^{187}Re(n,2nγ)   2015Ma60

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. C. Batchelder and A. M. Hurst, M. S. Basunia	NDS 183, 1 (2022)	1-Mar-2022

Adapted/Edited the XUNDL dataset compiled by C. Smith (ORNL/UTK) and C.D. Nesaraja (ORNL) 17 November, 2015.

Experimental Setup: A beam of spallation neutrons from LANSCE with energies in the range of 100 keV to 600 MeV incident on a 987.1 mg ^{187}Re target enriched to 99.52%. The neutron fluence for the run ranged from 1.3×10^8 to 5.0×10^8 neutrons/MeV decreasing with increasing neutron energy ($10 \le E_n \le 25$ MeV). The target was irradiated for 12 days at 40 Hz and an additional 5 days at 100 Hz.

Detectors: γ-rays were detected with the GErmanium Array for Neutron Induced Excitations spectrometer (GEANIE), a Compton-suppressed array of 18 HPGe detectors. The GEANIE target was located 20.34 m from the spallation source along the 60° right flight path and configured with eight planar and 10 coaxial detectors. Incident neutron energies were determined by the time-of-flight technique. Neutron flux at the target was measured with a fission chamber positioned at the terminus of the neutron beam tube, 18.48 m from the spallation target and consisted of an ionization chamber that incorporates stainless steel foils coated with ^{235}U and ^{238}U.

Measured: E_n using tof method, excitation functions, Eγ.

Analyzed: Excitation function generated with reaction codes COH 3.4 and TALYS 1.6 for the purpose of placing gamma transitions in the ^{186}Re level scheme. The authors have used the shapes of excitation functions to estimate the spins for levels above the isomer; transitions originating from low-spin states have excitation functions that rise sharply after the threshold energy of the (n,2n) reaction to peak at neutron energies near 13 MeV, while those originating from high-spin states rise more gradually and peak at neutron energies between 15 and 20 MeV.

Deduced: New excitation level, spins and new gamma transitions that led to improved excitation energy of the ^{186}Re isomer with smaller uncertainty.

^{186}Re Levels

E(level)†	J$^{π\#}$	Comments
0	1^-	
59.010‡ 3	2^-	Additional information 1.
99.361‡ 3	3^-	Additional information 2.
146.275‡ 4	3^-	Additional information 3.
148.2‡ 5	(8^+)	Additional information 4.
		E(level): Based on placement of 266.7γ as depopulating the 415-keV level.
180.2‡ 7	(6^-)	Additional information 5.
210.75 6	2^-	
268.77 6	4^-	
273.627‡ 5	4^-	Additional information 6.
313.98 3	(3^+)	
316.45 4	(1^-)	
322.378‡ 6	3^-	Additional information 7.
324.3 7	5^+	
351.202‡ 16	$(4)^+$	Additional information 8.
414.9 5	(9^+)	J^π: From analogue state at 446 keV in ^{184}Re and the shape of the experimental and modeled excitation functions (TALYS and COH codes) for the 266.7 γ transition.
420.560‡ 7	(4^+)	Additional information 9.
462.42 7	5^-	
465.5 7	6^+	
469.98 7	4^-	
500.43 9	$(5)^+$	
560.18 12	(5^+)	
587.90 15	(4^-)	
601.84 13	(1^+)	
624.28 14	(1^-)	

^{187}**Re(n,2nγ)**　　**2015Ma60 (continued)**

^{186}Re Levels (continued)

E(level)[†]	J$^{\pi}$[#]	Comments
665.1 *4*	(6)$^+$	
796.1 *5*	(10$^+$)	J$^{\pi}$: Supported by similarity with 728 level in ^{184}Re and from the shape of the experimental and modeled excitation functions (TALYS and COH codes) for the 381.2 and 647.7 γ transitions.
1007.5 *3*		
1101.3 *3*	(2$^-$,3$^-$)	

[†] From a least-squares fit to the γ-ray energies, except otherwise noted, yielding normalized χ^2=2.2. 111.74γ and 151.38γ from 210.75 keV level and 210.12γ from 268.77 keV level fit poorly. The uncertainty was increased for 111.74γ (tripled), 151.38γ (doubled), and 210.12γ (doubled) in the least squares fit.

[‡] From the Adopted Levels. Level energy held fixed in the least-squares fit.

[#] From the Adopted Levels, except as noted.

γ(^{186}Re)

E$_\gamma$[†]	E$_i$(level)	J$^{\pi}_i$	E$_f$	J$^{\pi}_f$	E$_\gamma$[†]	E$_i$(level)	J$^{\pi}_i$	E$_f$	J$^{\pi}_f$
111.74 *5*	210.75	2$^-$	99.361	3$^-$	214.60 *3*	313.98	(3$^+$)	99.361	3$^-$
117.92 *13*	587.90	(4$^-$)	469.98	4$^-$	[x]217.62 *10*				
122.45 *6*	268.77	4$^-$	146.275	3$^-$	255.05 *6*	313.98	(3$^+$)	59.010	2$^-$
139.62 *12*	560.18	(5$^+$)	420.560	(4$^+$)	257.45 *7*	316.45	(1$^-$)	59.010	2$^-$
141.23 *6*	465.5	6$^+$	324.3	5$^+$	266.69 *4*	414.9	(9$^+$)	148.2	(8$^+$)
144.08 *2*	324.3	5$^+$	180.2	(6$^-$)	[x]290.51 *13*				
147.60 *7*	469.98	4$^-$	322.378	3$^-$	316.45 *5*	316.45	(1$^-$)	0	1$^-$
149.23 *8*	500.43	(5$^+$)	351.202	(4$^+$)	[x]354.28 *9*				
151.38 *8*	210.75	2$^-$	59.010	2$^-$	381.23 *7*	796.1	(10$^+$)	414.9	(9$^+$)
164.7 *3*	665.1	(6$^+$)	500.43	(5$^+$)	391.09 *11*	601.84	(1$^+$)	210.75	2$^-$
169.44 *11*	268.77	4$^-$	99.361	3$^-$	413.53 *12*	624.28	(1$^-$)	210.75	2$^-$
[x]185.99 *6*					647.7 *2*	796.1	(10$^+$)	148.2	(8$^+$)
188.79 *7*	462.42	5$^-$	273.627	4$^-$	1007.5 *3*	1007.5		0	1$^-$
210.12 *10*	268.77	4$^-$	59.010	2$^-$	1101.3 *3*	1101.3	(2$^-$,3$^-$)	0	1$^-$
210.74 *6*	210.75	2$^-$	0	1$^-$					

[†] Assignment to ^{186}Re is based on analysis of excitation function. Energies obtained in spectrum gated by neutron energies between 10 and 25 MeV.

[x] γ ray not placed in level scheme.

^{187}**Re(n,2nγ)**   **2015Ma60**

Level Scheme

$^{186}_{75}$Re$_{111}$