Adopted Levels, Gammas

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh	NDS 156, 1 (2019)	31-Jan-2019

Q(β^-)=1088 *3*; S(n)=5091 *4*; S(p)=4600 *6*; Q(α)=6615.7 *15* 2017Wa10
S(2n)=11450 *50*, S(2p)=11120 *200* (syst) (2017Wa10).

1954Fi14: ^{254}Es isomer of 39 hours produced and identified in neutron-activation of ^{253}Es at Argonne National lab, measured half-life.

1954Ch23, 1955Ha35: ^{254}Es isomer of 39 hours produced and identified in neutron-activation of Pu and higher mass nuclides at Berkeley, followed by chemical separation and measurement of half-life β^- activity.

A 272-d activity in ^{254}Es was reported by B.G. Harvey et al., in 1955 as quoted on page 960 of book by 1964Hy02.

Later half-life and other measurements of ^{254}Es decay: 1956Jo09, 1958Sc35, 1962Un01, 1973Ah04, 1975Ah04, 1988Po05.

2009Se09, 2011Gu11: ^{254}Es produced through the irradiation of ^{252}Cf by neutrons at a reactor in Dimitrovgrad, Russia, followed by β^- decay to ^{253}Es, which then captured a neutron through the ^{253}Es(n,γ) reaction to produce ^{254}Es. The sample was radiochemically separated before being mass separated and implanted into an Fe foil at Bonn, Germany. Nuclear orientation experiments were performed in Leuven, Belgium. The α decays were detected by six Si PIN-diodes and γ rays by two large volume HPGe detectors. Count rates were recorded for both oriented and nonoriented nuclei, from which the angular distribution was determined. Measured magnetic dipole moment from the anisotropy of α particles from oriented nuclei, and the hyperfine magnetic field for Es impurities in Fe host. See also 2010Gu05, 2006Gu32, 2005Se08 and 2004Gu22 from the same group as 2009Se09 and about the same topic.

Additional information 1.

Theoretical studies: consult the NSR database at www.nndc.bnl.gov for 29 references dealing with theoretical calculations of half-lives for different decay modes, binding energies, fission characteristics, and other nuclear structure aspects.

^{254}Es Levels

1993Mo18 proposed a band based on bandhead 6$^-$ at 214.7 keV, with band members of 7$^-$ at 289.9, 8$^-$ at 376.8 and 9$^-$ at 469.2 keV, with configuration=π3/2[521]$\otimes\nu$9/2[615], K^π=6$^-$. But theoretical analysis by 2007Sa02 does not support this conjecture as the calculated energy of the 6$^-$ bandhead for this configuration is >350 keV. In addition, 376.8 level is assigned 8$^+$ by 2007Sa02 from agreement of the theoretical energy for configuration=π7/2[633]$\otimes\nu$9/2[615].

Cross Reference (XREF) Flags

A ^{258}Md α decay (51.50 d)

E(level)†	J$^\pi$	T$_{1/2}$	XREF	Comments
0.0‡	(7$^+$)	275.7 d *5*	A	%α≈100; %β^-=1.74×10^{-4} *8*; %SF<3×10^{-6}; %ε=? μ=4.35 *41* (2009Se09,2011Gu11,2014StZZ) μ: from $\alpha(\theta)$ in oriented nuclei, sign is unknown (2009Se09,2011Gu11,2010Gu05). A$_2$=+0.47 *7*; A$_4$=−0.030 *14* at 90 mK for the 6429 keV α transition from this level (2009Se09,2011Gu11). T$_{1/2}$: measurement by 1975Ah04. Other measured half-lives are: 266 d *4* (1988Po05), 276 d *76* (1962Un01), 480 d *70* (1958Sc35), 272 d (from G.G. Harvey et al. (1955) as quoted by 1964Hy02 on page 960). J$^\pi$: analogy to ^{253}Es suggests π7/2[633] for the 99th proton, and analogy to ^{255}Fm suggests ν7/2[613] for the 155th neutron state. From favored α to (7$^+$) ^{250}Bk, and $\alpha(\theta)$ from oriented nuclei (2005Se08), a high-spin assignment for the ^{254}Es g.s. is consistent with weak β and ε branches to ^{254}Fm and ^{254}Cf, respectively. No α branch from 51.5-d ^{258}Md is expected. The observation of a weak α suggests some admixture with other configurations. 1985Ok04 determined β^- decay/total=1.74×10^{-6} *8* from relative intensities of ^{254}Es and ^{254}Fm α's; ^{254}Fm was in equilibrium with ^{254}Es. Earlier measurement: %β^-<2×10^{-4}

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Adopted Levels, Gammas (continued)

^{254}Es Levels (continued)

E(level)†	Jπ	T1/2	XREF	Comments
				(1966Mc02).
				%SF<3×10^{-6} is from T1/2(SF)>2.5×10^{7} y, measured by 1967Fi03. Other measurement: 1965Me02.
				A partial half-life of ≈8×10^{3} s for ε decay, calculated by 1973Ta30 from the β gross theory, suggests %ε≈0.03%.
80.1‡ *1*	(8+)		A	Jπ: (M1+E2) γ to g.s.; (E1) γ from (8−), 447.9 level; band member.
84.2 *25*	2+	39.3 h *2*		%β−=98 *2*; %α=0.32 *1*; %ε=0.076 *7*; %IT<3; %SF<0.045 μ=2.90 *7* (1975Go05,2014StZZ) Q=+3.7 *5* (1975Go05,2016St14) T1/2: measurement by 1962Un01 from β and γ counting, weighted average of three results. Other measurements: 38.5 h *10* (1956Jo09), 36.3 h (1954Ch23), 37 h *1* (1954Fi14). %β−/%α=302 *9* (1973Ah04) from intensities of 39-h ^{254}Es and ^{254}Fm α decays. %ε/%β−=7.8×10^{-4} *6* (1963Ph01) from the rates of α emission and spontaneous fission in ^{254}Fm and ^{254}Cf daughters, chemically separated from ^{254}Es. %IT<3 was deduced by 1973Ah04 by following growth in the 6429α peak of 275.7-d ^{254}Es. %IT is probably much less than 3% as gamma transition to (7+) g.s. requires M5 multipolarity. %SF is calculated from T1/2(SF)>10 y, listed by 1954Fi14. All branchings are adopted from the experimental β−/α, ε/β−, T1/2(SF), and the upper limit for isomeric transition given above. Other measurements: %β−/%α=382 *30* (1967Fi03). Jπ: spin was measured by 1975Go05 by using atomic-beam resonance method; parity is from the hindrance factor of 6382α to the positive-parity level at 211-keV in ^{250}Bk, and agreement of measured μ with theoretical calculations (see 1975Go05) for a state with configuration=π7/2[633]⊗ν3/2[622], 2+. From their measured spectroscopic quadrupole moment, 1975Go05 calculated the deformation parameter, ε=0.21. E(level): From Q(α)(^{254}Es 39.3 h)=6699.9 *20* (based on Q(α) for g.s. in 2017Wa10), and Eα=6383.9 *20*, 6383.9 *20* recalibrated α from 39.3 h *2* ^{254}Es level to the 211.82-keV, 35.587 levels in ^{250}Bk, respectively.
171.1‡ *1*	(9+)		A	Jπ: (E1) γ from (8−); probable band member.
214.7? *2*			A	E(level): existence of a level at 214.7 keV is not certain, as it relies on only one γ ray to ground state, and another γ placed from the 402-keV level, from 189.1- and 214.7-keV gammas forming a cascade, whose ordering is not certain. Jπ: 1993Mo18 suggested that this level may be the 6− state with configuration=π3/2[521]⊗ν9/2[615]. A γ transition from this level to the g.s. with 7+, π7/2[633]⊗ν7/2[613] configuration would be highly hindered. Theoretical analysis by 2007Sa02 disagrees with the assignment of 6− bandhead for the proposed configuration, as the calculated bandhead energy for this configuration is predicted by 2007Sa02 as above 350 keV.
289.9? *3*	(7+)		A	No γ decay of this level is known. Jπ: possible (M1+E2) γ from (8+) level. Assignment by 1993Mo18 as 7− member of Kπ=6− band is not adopted here.
376.8 *2*	(8+)		A	Jπ: 1993Mo18 proposed this level as the 8− member of the suggested Kπ=6− band. For Kπ=8−, π7/2[514]⊗ν9/2[615] of the ^{258}Md g.s., α hindrance factor of 28 for the 6788α is inconsistent with the proposed configuration (HF of such an α transition between is expected as much greater than 100). 2007Sa02, in their theoretical analysis assign this level as Kπ=8+, Jπ=8+ with configuration= π7/2[633]⊗ν9/2[615].
403.8 *3*			A	The gamma decay of this level is largely unknown. Jπ: (7−) from theoretical analysis by 2007Sa02 with configuration= π7/2[514]⊗ν7/2[613], Kπ=7−.
447.9 *1*	(8−)		A	Jπ: favored α decay from 51.50-d ^{258}Md. Configuration of this state should be the same as that of the parent 51.50-d, ^{258}Md which is probably 8− with main configuration=π7/2[514]⊗ν9/2[615]. If the ground state (7+) has

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Adopted Levels, Gammas (continued)

^{254}Es Levels (continued)

E(level)†	Jπ	XREF	Comments
			configuration=π7/2[633]⊗ν7/2[613], large admixtures in g.s. or in 447.9-keV level configurations are expected because of the 447.9-keV γ transition which would be forbidden (since otherwise, it would require both the proton and the neutron states to change). By assuming that the 80.0- and 171.1-keV levels are the 8^+ and 9^+ states of the g.s. rotational band, 1993Mo18 pointed out that the relative intensities of the 276.8-, 376.8- and 447.9-keV gammas disagree with the expected relative Iγ values to 7^+, 8^+, and 9^+ rotational band members; and they proposed that the 447.9-keV level has an admixture from another rotational band.
469.2 *2*	(7^+ to 10^+)	A	Jπ: gammas to (8^+) and (9^+). 1993Mo18 proposed this level as 9^- member of $K^\pi=6^-$ band, which is not adopted here.

† From least-squares fit to Eγ values.
‡ Band(A): Probable $K^\pi=(7^+)$, g.s. band. Band parameter A=5.0. Proposed configuration=π7/2[633]⊗ν7/2[613] (1993Mo18).

γ(^{254}Es)

The level scheme given here is as proposed by 1993Mo18 in their study of α and γ data ^{258}Md α decay. It is not considered complete by the evaluators as information about multipolarities and mixing ratios is generally missing. There is also a serious problem with a non-physical negative transition intensity balance at the 171-keV level in ^{258}Md α decay.

E_i(level)	J_i^π	E_γ†	I_γ†	E_f	J_f^π	Mult.†	δ†	α#	Comments
80.1	(8^+)	80.1 *2*	100	0.0	(7^+)	(M1+E2)	1.25 *25*	49 *6*	α(L)=35 *4*; α(M)=9.9 *12*; α(N)=2.8 *4*; α(O)=0.70 *9*; α(P)=0.115 *13*; α(Q)=0.00127 *25*
171.1	(9^+)	91.0 *3*	26 *16*	80.1	(8^+)	[M1+E2]		25 *13*	α(L)=18.2 *89*; α(M)=5.0 *28* α(N)=1.42 *78*; α(O)=0.36 *19*; α(P)=0.060 *28*; α(Q)=0.00109 *79*
		171.1 *2*	100 *33*	0.0	(7^+)	[E2]		2.30	α(K)=0.1482 *21*; α(L)=1.546 *23*; α(M)=0.441 *7* α(N)=0.1246 *19*; α(O)=0.0313 *5*; α(P)=0.00509 *8*; α(Q)=3.22×10^{-5} *5*
214.7?		214.7‡@ *2*	100	0.0	(7^+)	[D,E2]		2.5 *24*	
376.8	(8^+)	86.9@ *2*	10 *3*	289.9?	(7^+)	(M1+E2)		30 *17*	α(L)=22 *12*; α(M)=6 *4*; α(N)=1.7 *10*; α(O)=0.44 *25* α(P)=0.07 *4*; α(Q)=0.0013 *9*
		205.7 *2*	22 *8*	171.1	(9^+)	[M1+E2]		3.2 *22*	
		296.7 *2*	100 *17*	80.1	(8^+)	[M1+E2]		1.1 *9*	
		376.8 *4*	32 *13*	0.0	(7^+)	[M1+E2]		0.6 *5*	
403.8		189.1‡@ *2*	100	214.7?		[D,E2]		3.5 *34*	
447.9	(8^-)	71.1 *1*	8.0 *5*	376.8	(8^+)	(E1)		0.366	
		276.8 *1*	20.2 *19*	171.1	(9^+)	(E1)		0.0556	
		367.8 *1*	100 *7*	80.1	(8^+)	(E1)		0.0308	
		447.9 *1*	37 *4*	0.0	(7^+)	(E1)		0.0209	
469.2	(7^+ to 10^+)	298.1 *3*	47 *14*	171.1	(9^+)	[D,E2]		0.98 *93*	
		389.1 *2*	100 *23*	80.1	(8^+)	[D,E2]		0.47 *44*	

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Adopted Levels, Gammas (continued)

$\gamma(^{254}Es)$ (continued)

† From ^{258}Md α decay (51.50 d).
‡ The ordering of the 189.1-214.7 γ cascade is not established.
# 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.
@ Placement of transition in the level scheme is uncertain.

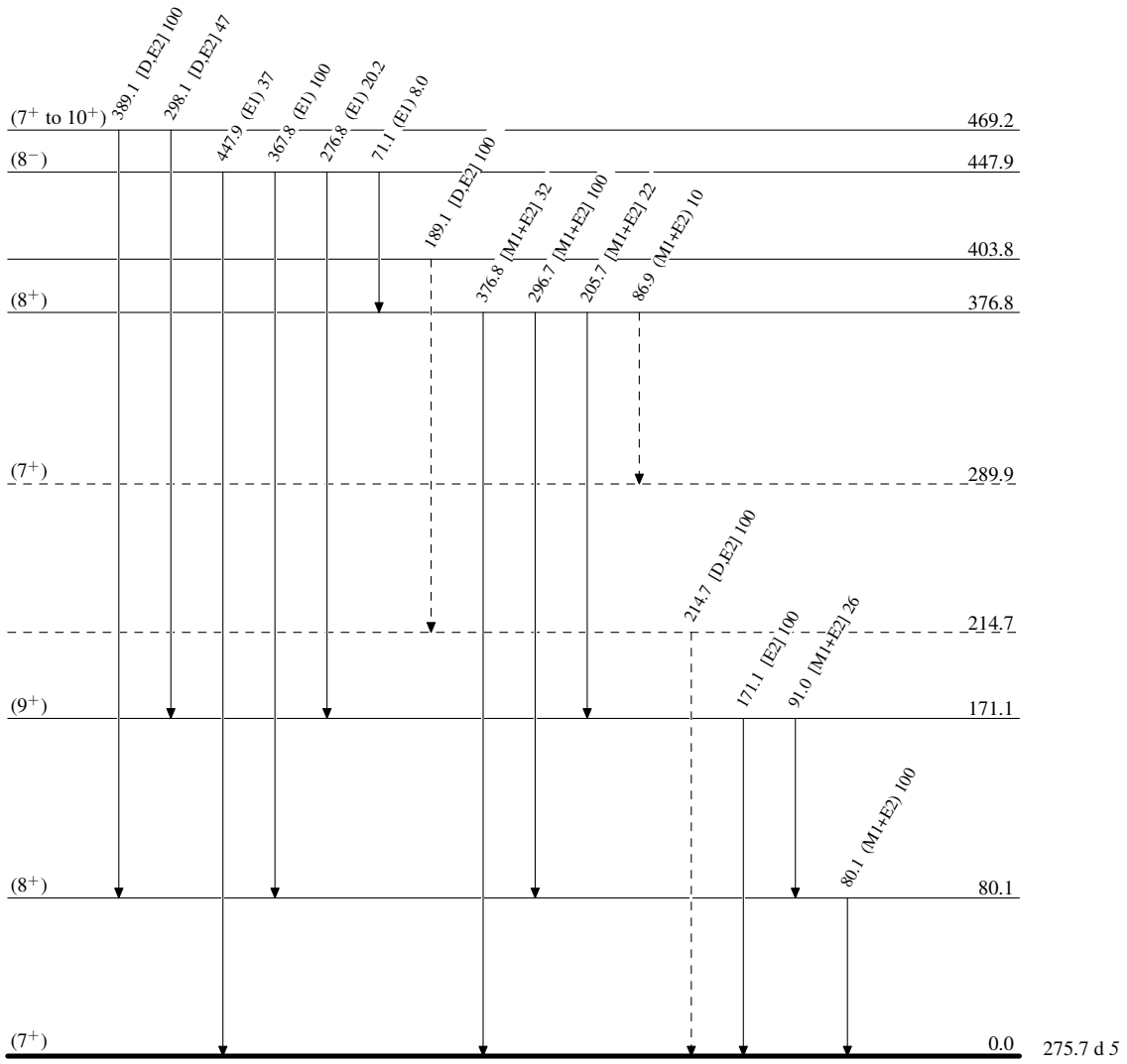
Adopted Levels, Gammas

Legend

Level Scheme

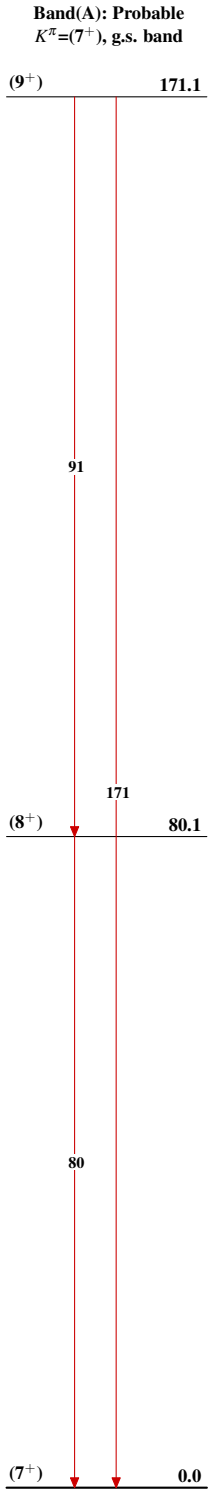
Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{254}_{99}Es_{155}$

Adopted Levels, Gammas



$^{254}_{99}Es_{155}$