Adopted Levels, Gammas

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh	ENSDF	15-Jan-2020

$Q(\beta^-)$=227.2 *3*; S(n)=9200.0 *3*; S(p)=16416.0 *23*; $Q(\alpha)$=−11483.8 *20* 2017Wa10
S(2n)=15787.36 *30*, S(2p)=29772 *3* (2017Wa10).
Note that S(n)=9203.218 keV *5* deduced by 2001Pa15 from ^{31}S(n,γ) is in disagreement with value from 2017Wa10, who had considered this measurement in their global AME analysis.
Mass measurements: 2003Bl17, 2009Kw02, 2009Sc09.
Mass deduced from IMME analysis: 2010Ka30.
Strong absorption radius measurement: 1999Ai02:
Theoretical nuclear structure calculations: consult Nuclear Science References database at www.nndc.bnl.gov/nsr/ for 65 primary references.
Additional information 1.

^{32}Si Levels

Cross Reference (XREF) Flags

A	^{32}Al β^- decay (32.3 ms)	E	^{31}Si(n,γ)
B	^{33}Al β^-n decay (41.5 ms)	F	Coulomb excitation
C	^{30}Si(t,p)	G	^{208}Pb(^{37}Cl,X)
D	^{30}Si(t,pγ)		

E(level)[†]	J^π	$T_{1/2}$[‡]	XREF	Comments
0.0	0^+	157 y *7*	ABCDEFG	$\%\beta^-$=100 r_0^2=1.15 fm^2 *7* (1999Ai02 in Si(^{32}Si,X) at 44.78 MeV/nucleon). Also cross section measured in this work. $T_{1/2}$: weighted average (NRM) of 159.4 y *56* (2015HeZY, decay rate); 178 y *10* (1998Ni19, measurement of the decrease of activity with depth in an accurately dated varved sediment core from the Kassjon lake, North Sweden, indirect but seemingly a reliable measurement); 132 y *13* (1993Ch10, average of 128 y *20* and 134 y *16*, two different samples, accelerator mass spectroscopy (AMS) technique); 162 y *12* (1991Th06, AMS and activity); 133 y *9* (1990Ho27, average of 135 y *10*, 132 y *9* and 136 *13* from three different samples, AMS and activity, uncertainty increased to 9.9 y in NRM); 172 y *4* (1986Al10, decay rate, uncertainty increased to 7.5 y in NRM); 108 y *18* (1980El01, AMS, uncertainty increased to 20 y in NRM); and 101 y *18* (1980Ku11, AMS, uncertainty increased to 22 y in NRM). Normalized χ^2=4.4, as compared to critical χ^2=2.0. Unweighted average is 143 y *10*, while regular weighted average is 161 y *7*, with normalized χ^2=6.4. $T_{1/2}$: Direct, specific activity methods for half-life measurement: 1993Ch10: source from implantation of separated projectile (^{40}Ar beam) fragments into an inert collector, decay equilibrium technique, two independent samples. 1991Th06: source produced in ^{18}O(^{16}O,2p) reaction. ^{32}Si/^{31}Si abundance ratio using AMS (accelerator mass spectrometry), and β scintillation spectrometry. 1990Ho27: source produced in ^{37}Cl(p,X) and ^{31}P(n,p) reactions. ^{32}Si/Si abundance ratio by AMS, and β spectrometry. Three independent samples. 1980Ku11: source from ^{30}Si(t,p), AMS technique and β-scintillation spectrometry. 1980El01: source from Cl(p,X), AMS technique and β-scintillation spectrometry. $T_{1/2}$: Direct decay rate methods: 2015HeZY: used the same detector system and source as in 1986Al10. Counting for 6000 hours between June 2013 and June 2015. 1986Al10: source from ^{30}Si(t,p), β decay rate measured over four years. $T_{1/2}$: the values from indirect methods, described below, were not used in the averaging procedure because the accumulation rates of ^{32}Si in ice cores and sediments are not known well, and the cross sections in reactions are poorly known for determining yields

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Adopted Levels, Gammas (continued)

^{32}Si Levels (continued)

E(level)†	J^π	$T_{1/2}$‡	XREF	Comments
				that were used to determine the half-life in the pre-1970 measurements. $T_{1/2}$: indirect methods (accumulation rates of the naturally occurring ^{32}Si in different environments): $T_{1/2}$: 178 y *10* (1998Ni19, measurement of the decrease of activity with depth in an accurately dated varved sediment core from the Kassjon lake, North Sweden, note that this value is close to the values from direct measurements, thus included in averaging); 276 y *32* (1980De46, natural source from varved core of Gulf of California, later corrected to 217 y *29* by J.B. Cumming, Radiochem. Radioanaly. Lett. 58, 297 (1983)); 330 y *40* (H.B. Clausen: Journal of Glaciology 12, 411 (1973), natural source from Greenland ice cores, later corrected to 250 y in 1980De46). $T_{1/2}$: indirect methods (reaction yields, mainly in successive neutron captures in ^{30}Si): $T_{1/2}$: ≈280 y (Jantsch, Kernenergie 10, 89 (1967)); ≈500 y (1964Ho31); ≈ 650 y (1962Ge16); ≈ 42 y (Roy: Can. Jour. Chem. 35, 176 (1957), 600 y/barn for ^{31}Si(n,γ) reaction, and σ=0.07 for E=thermal); ≈60 y (Turkevich: Phys. Rev. 94, 364 (1954)); ≈710 y (1953Li21). $T_{1/2}$: see 1991Ku26 for a review of ^{32}Si half-life measurements, 2009Se07 for discussion of possible oscillations in exponential decay of ^{32}Si in the measurement by 1986Al10; and 2010Ja03 and 2010St07 for power-spectrum analyses and discussion of variation of decay constant from solar influence. Using the BNL counting system and the ^{32}Si and ^{36}Cl sources (as used by 1986Al10), 2018Fi04 investigated correlation between the two decays in a 5-hour time interval immediately following the GW170817 binary neutron star inspiral on August 17, 2017; claiming observation of a correlation of the two decay rated on August 17, 2017, with an upward fluctuation peaking at 93 min following the arrival of the gravity wave detected by the LIGO apparatus.
1941.4 *3*	2^+	0.78 ps *22*	ABCD FG	B(E2)↑=0.0113 *33* (1998Ib01) J^π: E2 γ to 0^+; L(t,p)=2. $T_{1/2}$: weighted average of 0.91 ps *+37−21* from B(E2)(↑)=0.0113 *33* (1998Ib01), and 0.64 ps *22* from DSAM in (t,pγ) (1972Pr18). Other: 0.33 ps *5* from DSAM in (t,pγ) (1974Gu11) seems discrepant. $2016Pr01 evaluation gives $T_{1/2}$=0.84 ps *+17−19*.
4230.8 *8*	2^+	0.26 ps *9*	A CD	J^π: L(t,p)=2.
4983.9 *11*	0^+	<0.30 ps	A CD	J^π: L(t,p)=0.
5220 *3*	(1^+)	<80 fs	CD	J^π: possible unnatural-parity state from (p,t).
5288.8 *8*	3^-	152 fs *35*	CD	J^π: L(t,p)=3.
5412.4 *9*	1	<50 fs	D	E(level): see comment for 5427 level. J^π: 1 from $\gamma\gamma(\theta)$ in (t,pγ); dipole γ to 0^+.
5427 *14*	2^+		C	E(level): this level is different from the 5412 level in (t,pγ), as the spin assignments in (t,p) and (t,pγ) are different. J^π: L(t,p)=2.
5502 *4*	$(5^-,4^+)$		CD G	J^π: 5^- or 4^+ from L(p,t)=5,4 with some preference for L=5. In (p,t), 1982Fo02 support 5^- on the basis that observed cross section is three times as large as predicted for a 4^+ state from theoretical calculations. $T_{1/2}$: 2002AsZY assign isomer of $T_{1/2}$=33.4 ns *5* to this state. See 5581 level.
5581 *4*	(5^-)	27 ns *2*	G	E(level): level proposed by 1997Fo01 (also 1998Fo07). But 2002AsZY using ^{198}Pt(^{37}Cl,X) at 9 MeV/nucleon did not confirm this level since they did not observe a 79-keV γ ray. J^π: from systematics of (5^-) to (4^+) transitions in N=18 isotones e.g. ^{34}S and ^{36}Ar, as assigned and discussed by 1997Fo01. $T_{1/2}$: from γ(t) in ^{208}Pb(^{37}Cl,X) (1997Fo01). 2002AsZY report an isomer with $T_{1/2}$=33.1 ns *5* but assign this isomer to 5502 state.
5773 *2*	(1,2,3)	<139 fs	cD	J^π: D+Q γ to 2^+.
5785.7 *16*	$(0,1,2)^+$	≥0.8 ps	A cD	J^π: allowed β feeding (log *ft*=4.8) from 1^+ parent; L(t,p=(0) for one component of a doublet from L(t,p)=(0), other component could be 5773

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Adopted Levels, Gammas (continued)

^{32}Si Levels (continued)

E(level)[†]	J^π	$T_{1/2}$[‡]	XREF	Comments
				level.
5893 *8*	(3^+)		C	E(level): possible doublet in (p,t). J^π: possible unnatural-parity state from (p,t).
5954 *2*	2^+	≤55 fs	D	J^π: see comment for 5967 level. J^π: 2 from p$\gamma(\theta)$ in (t,pγ); E2 γ to 0^+.
5967 *4*	3^-		C	E(level): this level is different from the 5954 in (t,pγ), as the spins from the two studies are different. J^π: L(t,p)=3.
6170 *5*	(2^+)	≤55 fs	cD	E(level),J^π: 6208 *9* with L=1+2 in (t,p) is a doublet.
6195 *4*	1^-	≤38 fs	cD	E(level),J^π: 6208 *9* with L=1+2 in (t,p) is a doublet; dipole γ to 0^+.
6242 *5*	0^+	≤55 fs	CD	J^π: L(t,p)=0.
6388 *3*	2^+	<42 fs	CD	J^π: L(t,p)=2.
6477 *6*	3^-		C	J^π: L(t,p)=3.
6705 *6*	1^-		CD	XREF: C(6734). J^π: L(t,p)=1; dipole γ to 0^+.
6860 *5*	3^-		C	J^π: L(t,p)=3.
7083 *5*	2^+		C	J^π: L(t,p)=2.
7482 *9*			C	
7743 *6*			C	
7793 *9*	$3^-,4^+$		C	J^π: L(t,p)=3.
7887 *18*			C	
7978 *14*	3^-		C	J^π: L(t,p)=3.
8066 *9*	2^+		C	J^π: L(t,p)=2.
8321 *8*	5^-		C	J^π: L(t,p)=5.
8361 *10*	2^+		C	J^π: L(t,p)=2.
8422 *10*			C	
8567 *8*	3^-		C	J^π: L(t,p)=3.
8650 *15*	2^+		C	J^π: L(t,p)=2.
8758 *9*	$3^-,4^+$		C	J^π: L(t,p)=3,4.
8842 *13*			C	
8877 *8*			C	
8971 *9*			C	
9003 *7*			C	
9192 *12*			C	
(9203.218 *5*)	$1^+,2^+$		E	E(level): this value is in diasgreement with S(n)=9200.0 *3* in 2017Wa10. J^π: s-wave capture in $3/2^+$ g.s. of ^{31}S.
9543 *6*			C	
9701 *6*			C	
9782 *12*			C	
9934 *29*			C	
9975 *25*			C	
10052 *5*			C	
10237 *5*			C	
10279 *6*			C	
10317 *5*			C	
10461 *9*			C	
10603 *15*			C	
10664 *14*			C	
10725 *9*			C	
10778 *13*			C	
10846 *13*			C	
10888 *12*			C	
10971 *9*			C	
11398 *7*			C	
11454 *8*			C	

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Adopted Levels, Gammas (continued)

^{32}Si Levels (continued)

† From Eγ data, when uncertainties in Eγ are known, otherwise from (t,p) and/or (t,pγ).
‡ For excited states above 4 MeV, values are from DSAM in (t,pγ), unless otherwise stated.

γ(^{32}Si)

E_i(level)	J^π_i	E_γ†	I_γ‡	E_f	J^π_f	Mult.@	δ@	Comments
1941.4	2+	1941.4# *3*	100#	0.0	0+	E2		B(E2)(W.u.)=4.4 *13*
4230.8	2+	2289.4# *8*	61# *5*	1941.4	2+	M1+E2	−0.8 *4*	B(M1)(W.u.)=0.0016 *9*; B(E2)(W.u.)=0.8 *6*
		4230.0# *15*	100# *5*	0.0	0+	[E2]		B(E2)(W.u.)=0.17 *6*
4983.9	0+	3042.3# *10*	100#	1941.4	2+	[E2]		B(E2)(W.u.)>1.2
5220	(1+)	989&	<1	4230.8	2+			
		3278	100	1941.4	2+			
		5219&	<2	0.0	0+			
5288.8	3−	1058	12 *4*	4230.8	2+	(E1(+M2))	0.0 *2*	B(E1)(W.u.)=0.00039 *16*
		3347	100 *4*	1941.4	2+	(E1(+M2))	+0.02 *5*	B(E1)(W.u.)=0.000104 *25*
		5288&	<3.4	0.0	0+			
5412.4	1	1181	11 *3*	4230.8	2+			
		3471	100 *3*	1941.4	2+	D(+Q)	−0.13 *33*	
		5412	12.3 *24*	0.0	0+	D		
5502	(5−,4+)	1271&	<8	4230.8	2+			
		3560	100	1941.4	2+			E3 assigned in 2002AsZY, based on (5−) assignment for 5502 level, but E2 in 1997Fo01 based on 4+ assignment for 5502 level.
		5502&	<20	0.0	0+			
5581	(5−)	79 *1*		5502	(5−,4+)			E_γ: from 1997Fo01, not confirmed by 2002AsZY.
5773	(1,2,3)	3831	100	1941.4	2+	D+Q		
5785.7	(0,1,2)+	3844.0# *15*	100#	1941.4	2+			
5954	2+	4012	100 *4*	1941.4	2+	(M1(+E2))	−0.01 *6*	B(M1)(W.u.)>0.0046
		5953	35 *4*	0.0	0+	E2		B(E2)(W.u.)>0.059
6170	(2+)	4229		1941.4	2+			
6195	1−	4253	100 *10*	1941.4	2+			
		6194	56 *10*	0.0	0+	(E1)		B(E1)(W.u.)>2.7×10^{-5}
6242	0+	4301		1941.4	2+	[E2]		B(E2)(W.u.)>1.2
6388	2+	2161	6.4 *11*	4230.8	2+			
		4446	100.0 *11*	1941.4	2+	(M1(+E2))	+0.04 *4*	B(M1)(W.u.)>0.0055
		6387&	<3.2	0.0	0+	[E2]		B(E2)(W.u.)>0.0031
6705	1−	2474	22 *6*	4230.8	2+			
		4763	9 *7*	1941.4	2+			
		6704	100 *7*	0.0	0+	D		
(9203.218)	1+,2+	9201.798 *5*		0.0	0+			E_γ: from (n,γ).

† From level-energy differences in (t,pγ), unless otherwise stated.
‡ From (t,pγ), unless otherwise stated.
# From ^{32}Al β^- decay.
@ From (t,pγ), based on pγ(θ) data, and RUL when level half-lives are known.
& Placement of transition in the level scheme is uncertain.

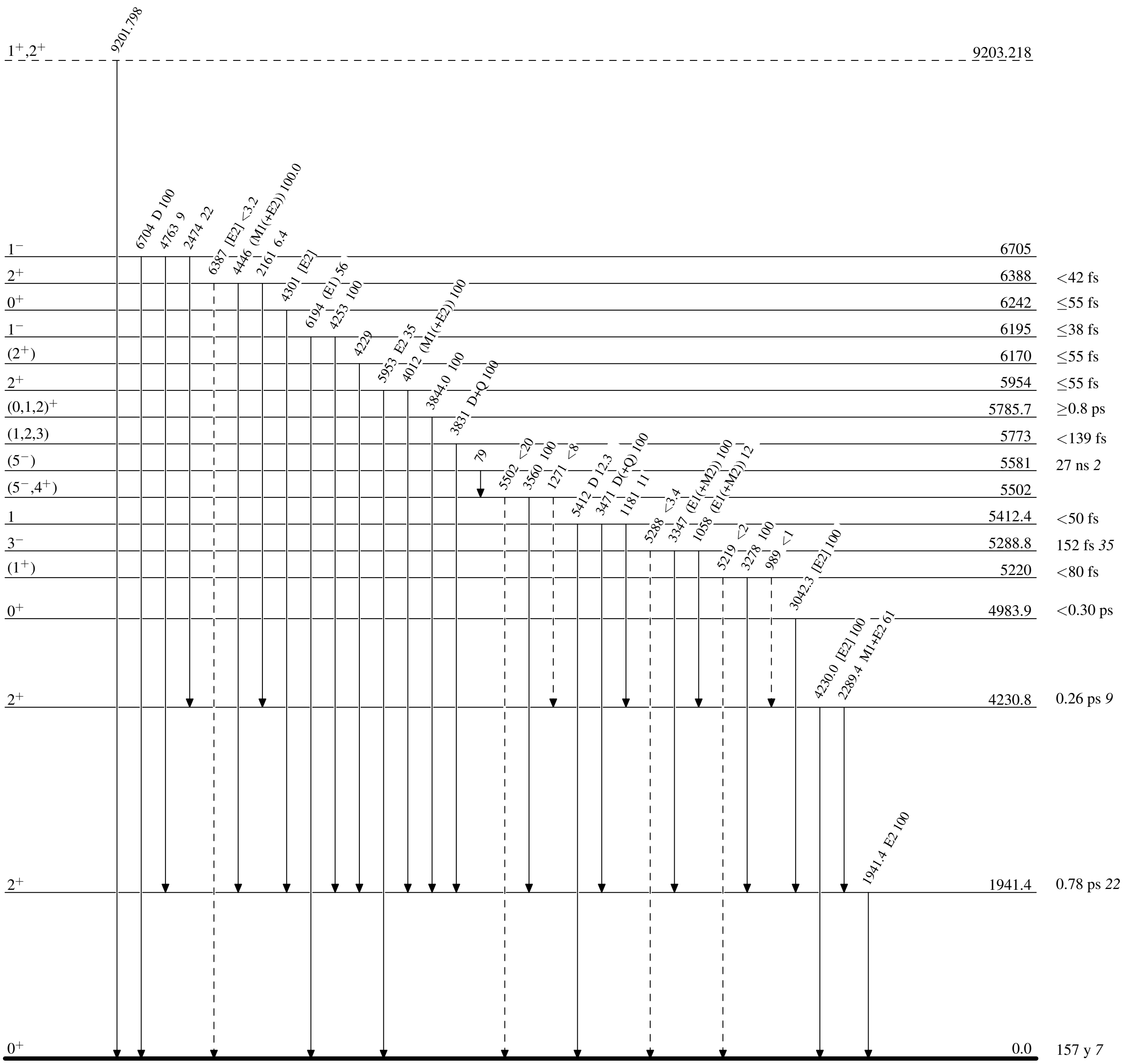
Adopted Levels, Gammas

Legend

Level Scheme

Intensities: Relative photon branching from each level

γ Decay (Uncertain)



$^{32}_{14}$Si$_{18}$