.2	(4)	(E2)		
228.9	1.07 *9*	1954.6	7+	1725.7	6+	(E2)		
258.7	0.37 *5*	1771.7	5−	1513.1	3−	E2		
268.6	1.37 *7*	1573.1	5+	1304.4	3+	E2		
273.1	0.94 *3*	2256.6	8+	1983.5	8+	(M1+E2)		
281.1	0.34 *4*	3246.6	11−	2965.5	(10+)	(E1)		
286.4[@]	<0.1	2775.3	(8)	2489.2	(6)	(E2)		
302.0	0.74 *4*	2256.6	8+	1954.6	7+	(M1+E2)		
308.8	2.92 *6*	1725.7	6+	1416.9	6+	(M1+E2)	+0.43 *8*	A_2=+0.064 *23*, A_4=−0.005 *36* for 308.8-582.5 cascade. δ: or −1.5 *2* (2016Hu10, for 2σ on A_4).
313.4	0.70 *3*	3246.6	11−	2933.2				
376.4	0.29 *2*	2965.5	(10+)	2589.1	9+	(M1)		
376.7	100.0	376.7	2+	0.0	0+	E2		I_γ: %I(377γ)=1.5 with 15% uncertainty (per 100 fissions of ^{252}Cf) (1971Ch44). (^{140}Xe fragment)(377)(θ): A_2=+0.61 *11*, A_4=−0.24 *12* (1976Wo04). (^{140}Xe fragment)(377)(θ): A_2=+0.077 *15* (2010SmZZ).
381.6	6.35 *26*	1954.6	7+	1573.1	5+	E2		δ: or 1.3 *2* (2016Hu10). A_2=+0.128 *11*, A_4=−0.003 *17* for 381.6-738.6 cascade (2016Hu10). A_2=+0.117 *11*, A_4=−0.007 *16* for 381.5-738.6 cascade (2017Na15).

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^{252}Cf SF decay 2016Hu10,1997Ha64 (continued)

γ(^{140}Xe) (continued)

E_γ	I_γ[#]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[†]	δ[‡]	Comments
384.4	0.36 *2*	3159.7	(10)	2775.3	(8)	(E2)		
412.9	1.00 *7*	2184.7	7⁻	1771.7	5⁻	E2		
447.0	0.25 *5*	3730.2	(12)	3283.2	(11⁺)	D		Mult.: (E1) not adopted (see general disagreement comment).
457.7	87.1 *13*	834.4	4⁺	376.7	2⁺	E2		I_γ: %I(458γ)=1.29 with 15% uncertainty (per 100 fissions of ^{252}Cf) (1971Ch44). A_2=+0.104 *5*, A_4=+0.000 *7* for 457.8-376.7 cascade (2017Na15). attenuated (458)(377)(θ): A_2=+0.095 *4*, A_4=+0.010 *6* (2009Go09). (^{140}Xe fragment)(457)(θ): A_2=+0.46 *12*, A_4=+0.07 *15* (1976Wo04). (^{140}Xe fragment)(457)(θ): A_2=+0.111 *14* (2010SmZZ).
459.0	0.73 *5*	2184.7	7⁻	1725.7	6⁺	(E1)		
470.0	2.73 *4*	1304.4	3⁺	834.4	4⁺	(M1)		
479.7	1.68 *7*	2736.3	9⁻	2256.6	8⁺	(E1)		
510.3	3.46 *11*	3246.6	11⁻	2736.3	9⁻	E2		
530.9	2.29 *5*	2256.6	8⁺	1725.7	6⁺	(E2)		
537.7	3.03 *6*	1954.6	7⁺	1416.9	6⁺	(M1(+E2))		A_2=−0.066 *34*, A_4=+0.019 *53* for 537.7-582.5 cascade; A_2=−0.086 *23*, A_4=+0.002 *35* for 537.7-457.7 cascade (2016Hu10). δ: 0 or +18 for 1.5σ on A_4 for 537.7-582.5 cascade; 0 or +40 for 1.5σ for 537.7-457.7 cascade (2016Hu10).
551.6	5.46 *26*	2736.3	9⁻	2184.7	7⁻	E2		
566.3	2.11 *9*	3812.9	(13⁻)	3246.6	11⁻	(E2)		
566.6	35.6 *5*	1983.5	8⁺	1416.9	6⁺	E2		A_2=+0.101 *6*, A_4=+0.023 *9* for 566.6-sum cascade (2017Na15).
570.5	0.44 *4*	3730.2	(12)	3159.7	(10)	(E2)		
570.6	1.78 *5*	3159.7	(10)	2589.1	9⁺	D		Mult.: (E1) not adopted (see general disagreement comment).
582.5	52.5 *8*	1416.9	6⁺	834.4	4⁺	E2		A_2=+0.093 *3*, A_4=+0.004 *6* (2017Na15).
605.6	3.32 *30*	2589.1	9⁺	1983.5	8⁺	(M1+E2)		
607.2	16.9 *2*	2590.7	10⁺	1983.5	8⁺	E2		
620.5	1.12 *6*	4433.4	(15⁻)	3812.9	(13⁻)	(E2)		
634.5	4.70 *10*	2589.1	9⁺	1954.6	7⁺	E2		A_2=+0.094 *17*, A_4=+0.008 *27* for 634.5-381.0 cascade.
655.9[@]	<0.1	3246.6	11⁻	2590.7	10⁺	(E1)		
679.1	7.25 *11*	3269.8	12⁺	2590.7	10⁺	E2		
692.5	1.36 *5*	3283.2	(11⁺)	2590.7	10⁺	(M1+E2)		
694.1	1.61 *6*	3283.2	(11⁺)	2589.1	9⁺	(E2)		
708.9	<0.1	2965.5	(10⁺)	2256.6	8⁺	(E2)		
717.7	0.13 *2*	2489.2	(6)	1771.7	5⁻	D(+Q)		Mult.: (M1+E2) not adopted (see general disagreement comment).
728.1	1.85 *6*	3997.9	14⁺	3269.8	12⁺	E2		A_2=+0.118 *27*, A_4=+0.001 *41* for 728.1-679.1 cascade.
732.8	0.84 *5*	5166.2	(17⁻)	4433.4	(15⁻)	(E2)		
738.6	12.1 *2*	1573.1	5⁺	834.4	4⁺	M1+E2	+0.51 *4*	A_2=+0.203 *8*, A_4=+0.003 *13* for 738.6-457.7 cascade, A_2=+0.189 *5*, A_4=−0.017 *8* for 738.6-sum cascade, A_2=+0.128 *11*, A_4=−0.003 *17* for 381.6-738.6 cascade (2016Hu10). A_2=+0.117 *11*, A_4=−0.007 *16* for 738.6-457.8 cascade (2017Na15).

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^{252}Cf SF decay 2016Hu10,1997Ha64 (continued)

γ(^{140}Xe) (continued)

E_γ	I_γ[#]	E_i(level)	J^π_i	E_f	J^π_f	Mult.[†]	δ[‡]	Comments
								δ: or +3.0 *3* for 381.6-738.6 cascade, +0.53 *3* or +1.6 *1* for 3σ on A_4 (2016Hu10); +0.48 *4* or +3.4 *4* (2017Na15).
746.8	0.76 *3*	4744.7	(16$^+$)	3997.9	14$^+$	(E2)		
752.8	4.24 *10*	2736.3	9$^-$	1983.5	8$^+$	(E1)		
759.7	0.34 *2*	5504.4	(18$^+$)	4744.7	(16$^+$)	(E2)		
767.8	5.11 *10*	2184.7	7$^-$	1416.9	6$^+$	(E1)		A_2=−0.072 *9*, A_4=−0.030 *19* for 767.9-sum cascade (2017Na15). δ: 0.00 *13* (2017Na15).
769.1	0.49 *5*	2282.2	(4)	1513.1	3$^-$	D(+Q)		Mult.: (M1+E2) not adopted (see general disagreement comment).
820.7	1.21 *6*	2775.3	(8)	1954.6	7$^+$	D		Mult.,δ: (M1+E2) with δ=+0.21 *11* or or +3.9 *15* (2017Na15), (E1) (2016Hu10), neither of which being adopted here (see general disagreement comment). A_2=+0.057 *60*, A_4=+0.038 *93* 820.8-3815 cascade (2017Na15).
839.7	3.21 *8*	2256.6	8$^+$	1416.9	6$^+$	E2		A_2=+0.116 *32*, A_4=+0.003 *49* for 839.7-582.5 cascade. Mult.: 2016Hu10 give (M1/E2) in Table I, however this is in disagreement with the 840γ corresponding to a 8$^+$ to 6$^+$ transition and the angular correlations results.
842.4	0.55 *4*	4125.6	(13$^+$)	3283.2	(11$^+$)	(E2)		
855.8	0.15 *2*	4125.6	(13$^+$)	3269.8	12$^+$	(M1+E2)		
891.3	4.16 *7*	1725.7	6$^+$	834.4	4$^+$	E2		A_2=+0.117 *25*, A_4=−0.014 *39* for 891.3-457.7 cascade (2016Hu10). A_2=+0.092 *17*, A_4=+0.007 *23* for 891.2-sum cascade (2017Na15). Mult.: 2016Hu10 give (M1/E2) in Table I, however this is in disagreement with the 891γ corresponding to a 6$^+$ to 4$^+$ transition and the angular correlations results. 2017Na15 gives E2 with δ(Q/D)=0.
915.9	0.38 *2*	2489.2	(6)	1573.1	5$^+$	D		Mult.: (E1) not adopted (see general disagreement comment).
927.7	3.88 *10*	1304.4	3$^+$	376.7	2$^+$	M1+E2	+0.55 *9*	δ: or +1.3 *2* (2016Hu10; +0.66 *20* (2017Na17). A_2=+0.203 *22*, A_4=−0.070 *34* for 927.7-376.7 cascade (2016Hu10). A_2=+0.254 *20*, A_4=+0.003 *29* for 927.9-376.7 cascade (2017Na17).
937.4	5.24 *8*	1771.7	5$^-$	834.4	4$^+$	(E1)		
949.7	1.47 *6*	2933.2		1983.5	8$^+$			
977.8	0.35 *3*	2282.2	(4)	1304.4	3$^+$	D		Mult.: (E1) not adopted (see general disagreement comment).
982.0	<0.1	2965.5	(10$^+$)	1983.5	8$^+$	E2		Mult.: 2016Hu10 give (M1/E2) in Table I, however this is in disagreement with the 982γ corresponding to a (10$^+$) to 8$^+$ transition.
1136.4	1.67 *7*	1513.1	3$^-$	376.7	2$^+$	(E1)		

[†] As given in 2016Hu10 based on measured γγ(θ), band structures and assignments in 2016Ur01. ΔJ=2 transitions were adopted as E2 (in some situations tentatively as considered by 2016Hu10) while ΔJ=1 transitions were adopted tentatively as (M1) or (E1) depending on other arguments. Some stronger quadrupole admixtures on dipole transitions can qualify as M1+E2 (unless they are tentative in 2016Hu10).

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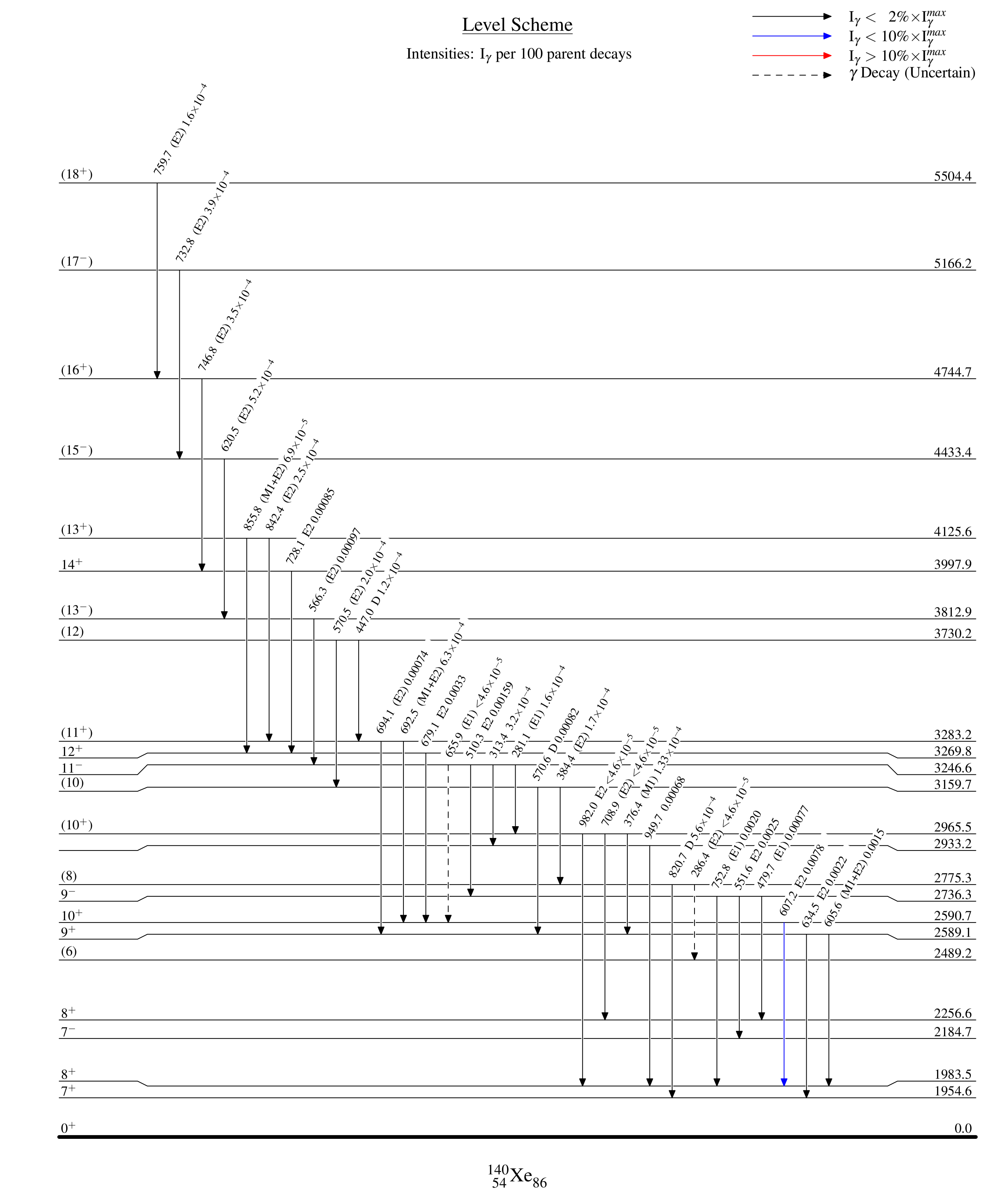
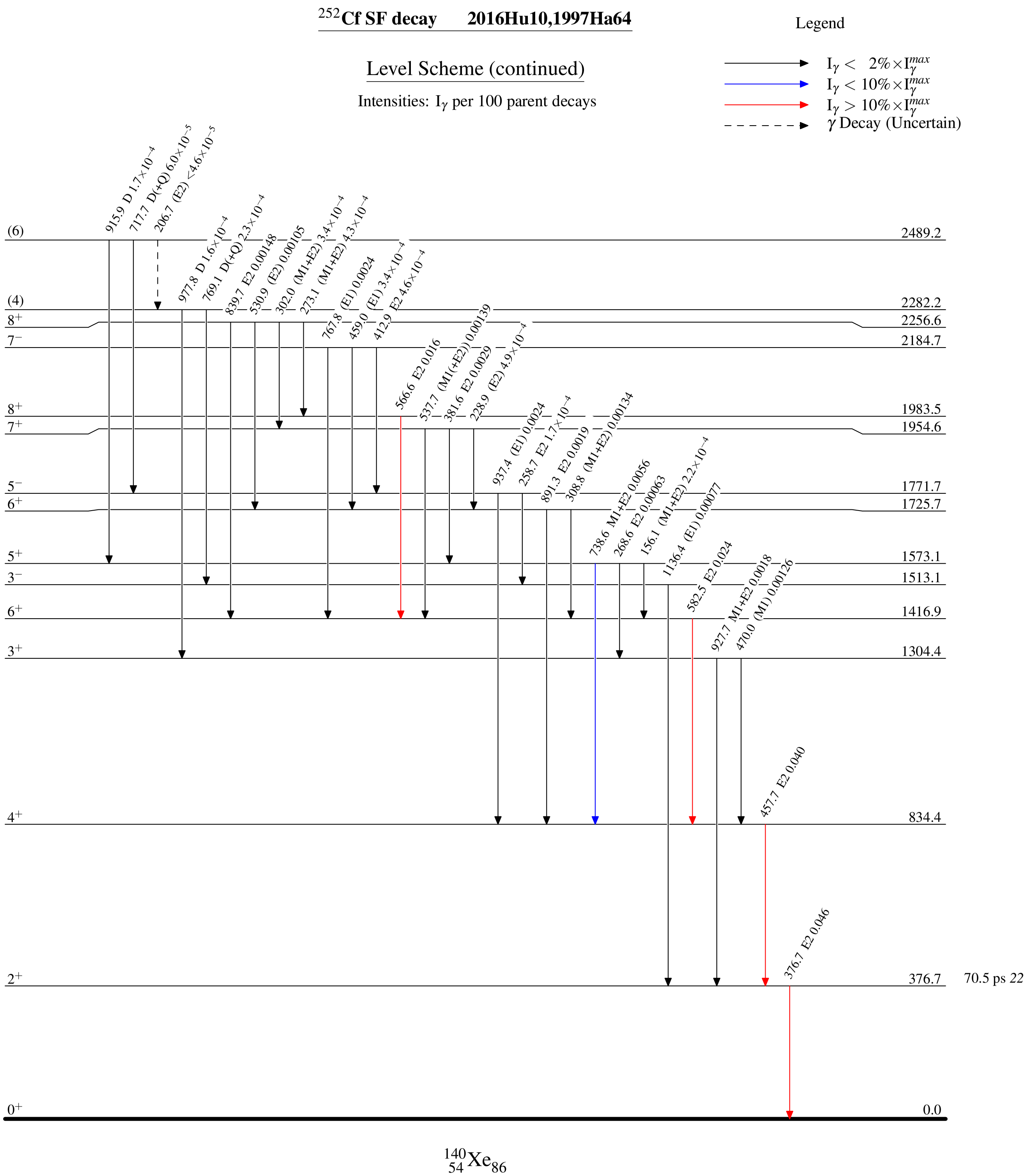
^{252}Cf SF decay 2016Hu10,1997Ha64 (continued)

$\gamma(^{140}Xe)$ (continued)

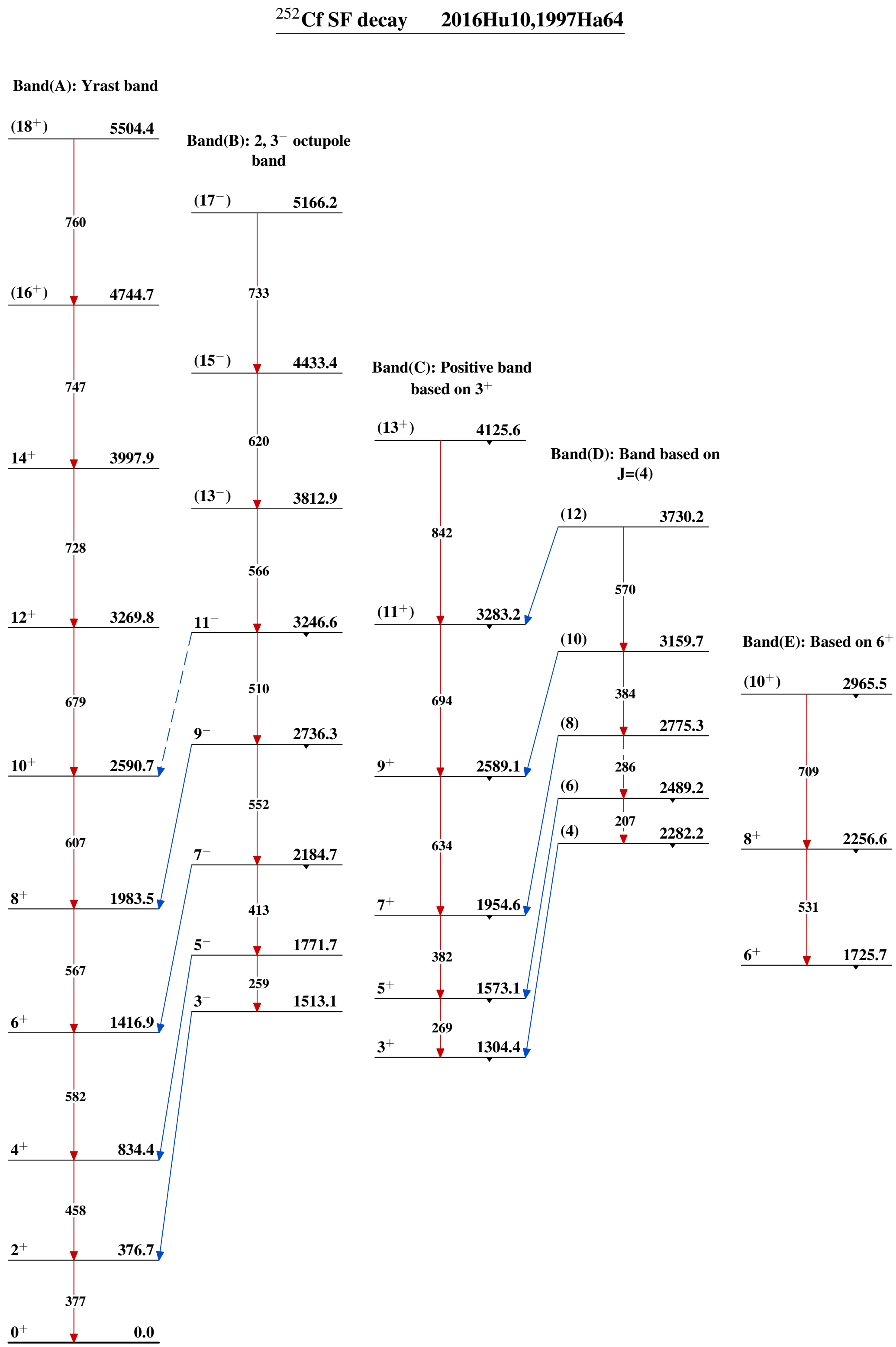
‡ Deduced by 2016Hu10 based on measured $\gamma\gamma(\theta)$ unless otherwise noted.
# For absolute intensity per 100 decays, multiply by 0.00046 *7*.
@ Placement of transition in the level scheme is uncertain.

^{252}Cf SF decay 2016Hu10,1997Ha64





252Cf SF decay 2016Hu10,1997Ha64
Level Scheme (continued)
Intensities: Iγ per 100 parent decays
Legend
Iγ < 2%×Iγmax
Iγ < 10%×Iγmax
Iγ > 10%×Iγmax
γ Decay (Uncertain)
(6) 2489.2
(4) 2282.2
8+ 2256.6
7− 2184.7
8+ 1983.5
7+ 1954.6
5− 1771.7
6+ 1725.7
5+ 1573.1
3− 1513.1
6+ 1416.9
3+ 1304.4
4+ 834.4
2+ 376.7 70.5 ps 22
0+ 0.0
915.9 D 1.7×10−4
717.7 D(+Q) 6.0×10−5
206.7 (E2) <4.6×10−5
977.8 D 1.6×10−4
769.1 D(+Q) 2.3×10−4
839.7 E2 0.00148
530.9 (E2) 0.00105
302.0 (M1+E2) 3.4×10−4
273.1 (M1+E2) 4.3×10−4
767.8 (E1) 0.0024
459.0 (E1) 3.4×10−4
412.9 E2 4.6×10−4
566.6 E2 0.016
537.7 (M1(+E2)) 0.00139
381.6 E2 0.0029
228.9 (E2) 4.9×10−4
937.4 (E1) 0.0024
258.7 E2 1.7×10−4
891.3 E2 0.0019
308.8 (M1+E2) 0.00134
738.6 M1+E2 0.0056
268.6 E2 0.00063
156.1 (M1+E2) 2.2×10−4
1136.4 (E1) 0.00077
582.5 E2 0.024
927.7 M1+E2 0.0018
470.0 (M1) 0.00126
457.7 E2 0.040
376.7 E2 0.046
140 54 Xe 86


^{252}Cf SF decay 2016Hu10,1997Ha64
Band(A): Yrast band
(18+) 5504.4
760
(16+) 4744.7
747
14+ 3997.9
728
12+ 3269.8
679
10+ 2590.7
607
8+ 1983.5
567
6+ 1416.9
582
4+ 834.4
458
2+ 376.7
377
0+ 0.0
Band(B): 2, 3− octupole band
(17−) 5166.2
733
(15−) 4433.4
620
(13−) 3812.9
566
11− 3246.6
510
9− 2736.3
552
7− 2184.7
413
5− 1771.7
259
3− 1513.1
Band(C): Positive band based on 3+
(13+) 4125.6
842
(11+) 3283.2
694
9+ 2589.1
634
7+ 1954.6
382
5+ 1573.1
269
3+ 1304.4
Band(D): Band based on J=(4)
(12) 3730.2
570
(10) 3159.7
384
(8) 2775.3
286
(6) 2489.2
207
(4) 2282.2
Band(E): Based on 6+
(10+) 2965.5
709
8+ 2256.6
531
6+ 1725.7

$^{140}_{54}Xe_{86}$