^{140}Ce(γ,γ') 1995He25,2006Vo11,2008Bu21

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

Dataset based on unevaluated XUNDL files compiled from 2006Vo11 by M. Mitchell and B. Singh (McMaster) and from 2008Bu21 by S. Geraedts and B. Singh (McMaster).

1974Te01: n-capture on Co for γ source, E_γ=0-6.5 MeV.

1995He25: E=4.1 MeV electron bremsstrahlung for γ source.

1997He01: same as 1995He25 for E=6.7 MeV electron bremsstrahlung; used cluster detector (Euroball).

2006Vo11 (also 2011Sa70, 2009SaZW, 2005Zi04): E=7.6, 9.9 MeV, bremsstrahlung beam provided by S-DALINAC linear accelerator at TU Darmstadt; γ rays detected with two Compton-suppressed HPGe detectors placed at 90° and 130° relative to the beam axis.

2008Bu21: bremsstrahlung (S-DALINAC at TU Darmstadt), HPGe detectors and a clover HPGe detector.

1995He25 and 1997He01 are from essentially the same group of authors, as are 2006Vo11 and 2008Bu21; all four were done using same lab environment. Most data come from 2006Vo11.

2015Ro09 (2015RoZY): bremsstrahlung beam with energy up to 8.0 MeV ((S-DALINAC) γ-ray spectra using self-absorption technique for 104 dipole states (no data given, only 6484γ as example).

2015ToZZ: polarized γ beam E=1-100 MeV, measured E_γ and I_γ B(E1)↑=600 *119* (in between 4.0 MeV to S(n)).

2016De05: polarized γ beam E=3.6 MeV at (HIγS) facility at TUNL, enriched target (99.72%); measured γ and $\gamma\gamma$ spectra, transition strengths.

Measured:

1964Be25,1960Dz03,1959Of17: σ(E).

1973MeYX,1974Te01,2008Bu21: linear pol.

1972Wo21,1974Te01,2006Vo11: $\gamma(\theta)$.

1995He25,1997He01,2006Vo11: deduced $\Gamma^2_{\gamma0}/\Gamma$ from measured Iγ' from which extracted $\Gamma_{\gamma0}$, then $T_{1/2}$, $\gamma,\gamma'(\theta)$, B(Eλ).

2015Ro09,2004Zi01,2003Ha33,2002MoZW,2002Zi05,2002ZiZZ,1994KnZZ: Electric dipole strength distribution below S(n) (Pygmy Dipole Resonance).

^{140}Ce Levels

B(E1)(↑) values are from 2006Vo11 unless noted otherwise.

E(level)	J^π[†]	$T_{1/2}$[‡]	Γ^2_0/Γ (eV)[#]	Comments
0.0	0+			
1596	2+[@]	0.0050[&] eV *4*	0.0050[a] *4*	$T_{1/2}$: $T_{1/2}$=0.091 ps *7*, no branching; others: 0.076 ps *11* (1959Of17); 0.15 ps *3* (1964Be25); $T_{1/2}$=3.3 ps *13* (1960Dz03). B(E2)=606×10^{-4} *48* (1995He25).
1903	0+			
2464	3−			
2899	2+[@]	0.0040[&] eV *9*	0.0024[a] *5*	$T_{1/2}$: $T_{1/2}$=0.067 ps *16*, Γ(γ0)/Γ(γ)=0.59 *3*, from low statistics 2899γ. B(E2)=4.9×10^{-4} *11* (1995He25).
3118	2+[@]	0.0129[&] eV *10*	0.0129[a] *10*	$T_{1/2}$: $T_{1/2}$=0.036 ps *3*. B(E2)=54.3×10^{-4} *42* (1995He25).
3320	2+[@]	0.0030[&] eV *7*	0.0030[a] *7*	$T_{1/2}$: $T_{1/2}$=0.154 ps *38*, no branching; from low statistics 3320γ. B(E2)=3.0×10^{-4} *7* (1995He25).
3643.8 *6*	1−	1.45 fs *19*		$T_{1/2}$: mean value of 1.62 fs *12* (1995He25), 1.48 fs *18* (1997He01), and 1.24 fs *20* (2006Vo11) with uncertainty covering all values. Γ^2_0/Γ (eV): 0.281 *20* (1995he25), 0.367 *56* (2006Vo11). B(E1)(↑) values: 16.7×10^{-5} *12* (1995He25), 18.2×10^{-5} *22* (1997He01), 21.7×10^{-5} *33* (2006Vo11). configuration: 2+ × 3− two-phonon state (1995He25).
4053	(1)			

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$^{140}Ce(\gamma,\gamma')$ 1995He25,2006Vo11,2008Bu21 (continued)

^{140}Ce Levels (continued)

E(level)	J^{π}†	$T_{1/2}$‡	Γ_0^2/Γ (eV)#	Comments
4173.6 *8*	1	3.6 fs *7*	0.128 *25*	B(E1)(↑)=5.1×10^{-5} *10*.
4331	(1)			
4354.9 *7*	1	3.7 fs *8*	0.12 *3*	B(E1)(↑)=4.3×10^{-5} *9*.
4371	(1)			
4388	(1)			
4437	(1)			
4514.9 *9*	1	2.7 fs *5*	0.17 *3*	B(E1)(↑)=5.3×10^{-5} *10*.
4655	(1)			
4787.8 *9*	1	2.3 fs *4*	0.20 *4*	B(E1)(↑)=5.2×10^{-5} *10*.
4875	(1)			
4883	(1)			
4951	(1)			
5157.3 *12*	1	2.6 fs *5*	0.18 *3*	B(E1)(↑)=3.7×10^{-5} *7*.
5190.2 *10*	1	2.1 fs *4*	0.22 *5*	B(E1)(↑)=4.6×10^{-5} *9*.
5211.6 *14*	1	3.6 fs *9*	0.13 *4*	B(E1)(↑)=2.7×10^{-5} *7*.
5245	(1)			
5330	(1)			
5337.3 *9*	1	1.8 fs *4*	0.25 *5*	B(E1)(↑)=4.8×10^{-5} *10*.
5470	(1)			
5494	(1)			
5548.4 *7*	1	0.97 fs *17*	0.47 *8*	B(E1)(↑)=7.9×10^{-5} *14*.
5573.8 *14*	1	1.7 fs *4*	0.27 *6*	B(E1)(↑)=4.5×10^{-5} *10*.
5624	(1)			
5659.9 *6*	1^{-}	0.27 fs *4*	1.65 *25*	B(E1)(↑)=26×10^{-5} *4* of 2006Vo11, consistent with B(E1)(↑)=24.8×10^{-5} *49* of 1997He01 (with Γ(γ0)/Γ(γ)=0.95 *5* from 1972Wo21). Other: B(E1)(↑)=19.1×10^{-5} *10* (with Γ(γ0)/Γ(γ)=0.93 *5* from 1974Te01).
5721	(1)			
5759	(1)			
5809	(1)			
5823	(1)			
5928.6 *10*	1	1.16 fs *24*	0.39 *8*	B(E1)(↑)=5.4×10^{-5} *11*.
5940	(1)			
6029	(1)			
6119.1 *15*	1^{-}	0.69 fs *12*	0.66 *11*	B(E1)(↑)=8.2×10^{-5} *14*.
6130.6 *12*	1	1.5 fs *3*	0.30 *6*	B(E1)(↑)=3.8×10^{-5} *8*.
6161.7 *14*	1	1.08 fs *20*	0.42 *10*	B(E1)(↑)=5.2×10^{-5} *12*.
6226	(1)			
6245	(1)			
6255	(1)			
6273.6 *10*	1	1.05 fs *20*	0.43 *8*	B(E1)(↑)=5.0×10^{-5} *9*.
6295.3 *8*	1^{-}	0.46 fs *8*	0.99 *18*	B(E1)(↑)=11.4×10^{-5} *20*.
6327.8 *12*	1	1.3 fs *5*	0.35 *13*	B(E1)(↑)=4.0×10^{-5} *15*.
6343.3 *11*	1	0.78 fs *15*	0.58 *11*	B(E1)(↑)=6.6×10^{-5} *13*.
6352.7 *10*	1	0.69 fs *13*	0.66 *12*	B(E1)(↑)=7.4×10^{-5} *14*.
6397.2 *8*	1^{-}	0.28 fs *5*	1.59 *26*	B(E1)(↑)=17×10^{-5} *3*.
6439.9 *14*	1$^{(-)}$	0.53 fs *9*	0.85 *15*	B(E1)(↑)=9.1×10^{-5} *16*.
6449.9 *15*	1$^{(-)}$	0.90 fs *18*	0.50 *10*	B(E1)(↑)=5.4×10^{-5} *11*.
6458.5 *15*	1$^{(-)}$	1.00 fs *20*	0.45 *9*	B(E1)(↑)=4.8×10^{-5} *10*.
6484.8 *10*	1	1.00 fs *20*	0.45 *9*	B(E1)(↑)=4.7×10^{-5} *10*.
6497.0 *7*	1^{-}	0.33 fs *6*	1.37 *23*	B(E1)(↑)=14.3×10^{-5} *24*.
6535.8 *6*	1^{-}	0.22 fs *3*	2.1 *3*	B(E1)(↑)=21×10^{-5} *3*.
6549.1 *11*	1	1.3 fs *3*	0.36 *8*	B(E1)(↑)=3.7×10^{-5} *8*.
6574.9 *15*	1	1.16 fs *23*	0.39 *8*	B(E1)(↑)=4.0×10^{-5} *8*.
6605.5 *10*	1$^{(-)}$	0.69 fs *12*	0.66 *11*	B(E1)(↑)=6.5×10^{-5} *11*.

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^{140}Ce(γ,γ') 1995He25,2006Vo11,2008Bu21 (continued)

^{140}Ce Levels (continued)

E(level)	J^{π}[†]	$T_{1/2}$[‡]	Γ_0^2/Γ (eV)[#]	Comments
6616.2 *10*	$1^{(-)}$	0.74 fs *13*	0.61 *11*	B(E1)(↑)=6.0×10^{-5} *11*.
6771.7 *14*	(2^+)			B(E2)(↑)=110×10^{-4} *30*.
6781.9 *15*	1	0.85 fs *19*	0.53 *12*	B(E1)(↑)=4.9×10^{-5} *11*.
6841.8 *12*	1	0.79 fs *22*	0.58 *16*	B(E1)(↑)=5.2×10^{-5} *14*.
6862.4 *7*	1^-	0.24 fs *4*	1.9 *3*	B(E1)(↑)=17×10^{-5} *3*.
6905.9 *15*	1	0.45 fs *10*	1.01 *22*	B(E1)(↑)=8.8×10^{-5} *19*.
6932.6 *14*	1	0.52 fs *11*	0.88 *19*	B(E1)(↑)=7.5×10^{-5} *16*.
6960.4 *12*	1	0.47 fs *10*	0.96 *20*	B(E1)(↑)=8.2×10^{-5} *17*.
7206.0 *14*	1	0.31 fs *5*	1.43 *24*	B(E1)(↑)=11.0×10^{-5} *19*.
7214.8 *15*	1	0.34 fs *6*	1.33 *23*	B(E1)(↑)=10.2×10^{-5} *17*.
7341.5 *14*	1	0.9 fs *2*	0.51 *20*	B(E1)(↑)=3.7×10^{-5} *14*.
7673.4 *12*	1	0.76 fs *18*	0.60 *14*	B(E1)(↑)=3.8×10^{-5} *9*.

[†] Unless noted otherwise, spins are from 2006Vo11 and parities from 2008Bu21 based on γ-ray multipolarity and parity measurements (all γ's decay to the 0^+ g.s.).
[‡] Unless noted otherwise, deduced from Γ_0^2/Γ values in 2006Vo11, when available, assuming $\Gamma_0=\Gamma$ based on the observation of only the ground-state transitions. As no transitions other than those to the ground-state were observed, it is a reasonable approximation.
[#] Unless noted otherwise, from 2006Vo11.
[@] Spins adopted by 1995He25 from measured angular correlations (parities from literature).
[&] $\Gamma_{\gamma 0}$, from 1995He25.
[a] From 1995He25.

γ(^{140}Ce)

E_γ[†]	E_i(level)	J_i^{π}	E_f	J_f^{π}	Mult.[‡#]	Comments
1179[c]	3643.8	1^-	2464	3^-		B(E2)(W.u.)<28 (2016De05)
1596[@]	1596	2^+	0.0	0^+	E2[&]	
1740	3643.8	1^-	1903	0^+		B(E1)(W.u.)=0.00075 *6* (2016De05)
2047	3643.8	1^-	1596	2^+		B(E1)(W.u.)=0.00054 *3* (2016De05)
2899[@]	2899	2^+	0.0	0^+	E2[&]	γ peak close to detection limit (1995He25).
3118[@]	3118	2^+	0.0	0^+	(E2)[&]	
3320[@]	3320	2^+	0.0	0^+	(E2)[&]	γ peak close to detection limit.
3643.8 *6*	3643.8	1^-	0.0	0^+	E1	Mult.: POL=−5.5 *24* (2008Bu21); also from linear pol (1973MeYX).
4053	4053	(1)	0.0	0^+	(D)	
4173.5 *8*	4173.6	1	0.0	0^+	D	
4331	4331	(1)	0.0	0^+	(D)	
4354.8 *7*	4354.9	1	0.0	0^+	D	
4371	4371	(1)	0.0	0^+	(D)	
4388	4388	(1)	0.0	0^+	(D)	
4437	4437	(1)	0.0	0^+	(D)	
4514.8 *9*	4514.9	1	0.0	0^+	D	
4655	4655	(1)	0.0	0^+	(D)	
4787.7 *9*	4787.8	1	0.0	0^+	D	
4875	4875	(1)	0.0	0^+	(D)	
4883	4883	(1)	0.0	0^+	(D)	
4951	4951	(1)	0.0	0^+	(D)	
5157.2 *12*	5157.3	1	0.0	0^+	D	
5190.1 *10*	5190.2	1	0.0	0^+	D	

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$^{140}Ce(\gamma,\gamma')$ 1995He25,2006Vo11,2008Bu21 (continued)

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

E_γ[†]	E_i(level)	J_i^π	E_f	J_f^π	Mult.[‡#]	Comments
5211.5 *14*	5211.6	1	0.0	0^+	D	
5245	5245	(1)	0.0	0^+	(D)	
5330	5330	(1)	0.0	0^+	(D)	
5337.2 *9*	5337.3	1	0.0	0^+	D	
5470	5470	(1)	0.0	0^+	(D)	
5494	5494	(1)	0.0	0^+	(D)	
5548.3 *7*	5548.4	1	0.0	0^+	D	
5573.7 *14*	5573.8	1	0.0	0^+	D	
5624	5624	(1)	0.0	0^+	(D)	
5659.8 *6*	5659.9	1^-	0.0	0^+	E1	E_γ: from 2006Vo11. Mult.: from linear pol and $\gamma(\theta)$ (1974Te01); POL=−2.9 *16* (2008Bu21).
5721	5721	(1)	0.0	0^+	(D)	
5759	5759	(1)	0.0	0^+	(D)	
5809	5809	(1)	0.0	0^+	(D)	
5823	5823	(1)	0.0	0^+	(D)	
5928.5 *10*	5928.6	1	0.0	0^+	D	
5940	5940	(1)	0.0	0^+	(D)	
6029	6029	(1)	0.0	0^+	(D)	
6119.0 *15*	6119.1	1^-	0.0	0^+	E1	POL=−7.3 *44*.
6130.5 *12*	6130.6	1	0.0	0^+	D	
6161.6 *14*	6161.7	1	0.0	0^+	D	
6226	6226	(1)	0.0	0^+	(D)	
6245	6245	(1)	0.0	0^+	(D)	
6255	6255	(1)	0.0	0^+	(D)	
6273.4 *10*	6273.6	1	0.0	0^+	D	
6295.1 *8*	6295.3	1^-	0.0	0^+	E1	POL=−3.8 *34*.
6327.6 *12*	6327.8	1	0.0	0^+	D	
6343.1 *11*	6343.3	1	0.0	0^+	D	
6352.5 *10*	6352.7	1	0.0	0^+	D	
6397.0 *8*	6397.2	1^-	0.0	0^+	E1	POL=−6.8 *24*.
6439.7[a] *14*	6439.9	$1^{(-)}$	0.0	0^+	(E1)	POL=−2.6 *27* for 6439γ+6449γ+6459γ.
6449.7[a] *15*	6449.9	$1^{(-)}$	0.0	0^+	(E1)	
6458.3[a] *15*	6458.5	$1^{(-)}$	0.0	0^+	(E1)	
6484.6 *10*	6484.8	1	0.0	0^+	D	
6496.8 *7*	6497.0	1^-	0.0	0^+	E1	POL=−1.3 *24*.
6535.6 *6*	6535.8	1^-	0.0	0^+	E1	POL=−3.7 *22*.
6548.9 *11*	6549.1	1	0.0	0^+	D	
6574.7 *15*	6574.9	1	0.0	0^+	D	
6605.3[b] *10*	6605.5	$1^{(-)}$	0.0	0^+	(E1)	POL=−2.6 *42* for 6606γ+6616γ.
6616.0[b] *10*	6616.2	$1^{(-)}$	0.0	0^+	(E1)	
6771.5 *14*	6771.7	(2^+)	0.0	0^+	(E2)	
6781.7 *15*	6781.9	1	0.0	0^+	D	
6841.6 *12*	6841.8	1	0.0	0^+	D	
6862.2 *7*	6862.4	1^-	0.0	0^+	E1	POL=−5.7 *32*.
6905.7 *15*	6905.9	1	0.0	0^+	D	
6932.4 *14*	6932.6	1	0.0	0^+	D	
6960.2 *12*	6960.4	1	0.0	0^+	D	
7205.8 *14*	7206.0	1	0.0	0^+	D	
7214.6 *15*	7214.8	1	0.0	0^+	D	
7341.3 *14*	7341.5	1	0.0	0^+	D	
7673.2 *12*	7673.4	1	0.0	0^+	D	

[†] From 2006Vo11 (corrected for recoil by evaluator) except when noted otherwise.

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^{140}Ce(γ,γ′) 1995He25,2006Vo11,2008Bu21 (continued)

γ(^{140}Ce) (continued)

‡ Except where noted otherwise, multipolarities were determined by 2006Vo11 and parities by 2008Bu21. Multipolarities were determined by γ intensity ratio in the 90° detector and 130° detector (ΔJ=1 dipole for ratio=0.7; ΔJ=2 quadrupole for ratio=2.1). Parities were determined by linear polarization measurements using Compton polarimetry (positive asymmetries correspond to positive parity and negative asymmetries to negative parity).

\# Although all adopted spin values in Table 3 (2006Vo11) are J=1 as result of dipole, ΔJ=1 transitions to g.s., only about two thirds of the total number of γ′s, which can not be individually identified, are shown as measured on the graph in Fig. 3 (2006Vo11). The evaluator assumed that these are those having measured Γ_0^2/Γ values in Table 3 (also about two thirds), for which assigned D-dipole, while for the remaining transitions the tentative (D) dipole character was assigned.

@ From 1995He25.

& From 1995He25 by angular correlation (parities from literature).

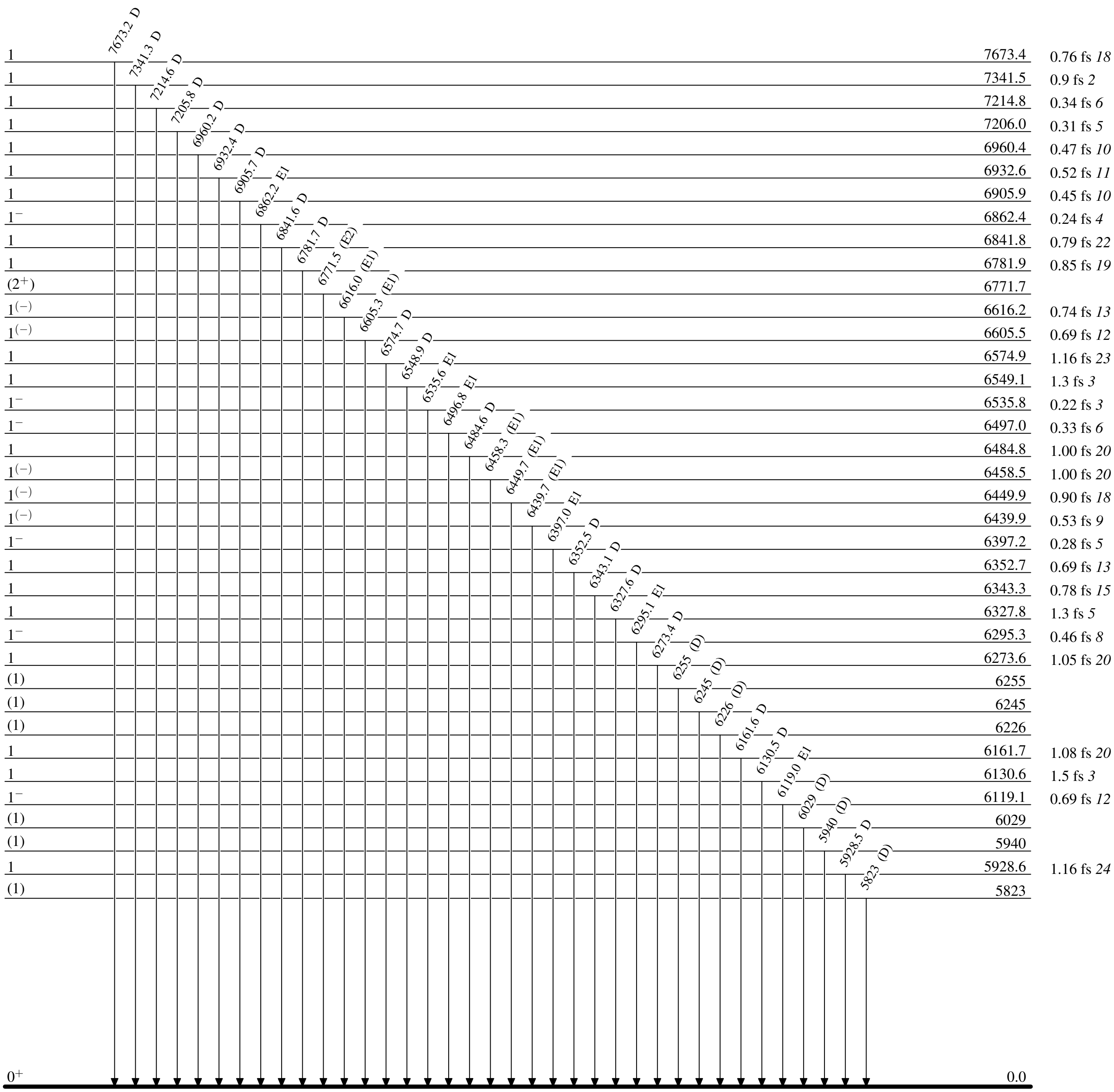
[a] Analyzed as a composite unresolved structure of 6439γ+6449γ+6459γ by 2008Bu21.

[b] Analyzed as a composite unresolved structure of 6606γ+6616γ by 2008Bu21.

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

$^{140}Ce(\gamma,\gamma')$ 1995He25,2006Vo11,2008Bu21

Level Scheme



$^{140}_{58}Ce_{82}$

$^{140}Ce(\gamma,\gamma')$ 1995He25,2006Vo11,2008Bu21

Level Scheme (continued)