^{100}Sn ε decay (1.18 s) 2019Lu08,2012Hi07

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	Balraj Singh and Jun Chen	NDS 172, 1 (2021)	31-Jan-2021

Parent: ^{100}Sn: E=0.0; $J^\pi=0^+$; $T_{1/2}$=1.18 s *8*; Q(ε)=7.46×10^3 *16*; %ε+%$β^+$ decay=100.0

^{100}Sn-$T_{1/2}$: weighted average of 1.18 s *8* (2019Lu08, average of 1.17 s *10* from decay correlations of 2500 ^{100}Sn implantations, and 1.19 s *10* from implant-γ correlations); and 1.16 s *20* (2012Hi07, from time distribution of decay events correlated with 163 ^{100}Sn implantations analyzed by maximum likelihood method taking into account half-life of daughter nuclei and small background). Others: 0.55 s *+70−31* (2008Ba53, from β decays correlated with 14 *5* implanted nuclei); 1.00 s *+54−26* (2002Fa13, from one event in 2002Fa13 and six in 1996Ki23,1994Sc22; also 0.94 s *+54−27* from analysis of seven events, 1997Su06,1996Ki23, 1994Sc22); 0.66 s *+59−22* (1995Sc28,1995Sc33, from four events). Weighted average of all the measured values from 2019Lu08, 2012Hi07, 2008Ba53, 2002Fa13, and 1995Sc28 is 1.16 s *8*, close to the Adopted value here.

^{100}Sn-Q(ε): From averaged β-endpoint energy=3.69 MeV *16* to the 2720+x and assuming x=25 keV *25*. Other: 7.03 MeV *24* (2017Wa10, based on data in 2012Hi07).

^{100}Sn-%ε+%$β^+$ decay: %ε+%$β^+$=100. %εp<17 (1997Su06,1996Ki23), <35 (2012Lo08).

2019Lu08: ^{100}Sn from 345 MeV/nucleon ^{124}Xe beam incident on a 4 m.m. thick ^{9}Be target at the RIKEN-RIBF facility. The identification of the nuclide of interest was made through the BigRIPS separator and the ZeroDegree spectrometer by determining the atomic number and the mass-to-charge ratio of the ion using the tof-Bρ-ΔE method. The secondary beam was stopped in the double-sided silicon strip detector of the WAS3ABi spectrometer. A total of 2500 nuclei of ^{100}Sn were detected. The γ rays were detected by EURICA array comprising 47 HPGe detectors. Measured Eγ, Iγ, $β^+$, γγ-coin, (implant)γ-coin, end-point energy from $β^+$ spectrum, and half-life of ^{100}Sn decay by (implant)γ-decay and implantations decay curves. Comparisons with previous experimental data and shell-model calculations.

2012Hi07: ^{100}Sn produced in fragmentation of ^{124}Xe beam at 1.0 GeV/nucleon with a 4.008 g/cm^2 thick beryllium target at GSI facility. The FRS fragment separator was used to separate reaction products. Fragments were separated and identified event-by-event with respect to A/Q and Z based on magnetic rigidity and flight times. A total of 259 ^{100}Sn nuclei were identified, much more than in any previous experiment. The ions were implanted into segmented Si strip detectors surrounded by the RISING array consisting of 105 Ge detectors. Measured Eγ, Iγ, γγ-coin, Eβ, Iβ, ^{100}Sn half-life by detecting radiations in correlation with 163 ^{100}Sn nuclei stopped in the implantation layer. Out of 163 ^{100}Sn implanted nuclei, 126 decay chains could be assigned. A tentative decay scheme with γ rays is proposed by 2012Hi07 for the first time.

2008Ba53: measured half-life of the decay of ^{100}Sn, and production cross section in ^{9}Be(^{112}Sn,X),E=120 MeV/nucleon at NSCL-MSU.

2002Fa13: measured half-life of ^{100}Sn decay and β-endpoint energy.

1997Su06, 1996Ki23: measured half-life of ^{100}Sn decay and β-endpoint energy.

Identification and production of ^{100}Sn: 1995Sc28 (also 1994Sc22, 1995Sc33) and 1995Le14 (also 1994Le27, 1995Ry03).

The proposed decay scheme is based on experimental observation of five gamma rays and a theoretical level scheme from large-scale shell model calculations (2012Hi07). Based on measured intensities, all five gamma rays could be placed in a single cascade with the energy of the 1^+ state at about 4 MeV, but measured Q(ε)=4.31 MeV does not permit such placement, thus parallel paths are proposed for the 1297 and 2048 γ rays. All the five γ rays were confirmed in 2019Lu08, where the number of implanted ^{100}Sn was an order of magnitude larger than in 2012Hi07. With higher statistics, 2019Lu08 could also have γγ-coin data for the 95, 141, 436 and 1297 γ rays, while only event is observed for 95γ, when gated on 2048-keV γ ray.

^{100}In Levels

E(level)†	J^π‡	$T_{1/2}$	Comments
0	(6^+)	5.65 s *6*	$T_{1/2}$: weighted average of 5.62 s *6* (2019Pa16, weighted average of 5.60 s *6* from β-correlated decay curve and 5.70 s *16* from βp-correlated decay curve); 5.8 s *2* (2019Lu08, (implant)γ-correlated decay curve); 5.7 s *3* (2012Lo08, βγ- and βp-implants-correlated decay curves); and 5.9 s *2* (2002Pl03). Others: 6.1 s *9* (1995Sz01), 7.8 s *8* (1995Sc33).
0+x	(5^+)		E(level): x<50 keV (estimated by 2019Lu08), <80 keV (estimated by 2012Hi07).
95+x	(4^+)		
236+x *2*	(3^+)		
672+x *2*	(2^+)		
(1423+x *2*)	(2^+)		E(level): level proposed from deexcitation of 1297γ from the 2721+x level, but no deexciting γ

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^{100}In Levels (continued)

E(level)†	Jπ‡	Comments
		transitions reported in either 2012Hi07 or 2019Lu08. From large-scale shell-model calculations, 2012Hi07 proposed decays to 236+x, a (3+) level below the 672+x level, and 672+x level with branching ratios of 78%, 11% and 11%, respectively.
2720+x *2*	1+	E(level): value is consistent with measured E(β-endpoint)=2.6 MeV *10*, 2.93 MeV *34* from observation of a single event of β-delayed proton emission (2012Hi07), and 2.76 MeV *43* from TAGS data (1996Ki23, 1997Su06). Theoretical calculations suggest 1+ level at 2533 (1996Ki23), 2963 (2012Hi07). Jπ: Gamow-Teller transition from 0+ parent state with log *ft*=2.85, assuming 100% β++ε feeding to this level. From observation of a single proton event attributed to delayed proton decay in 2012Hi07, %p decay of this level is estimated by 2012Hi07 as <1%. Other: <17% (1997Su06,1996Ki23).

† From Eγ data.

‡ From large-scale shell model calculations (2012Hi07); levels have either pure configuration=$\pi g^{-1}_{9/2}\otimes\nu g^{1}_{7/2}$ or belong to $\pi g^{-1}_{9/2}\otimes\nu d^{1}_{5/2}$ multiplet.

ε,β+ radiations

E(decay)	E(level)	Iβ+ †	Iε†	Log *ft*	I(ε+β+)†	Comments
4.71×10^3 *16*	2720+x	≈90	≈10	2.85 *9*	≈100	av Eβ=1685 *77*; εK=0.085 *11*; εL=0.0108 *14*; εM+=0.0027 *4* E(decay): measured E(β-endpoint)=3.91 MeV *15* (2019Lu08, weighted average of 3.88 MeV *16* from ungated β spectrum and 4.12 MeV *27* from γ-gated β spectrum); 3.29 MeV *20* (2012Hi07); 3.8 MeV *+7−3* (2002Fa13), 3.4 MeV *+7−3* in 1997Su06 and 1996Ki23. Weighted averaged β-endpoint energy=3.69 MeV *16*, which gives Q(ε)=7.46 MeV *16*, assuming x=25 keV *25*. 2019Lu08 give 7.69 MeV *16* based on their measured β-endpoint energy. This transition is expected to be superallowed Gamow-Teller (0+ to 1+) transition. Deduced log *ft* value=2.95 *8* (2019Lu08), 2.62 *+13−11* (2012Hi07), assuming 100% ε+β+ branch to 2720+x, 1+ level. This log *ft* value is one of lowest values in the nuclear chart, being lower than that for the 0+ to 0+ superallowed β transitions. I(ε+β+): summed γ intensity of 1297 and 2048 γ rays in 2019Lu08 almost equals the observed number of annihilation pairs, pointing out no significant β++ε feedings to higher levels, and also no significant β+p decay mode. B(GT)=4.4 *+9−7* (2019Lu08), 9.1 *+26−30* (2012Hi07) if 100% β++ε decay occurs to 1+ state at 2721+x. 2012Hi07 estimated B(GT)=7.6 *+22−25* if additional four lowest 1+ states are assumed populated in β+ decay.

† Absolute intensity per 100 decays.

γ(^{100}In)

Iγ normalization, I(γ+ce) normalization: The γ-normalization obtained by equating 960 *166* annihilation pairs in 2019Lu08 to 100. For the γ intensities given in 2012Hi07, which are per 100 decays of the parent, γ-normalization factor would be 0.83 *24* from summed Iγ=100 for 1297γ and 2048γ. The normalization factor is treated by the evaluators as approximate as the γ intensities in the work of 2019Lu08 are not corrected for all the relevant factors (e-mail of Dec 18, 2019 from J. Park).

Measured absolute intensity of the annihilation pairs=960 *166* (e-mail reply from authors of 2019Lu08).

The γγ-coin data are mainly from 2019Lu08.

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γ(^{100}In) (continued)

E_γ †	I_γ ‡#	E_i(level)	J_i^π	E_f	J_f^π	Mult.	α @	$I_{(\gamma+ce)}$ ‡#	Comments
95 *1*	63×10[1] *12*	95+x	(4$^+$)	0+x	(5$^+$)	(M1)	0.573 *19*	99×10[1] *19*	$I_{(\gamma+ce)}$: 988 *191* (e-mail reply from authors of 2019Lu08). Absolute I(γ+ce)=79 *40* for 96γ (2012Hi07), implying Iγ=50 *25*. The 96 and 141 γ rays were found to be in coincidence in 2012Hi07.
141 *1*	92×10[1] *13*	236+x	(3$^+$)	95+x	(4$^+$)	(M1)	0.196 *5*	110×10[1] *16*	$I_{(\gamma+ce)}$: 1098 *160* (e-mail reply from authors of 2019Lu08). Absolute I(γ+ce)=100 *31* for 141γ (2012Hi07), implying Iγ=84 *26*.
436 *1*	98×10[1] *13*	672+x	(2$^+$)	236+x	(3$^+$)	[M1+E2]	0.0103 *2*		I_γ: 977 *128* (e-mail reply from authors of 2019Lu08). Absolute Iγ=59 *22* for 436γ (2012Hi07).
1297 *1*	64×10[1] *12*	2720+x	1$^+$	1423+x?	(2$^+$)	[M1+E2]	0.00078 *6*		I_γ: 637 *123* (e-mail reply from authors of 2019Lu08). Absolute Iγ=72 *26* for 1297γ (2012Hi07).
2048 *1*	36×10[1] *12*	2720+x	1$^+$	672+x	(2$^+$)	[M1+E2]	0.00062 *1*		When gated on 2048γ, only one event was seen at 95 keV in 2019Lu08. I_γ: 365 *114* (e-mail reply from authors of 2019Lu08). Absolute Iγ=53 *26* for 2048γ (2012Hi07).

† From 2019Lu08, uncertainty of 1 keV for each Eγ value from e-mail reply of May 3, 2019 from T. Faestermann. Values are the same in 2012Hi07, except 96 keV instead of 95 keV in 2019Lu08, and no uncertainty for Eγ was available.

‡ Absolute intensities deduced from data for 1970 implanted ^{100}Sn nuclei: data provided in e-mail reply of May 3, 2019 from T. Faestermann. In a further e-mail of Dec 18, 2019 from J. Park, it was indicated that while efficiency correction was applied for the gamma-detection, but not for the β-correlated and conversion electrons events. Also no dead-time correction was applied. Values supplied by authors of 2019Lu08 have been divided by a factor of 10. Absolute Iγ values from 2012Hi07 are given under comments.

For absolute intensity per 100 decays, multiply by ≈0.10.

@ 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.

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