^{32}Na β^- decay (13.2 ms) 2007Ma04,2008Tr04,1993Kl02

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	Jun Chen	NDS 201,1 (2025)	31-Oct-2024

Parent: ^{32}Na: E=0; J$^\pi$=(3$^-$); $T_{1/2}$=13.2 ms *4*; Q(β^-)=19470 *40*; %β^- decay=100

^{32}Na-J$^\pi$,$T_{1/2}$: From Adopted Levels of ^{32}Na.

^{32}Na-Q(β^-): From 2021Wa16.

^{32}Na-%β^- decay: %β^-n=24 *7* and %β^-2n=8.3 *21* (1993Kl02), adopted in Adopted Levels of ^{32}Na. Others: %β^-n=32 *13* (1984Gu19), 21 *8* (1984La03); %β^-2n=8 *3* (1984Gu19), 9.4 *25* (1984La03).

2007Ma04: ^{32}Na source was produced by bombarding a 22.4 g/cm^2 tantalum target with a 500 MeV proton beam from the TRIUMF cyclotron, and delivered to the 8π experimental station. β particles were detected with the SCintillating Electron Positron Tagging ARray (SCEPTAR) consisting of 20 plastic scintillators, a nearly 4π inner array; γ rays were detected with the 8π spectrometer consisting of 20 HPGe detectors. Measured Eγ, Iγ, $\gamma\gamma$-coin, $\beta\gamma\gamma$-coin. Deduced levels. Comparisons with available data.

2008Tr04: ^{32}Na source was produced in reaction ^{9}Be(^{48}Ca,X) with E=140 MeV/nucleon beam provided by NSCL at Michigan State University. Fragments were separated by A1900 spectrometer and implanted into a double-sided silicon strip detector (DSSD) as part of Beta counting system. Measured half-lives using time-of-flight. γ rays were detected with the segmented SeGA array of 16 HPGe detectors. Measured Eγ, Iγ, $\gamma\gamma$-coin, $\beta\gamma$-coin, γ(t). Deduced levels, J, π, β-decay branching ratios, log *ft*. Comparisons with theoretical calculations.

1993Kl02: Na isotopes were produced by bombarding an Uranium Carbide target with 600 MeV protons from the CERN synchrocyclotron and separated by the ISOLDE2 separator. β particles were detected with a thin plastic scintillator, neutrons were detected with an detector liquid scintillator, and γ rays were detected with two Ge detectors. Measured Eγ, Iγ, $\beta\gamma$-coin, $\beta\gamma\gamma$-coin, $\beta\gamma$-n-coin. Deduced levels, J, π, branching ratios, log *ft*.

1984Gu19: Na isotopes were produced by bombarding a 30 g/cm^2 Ir target with 10 GeV proton beam from the CERN synchrotron. Fragments were separated and collected into a thin stainless steel tube. γ rays were detected with two Ge(Li) detectors and β particles were detected with two plastic scintillators. Measured Eγ, Iγ, $\beta\gamma$(t), $\beta\gamma$-coin, $\beta\gamma\gamma$-coin. Deduced levels, $T_{1/2}$, γ-ray branching ratios, β-delayed neutron-emission probabilities. Other papers from the same group with the same experimental setup are 1984La03: measured %β^-n, half-life and βn-coin; 1983De04: measured Q value, $\beta\gamma$-coin; 1979De02: measured γ(t), $\beta\gamma$-coin.

Others:

2005Ma96, 2005Ma81: measured Eγ, $\gamma\gamma$-coin, $\beta\gamma\gamma$-coin, Iγ, and lifetime using an Advanced Time Delayed method. The β particles were detected with a thin plastic scintillator, γ-rays detected with two large volume Ge detectors. The ^{32}Na isotope produced by 1.4 GeV proton induced reaction in UC_x graphite target at ISOLDE facility.

1998NoZW, 1999YoZW: $T_{1/2}$, β^-n.

1983De04, 1980De26, 1979De02, 1978De39, 1975Th08: measured Q value.

1972Kl04 (also 1972RiZJ thesis): measured $T_{1/2}$, first isotopic identification in U(p,X) reaction at E=24 GeV, CERN-ISOLDE.

From RADLIST code, deduced energy balance=12420 keV *820* is in an agreement with 13240 keV *1360* from Q-value=19470 *40* (2021Wa16) and adopted branching of 68% *7* for population of levels in ^{32}Mg by β^- decay.

^{32}Mg Levels

S(n)=5778 *4* and S(2n)=8090 *4* for ^{32}Mg (2021Wa16).

A 2117 level proposed by 1993Kl02 is omitted here due to the revised placement of the 1231.7γ.

E(level)[†‡]	J$^\pi$[#]	$T_{1/2}$[#]	Comments
0.0	0$^+$	80.4 ms *4*	
885.0 *4*	2$^+$	13.1 ps *10*	$T_{1/2}$: other: 16 ps *4* from $\beta\gamma\gamma$(t) (2005Ma96,2005Ma81, preliminary result) in this study.
2320.8 *6*	4$^+$	0.62 ps *15*	
2550.8 *4*	(1$^-$,2$^+$)		
2858.3 *6*	(1$^-$,3$^-$)		J$^\pi$: other: (2$^-$,3$^-$) proposed in 2008Tr04.
3036.9 *5*	(2$^-$)		
3552.2 *6*	(3$^-$,4$^-$)[@]		
4783.9 *8*			

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^{32}Na β^- decay (13.2 ms) 2007Ma04,2008Tr04,1993Kl02 (continued)

^{32}Mg Levels (continued)

E(level)[†‡]	J$^\pi$[#]	Comments
4819.6 *5*	(2$^-$,3$^-$)[@]	
5778+x		E(level): x<13690 *40* from Q(β^-)(^{32}Na)-S(n)(^{32}Mg), where Q(β^-)=19470 *40* and S(n)=5778 *4* from 2021Wa16. This represents a range of unobserved levels that subsequently decay to ^{31}Mg via one-neutron emission.
8652+y		E(level): y<11380 *40* from Q(β^-)(^{32}Na)-S(2n)(^{32}Mg), where S(2n)=8090 *4* from 2021Wa16. This represents a range of unobserved levels that subsequently decay to ^{30}Mg via two-neutron emission.

[†] Additional information 1.
[‡] From a least-squares fit to γ-ray energies.
[#] From Adopted Levels, unless otherwise noted.
[@] Adopted assignment is from shell-model predictions in 2008Tr04.

β^- radiations

E(decay)	E(level)	Iβ^-[†‡]	Log *ft*	Comments
(5×10^3[@] *5*)	8652+y	8.3 *21*		Iβ^-: from adopted %β^-2n=8.3 *21* for the decay of ^{32}Na g.s.
(7×10^3[@] *7*)	5778+x	24 *7*		Iβ^-: from adopted %β^-n=24 *7* for the decay of ^{32}Na g.s.
(1.465×10^4 *4*)	4819.6	13.8 *15*	5.0	av Eβ=7054 *20*
(1.469×10^4 *4*)	4783.9	<2.5	>5.7	av Eβ=7071 *20*
(1.592×10^4 *4*)	3552.2	<6	>5.5	av Eβ=7679 *20*
(1.643×10^4 *4*)	3036.9	22.7 *19*	5.0	av Eβ=7932 *20*
(1.661×10^4 *4*)	2858.3	4.6 *25*	5.7	av Eβ=8020 *20*
(1.692×10^4 *4*)	2550.8	2.9 *7*	6.0	av Eβ=8172 *20*
(1.715×10^4[#] *4*)	2320.8	4.4 *16*	5.8	av Eβ=8285 *20* Iβ^-,Log *ft*: this decay branch is also considered questionable, since this would be expected to be first-forbidden with no or very small feeding.
(1.859×10^4[#] *4*)	885.0	10.0 *18*	5.6	av Eβ=8991 *20* Iβ^-,Log *ft*: if the predicted J^π(^{32}Na)=(3$^-$) is correct, this decay branch should be first-forbidden with no or small β-feeding, which however contradicts to the large Iβ=10.0 *18* from γ-intensity balance and to the allowed log *ft* value from this Iβ. This may also indicate that there are probably unobserved γ transitions to this level from unobserved levels in the 5-20 MeV gap. On the contrary, if the decay scheme in this dataset is complete, the allowed log *ft* value here would firmly determine π=+ for ^{32}Na parent and J=1,2,3, contradicting to π=− for ^{32}Na g.s. in all theoretical predictions. Further investigation is needed to obtain a complete decay scheme and and thus accurately determine the β-decay feedings.

[†] From γ intensity balance at each level. Due to a large energy gap of about 15 MeV between the highest observed level and Q-value, the β feedings to unobserved levels in this gap may not be solely accounted for by observed β-delayed neutrons and there could be also unobserved γ transitions to low-lying levels or unobserved neutrons. Therefore, the decay scheme here should be considered incomplete and thus the β-feeding should be considered as upper limits and associated logft values considered as lower limits.
[‡] Absolute intensity per 100 decays.
[#] Existence of this branch is questionable.
[@] Estimated for a range of levels.

^{32}Na β^- decay (13.2 ms) 2007Ma04,2008Tr04,1993Kl02 (continued)

$\gamma(^{32}Mg)$

Iγ normalization: Absolute intensity of 885γ=58 *3* in 2008Tr04, deduced from total number of β-decaying implants 12065 *250*. This value agrees with less precise values of 59 *8* from 1993Kl02 and 60 *9* from 1984Gu19 both deduced from renormalization of ΣI(γ to g.s.).

A transition at Eγ=239.5 *12* with Iγ=28 *3* is assigned to the decay of ^{32}Na decay in 1984Gu19, apparently to feed ^{32}Mg, but in 1993Kl02 this γ is assigned to delayed one-neutron decay mode. The latter assignment is adopted here.

For absolute γ-ray intensities under comments, values from 2008Tr04 are determined using measured γ-ray intensities and the total number of decays, while values from 1993Kl02 and 1984Gu19 are from normalization of ΣI(γ to g.s.) to 100−%β⁻n-%β⁻2n by assuming no β-feeding to ground state. No %Iγ is deduced in 2007Ma04.

E_γ[†]	I_γ[†@]	E_i(level)	J^π_i	E_f	J^π_f	Comments
486.1 *5*	1.3 *3*	3036.9	(2⁻)	2550.8	(1⁻,2⁺)	%Iγ=0.75 *+22−21* E_γ,I_γ: other: 485.0 *10*, Iγ=6 *1* (2008Tr04). Additional information 5.
693.5 *5*	<7.5	3552.2	(3⁻,4⁻)	2858.3	(1⁻,3⁻)	%Iγ<4.4 E_γ,I_γ: doublet with total intensity=6.9 *6*. The second component is from ^{31}Na decay to ^{31}Mg. E_γ: others: 694.4 *12* (1984Gu19), 696.0 *10* (2008Tr04). I_γ: others: 3.8 *16* (1984Gu19), 6 *1* (2008Tr04). Additional information 7.
885.0 *5*	100	885.0	2⁺	0.0	0⁺	%Iγ=58 *3* E_γ: others: 885.5 *7* (1984Gu19), 885 (1993Kl02), 885.0 *5* (2008Tr04). %Iγ: 58 *3* from (2008Tr04). Others: 59 *9* (1993Kl02), 60 *9* (1984Gu19).
1231.7[&#] *5*	<4.3	3552.2	(3⁻,4⁻)	2320.8	4⁺	%Iγ<2.5 E_γ: others: 1232.2 *12* (1984Gu19), 1232 (1993Kl02), 1232.0 *10* (2008Tr04). I_γ: from 3.8 *5* for a doublet. Others: 4.9 *14* (1984Gu19), 4.8 *17* (1993Kl02), 10 *2* (2008Tr04), for doublet. Additional information 8.
1231.7[&#] *5*	<4.3	4783.9		3552.2	(3⁻,4⁻)	%Iγ<2.5
1436.1 *5*	9.8 *7*	2320.8	4⁺	885.0	2⁺	%Iγ=5.7 *5* E_γ: others: 1436.1 *10* (1984Gu19), 1436 (1993Kl02), 1436.0 *10* (2008Tr04). I_γ: others: 10.2 *20* (1984Gu19), 9.8 *25* (1993Kl02), 15 *2* (2008Tr04). Additional information 2.
1665.6 *5*	2.4 *4*	2550.8	(1⁻,2⁺)	885.0	2⁺	%Iγ=1.39 *+32−29* E_γ: other: 1666.0 *10*, Iγ=2 *1* (2008Tr04).
1782.7 *9*	9.2 *20*	4819.6	(2⁻,3⁻)	3036.9	(2⁻)	%Iγ=5.3 *+15−14* E_γ: weighted average of 1782.4 *9* (1984Gu19) and 1783.0 *10* (2008Tr04). A 1783γ was seen by 2007Ma04 but the intensity was not deduced due to the presence of a 1778.9γ from ^{28}Al decay to ^{28}Mg. I_γ: weighted average 8.3 *20* (1984Gu19) and 10 *2* (2008Tr04). Additional information 9.
1972.9 *5*	11.6 *8*	2858.3	(1⁻,3⁻)	885.0	2⁺	%Iγ=6.7 *6* E_γ: others: 1973.0 *12* (1984Gu19), 1973 (1993Kl02), 1974.0 *10* (2008Tr04). I_γ: others: 14.3 *25* (1984Gu19), 19.7 *25* (1993Kl02), 13 *2* (2008Tr04). Additional information 4.
2151.7 *5*	47.0 *17*	3036.9	(2⁻)	885.0	2⁺	%Iγ=27.3 *17*

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^{32}Na β^- decay (13.2 ms) 2007Ma04,2008Tr04,1993Kl02 (continued)

$\gamma(^{32}Mg)$ (continued)

E_γ[†]	I_γ[†@]	E_i(level)	J_i^π	E_f	J_f^π	Comments
						E_γ: others: 2151.5 *7* (1984Gu19), 2152 (1993Kl02), 2152.0 *10* (2008Tr04). I_γ: others: 53 *6* (1984Gu19), 48.5 *37* (1993Kl02), 47 *4* (2008Tr04). Additional information 6.
2268.5 *5*	2.5 *3*	4819.6	$(2^-,3^-)$	2550.8	$(1^-,2^+)$	%Iγ=1.45 *+26−24* E_γ,I_γ: other: 2269.0 *10*, Iγ=4 *1* (2008Tr04). Additional information 10.
2550.7 *5*	6.4 *6*	2550.8	$(1^-,2^+)$	0.0	0^+	%Iγ=3.7 *4* E_γ: others: 2550.7 *10* (1984Gu19), 2551 (1993Kl02), 2551.0 *10* (2008Tr04). I_γ: others: 9.1 *20* (1984Gu19), 10.2 *25* (1993Kl02), 8 *2* (2008Tr04). Additional information 3.
[x]2869.2[‡a] *8*	1.1 *2*					%Iγ=0.64 *+16−14*
[x]2925.8[‡a] *6*	3.3 *4*					%Iγ=1.91 *+34−32*
3934.5 *5*	12.0 *8*	4819.6	$(2^-,3^-)$	885.0	2^+	%Iγ=7.0 *6* E_γ: others: 3934.8 *18* (1984Gu19), 3935 (1993Kl02), 3935.0 *15* (2008Tr04). I_γ: others: 13 *3* (1984Gu19), 18.3 *37* (1993Kl02), 18 *4* (2008Tr04). Additional information 11 (2008Tr04).
[x]4575[‡a] *3*	2.4 *4*					%Iγ=1.39 *+32−29*
[x]5470[‡a] *3*	3.3 *6*					%Iγ=1.9 *+5−4*

[†] From 2007Ma04, unless otherwise stated. Values from 1984Gu19, 1993Kl02 and 2008Tr04 given under comments are in agreement but generally less precise. The spectral purity and statistics are better in 2007Ma04 than in other studies. Some of the relative gamma-ray intensities in 2008Tr04 are much higher as compared to those in 2007Ma04 and 1993Kl02, for example, for 1436γ, Iγ=15 *2* in 2008Tr04 while it is near 10 in other three studies quoted above. Other problematic intensities are for 485γ, 1232γ.

[‡] From 2007Ma04 only; assignments to ^{32}Na decay are uncertain.

[#] The 1231.7γ was placed from a 2117 level by 1993Kl02. Here the revised double placement from γγ-coin data of 2007Ma04 is adopted; 2117 level is no longer present in the revised level scheme.

[@] For absolute intensity per 100 decays, multiply by 0.58 *3*.

[&] Multiply placed.

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

[x] γ ray not placed in level scheme.

^{32}Na β^- decay (13.2 ms) 2007Ma04,2008Tr04,1993Kl02

Decay Scheme

Intensities: $I_{(\gamma+ce)}$ per 100 parent decays