

Energy levels and branching ratios [89Ak03].

 **$^{229}_{91}\text{Pa}$** 

$E^*$	$E^*$	$2J^\pi$	$L$	$\sigma$ (p,t)	$\sigma$ (p,t)	$T_{1/2}$ or	Ref.
[keV]	[keV]		(p,t)	$\mu\text{b/sr}$	<i>rel.</i>	$\Gamma_{\text{cm}}$	
0.0		$\langle 5^+ \rangle$				1.50(5) d	98LeZU
0.16(10)		$\langle 5^- \rangle$				0.42(3) $\mu\text{s}$	
19(9)	0.0	$3^-$	0	401(22)	100		94Le22
34(10)	15.1(4)**	$1^-$		0.3(11)	5.1(4)		94Le22
75(10)	56.1(3)	$7^-$	2	46(2)	11.4(8)		94Le22
107(10)	87.7(3)**	$5^-$	2	13.0(7)	3.2(2)		94Le22
122.7*		$\langle 3^- \rangle$					
140(2)*		$\langle 1^- \rangle$					
144(10)	125.1(4)	$\langle 5^- \rangle$	2	0.5(1)	0.12(3)		94Le22
185(10)	166.1(3)	$11^-$	4	9.9(5)	2.5(2)		94Le22
187(3)*		$\langle 7^- \rangle$					
211.1(1)*		$\langle 1^+ - 5^+ \rangle$					
217(3)*		$\langle 5^- \rangle$					
227(10)	208.3(4)**	$9^-$	4	5.4(3)	1.35(11)		94Le22
241.9(1)*		$\langle 1^+ - 5^+ \rangle$					
259(10)	240.3(5)	$1^+$	1	0.5(1)	0.13(3)		94Le22
291(10)	272.3(3)	$5^+$	3	1.6(2)	0.40(6)		94Le22
310(10)	291.4(3)	$3^+$	3	0.9(1)	0.24(3)		94Le22
345(10)	326.3(3)	$15^-$	6	4.5(3)	1.12(10)		94Le22
384(10)	365.1(3)	$9^+$	3	1.0(1)	0.25(3)		94Le22
396(11)	377.3(6)	$13^-$	6	1.1(1)	0.28(3)		94Le22
458.9(1)*		$\langle 1-5 \rangle$					
528(11)	509.3(5)	$13^+$	5	0.4(1)	0.09(1)		94Le22
553(11)	533.9(7)	$19^-$	8	0.30(4)	0.08(1)		94Le22
602(13)	583.1(9)	$17^-$	8	0.12(2)	0.03(1)		94Le22
697(11)	677.6(6)	$15^+$	7	0.23(3)	0.06(1)		94Le22
722(12)	702.8(7)	$3^-$	0	1.5(2)	0.38(4)		94Le22
746(13)	727.1(9)	$\langle 1^- \rangle$	$\langle 2 \rangle$	1.4(2)	0.35(5)		94Le22
775(11)	755.8(6)	$\langle 7^- \rangle$	2	1.0(1)	0.25(3)		94Le22
796(12)	776.8(7)			0.8(2)	0.20(4)		94Le22
800(13)	780.7(8)	$\langle 23^- \rangle$	$\langle 10 \rangle$	<0.3	<0.08		94Le22
819(11)	800.5(6)	$\langle 5^- \rangle$	2	0.8(1)	0.20(3)		94Le22
849(11)	830.5(6)	$3^-$	0	20.0(11)	5.4(4)		94Le22
866(13)	846.6(9)	$\langle 1^- \rangle$	2	0.9(1)	0.22(3)		94Le22
884(12)	865.0(7)	$\langle 7^- \rangle$	2	3.7(3)	0.92(8)		94Le22
910(12)	891.2(8)	$\langle 5^- \rangle$	$\langle 2 \rangle$	0.20(3)	0.05(1)		94Le22
949(14)	930.5(10)	$\langle 11^- \rangle$	4	2.0(2)	0.50(5)		94Le22
985(13)	966.4(10)	$3^-$	0	30(2)	7.6(6)		94Le22
999(13)	979.6(9)	$3^-$	0	17.5(10)	4.4(3)		94Le22
1013(13)	994.3(9)	$3^-$	0	24.6(13)	6.1(5)		94Le22
1032(18)	1012.6(15)		$\langle 2 \rangle$	2.6(3)	0.64(8)		94Le22
1041(14)	1022.0(10)		2	8.7(5)	2.2(2)		94Le22
1076(14)	1056.9(10)		2	5.9(4)	1.47(13)		94Le22
1083(16)	1063.9(13)		2	2.0(2)	0.49(6)		94Le22
1092(14)	1073.4(10)		2	6.6(5)	1.6(2)		94Le22

(continued)

**<sup>229</sup>Pa**  
**<sub>91</sub>**

$E^*$	$E^*$	$2J^\pi$	$L$	$\sigma$ (p,t)	$\sigma$ (p,t)	$T_{1/2}$ or	Ref.
[keV]	[keV]		(p,t)	$\mu\text{b/sr}$	<i>rel.</i>	$\Gamma_{\text{cm}}$	
1124(14)	1104.8(10)	$\langle 3^- \rangle$	$\langle 0 \rangle$	5.4(4)	1.34(12)		94Le22
1140(14)	1121.3(11)		$\langle 2 \rangle$	2.6(2)	0.65(7)		94Le22
1153(15)	1134.3(12)		$\langle 2 \rangle$	2.8(3)	0.70(8)		94Le22
1169(14)	1149.7(11)		2	6.8(5)	1.71(15)		94Le22
1180(14)	1161.0(10)		2	13.6(8)	3.4(3)		94Le22
1193(15)	1173.9(12)		$\langle 2 \rangle$	1.8(2)	0.44(5)		94Le22
1203(15)	1184.5(12)		$\langle 2 \rangle$	5.3(4)	1.33(12)		94Le22
1219(14)	1199.8(11)		2	14.0(10)	3.5(3)		94Le22
1227(14)	1208.5(11)		2	9.0(8)	2.2(2)		94Le22
1248(14)	1229.2(11)		$\langle 4 \rangle$	3.9(3)	0.98(10)		94Le22
1272(15)	1252.7(11)		$\langle 2 \rangle$	6.4(4)	1.59(14)		94Le22
1306(16)	1286.9(12)		$\langle 4 \rangle$	2.6(3)	0.65(8)		94Le22
1321(15)	1302.2(12)		$\langle 4 \rangle$	2.7(5)	0.67(12)		94Le22
1378(14)	1359.0(10)	$3^-$	0	6.1(4)	1.52(13)		94Le22
1420(14)	1400.9(11)	$3^-$	0	2.5(3)	0.62(7)		94Le22
1446(14)	1427.0(11)	$\langle 3^- \rangle$	$\langle 0 \rangle$	4.8(3)	1.21(11)		94Le22
1476(15)	1457.2(12)	$\langle 3^- \rangle$	$\langle 0 \rangle$	2.8(3)	0.71(7)		94Le22
1498(15)	1479.3(12)			<0.9	<0.2		94Le22
1529(16)	1510.2(13)	$3^-$	0	20.7(14)	5.2(5)		94Le22
1543(16)	1523.7(13)	$3^-$	0	84(5)	21.1(18)		94Le22
1559(17)	1540.0(14)	$1^-$	2	5.3(6)	1.3(2)		94Le22
1589(16)	1569.8(13)	$7^-$	2	13.6(10)	3.4(3)		94Le22
1612(16)	1592.7(13)	$5^-, 1^+$	2+1	16.7(11)	4.2(3)		94Le22
1636(16)	1616.8(13)	$5^+$	3	4.8(4)	1.2(11)		94Le22
1655(16)	1636.4(13)	$3^+$	3	5.9(5)	1.47(14)		94Le22
1672(16)	1653.0(13)			3.5(3)	0.88(9)		94Le22
1686(16)	1666.7(14)	$\langle 11^- \rangle$	4	3.5(3)	0.88(9)		94Le22
1705(17)	1786.2(14)	$\langle 9^+ \rangle$	$\langle 3 \rangle$	3.6(4)	0.91(10)		94Le22
1728(17)	1708.9(14)	$\langle 9^- \rangle$	$\langle 4 \rangle$	5.2(4)	1.29(13)		94Le22
1750(17)	1731.3(14)			2.6(3)	0.65(8)		94Le22
1761(17)	1742.1(14)			3.1(3)	0.78(9)		94Le22
1776(17)	1756.7(14)			11.7(8)	2.9(3)		94Le22
1792(17)	1773.2(14)			10.3(7)	2.6(2)		94Le22
1852(17)	1832.6(15)			10.6(9)	2.6(3)		94Le22
				94Le22	94Le22		Ref.

Additional data on this isotope can be found in [94Lo10, 91Gr13, 82Ah08].

\* These levels were forming the previous Adopted Levels scheme [89Ak03] not supported by new data; we consider them obsolete as well as presented here branching ratios; see new branching ratios in [94Le22].

\*\* According to [91Gr13] these levels are forming the band, similar to that known in <sup>231</sup>Pa.

Two columns of  $E^*$  correspond to absolute and normalized energies given in [94Le22, 91Gr13].

Energy levels and branching ratios [89Ak03]. Part 2

 **$^{229}_{91}\text{Pa}$** 

$E^*$ [keV]	$2J^\pi$	Branching ratios in percentage					
		$E_f^*:$ $2J_f^\pi:$	0.0 $\langle 5^+ \rangle$	0.16 $\langle 5^- \rangle$	123 $\langle 3^- \rangle$	211	242
	$\langle 5^- \rangle$		x				
	$\langle 3^- \rangle$			x			
	$\langle 1^+ - 5^+ \rangle$		x		x		
	$\langle 1^+ - 5^+ \rangle$		x		x		
	$\langle 1-5 \rangle$					x	x

Energy levels [93Ak02].

 **$^{230}_{91}\text{Pa}$** 

$E^*$ [keV]	$J^\pi$	$T_{1/2}$ or $\Gamma_{\text{cm}}$	Ref.
0.0 17763(18)	$\langle 2^- \rangle$ $0^+$	17.4(5) d	91Ja04

Energy levels and branching ratios [01Br31].

 **$^{231}_{91}\text{Pa}$** 

$E^*$	$2J^\pi$	$I_d$	$I_p$	$\sigma$ ( $\alpha$ ,t)	$T_{1/2}$ or	Ref.	Branching ratios in percentage					
[keV]		(d,d')	(p,p')	$\mu$ b/sr	$\Gamma_{\text{cm}}$		$E_f^*$ : $2J_f^\pi$ :	0 3 <sup>-</sup>	9.2 1 <sup>-</sup>	58.6 7 <sup>-</sup>	77.7 5 <sup>-</sup>	84.2 5 <sup>+</sup>
0.0 <sup>a</sup>	3 <sup>-</sup>	100	100	13.2(11)	32760(110) yr	96Le01						
9.206(25) <sup>a</sup>	1 <sup>-</sup>	49.0	6.4	5.3(10)		75Er01	100					
58.5699(24)	7 <sup>-</sup>	31.0	2.9	19.6(12)	274(10) ps	75Er01	100					
77.685(17) <sup>a</sup>	5 <sup>-</sup>	12.2	0.67	5.4(8)		75Er01	42(7)	58(3)	x			
84.2148(13) <sup>b</sup>	5 <sup>+</sup>				45.1(13) ns		31.8(13)			68(3)		
101.4092(21) <sup>b</sup>	7 <sup>+</sup>			4.7(9)	$\leq 0.7$ ns	75Er01				100.0(23)		x
102.2692(13) <sup>b</sup>	3 <sup>+</sup>			incl	$\leq 0.7$ ns		90(3)	9.7(12)				$\leq 4.5$
111.653(12) <sup>b</sup>	9 <sup>+</sup>	30.3	0.04	5.5(9)		75Er01						
134(5)	$\langle 11^+ \rangle$			1.2(6)		75Er01						
168.6(2) <sup>a</sup>	11 <sup>-</sup>	7.4	0.32			96Le01				100		
171.5(2) <sup>b</sup>	$\langle 11^+ \rangle$			5.7(21)		75Er01						
174.161(4)	$\langle 5 \rangle^-$			incl			1.40(5)	0.270(11)	0.083(16)			78(3)
183.4962(17)	5 <sup>+</sup>				$\leq 0.19$ ns		2.14(9)			3.76(9)	0.51(5)	8.5(5)
188.9(2) <sup>b</sup>	$\langle 13^+ \rangle$			42(4)		75Er01						
193.5(2) <sup>a</sup>	$\langle 9 \rangle^-$	3.1	0.08			96Le01				x	100	
218.240(13)	$\langle 7 \rangle^-$			10(2)		75Er01					1.1(1)	38(1)
247.320(5)	7 <sup>+</sup>									1.11(9)	0.44(3)	52(2)
272(1)	$\langle 9 \rangle^-$			24.3(15)		75Er01						
273.8(2) <sup>c</sup>	$\langle 1^+ \rangle$	0.7	0.03	5.0(8)		75Er01	60(12)	21(14)			$\leq 0.5$	$\leq 0.5$
296.6(4)		0.6	0.03			96Le01						

(continued)

 **$^{231}_{91}\text{Pa}$** 

$E^*$	$2J^\pi$	$I_d$	$I_p$	$\sigma$ ( $\alpha, t$ )	$T_{1/2}$ or	Ref.	Branching ratios in percentage					
[keV]		(d,d')	(p,p')	$\mu\text{b/sr}$	$\Gamma_{\text{cm}}$		$E^*_f$ : $2J^\pi_f$ :	0 3 <sup>-</sup>	9.2 1 <sup>-</sup>	58.6 7 <sup>-</sup>	77.7 5 <sup>-</sup>	84.2 5 <sup>+</sup>
300.7(2) <sup>b</sup>	$\langle 15^+ \rangle$											
304	$\langle 9^+ \rangle$											
311.5(1) <sup>c</sup>	$\langle 5^+ \rangle$	0.1		2.7(7)		75Er01		32(5)		30(5)	38(5)	
316.8(2) <sup>b</sup>	$\langle 17^+ \rangle$	1.7	0.12			96Le01						
317.95(4) <sup>c</sup>	$\langle 3^+ \rangle$							13(2)	49(4)		39(4)	
320.209(18)	3 <sup>-</sup>							0.26(6)	5.4(3)		1.45(7)	16.1(7)
328.7(2) <sup>a</sup>	15 <sup>-</sup>	1.8	0.06			96Le01						
340(3)	$\langle 11^- \rangle$			2.8(8)		75Er01						
351.5(2) <sup>a</sup>	$\langle 13^- \rangle$	0.7	0.02			96Le01						9.2(16)
351.84(4)	$\langle 5^- \rangle$							2.4(5)			1.2(4)	45(3)
385(5)				1.0(5)		75Er01						
391.7(2) <sup>c</sup>	$\langle 9^+ \rangle$	0.04	0.01	7.5(20)		75Er01				72(8)		
409.0(2) <sup>c</sup>	$\langle 7^+ \rangle$	0.35	0.02			96Le01					60(8)	
424.5(6)		0.35	0.04			96Le01						
443.0(5)		0.40	0.01	4.8(5)		75Er01						
455(2)				2.4(5)		75Er01						
487.5(3) <sup>b</sup>	$\langle 19^+ \rangle$											
495.0(3) <sup>b</sup>	$\langle 21^+ \rangle$											
507(3)				1.9(4)		75Er01						
513.5(12)		0.13		0.8(4)		75Er01						
525.2(2) <sup>c</sup>	$\langle 13^+ \rangle$			incl								
535.7(2) <sup>a</sup>	19 <sup>-</sup>	0.48				96Le01						
543.3(2) <sup>c</sup>	$\langle 11^+ \rangle$											
551.3(2) <sup>a</sup>	17 <sup>-</sup>	0.30				96Le01						
567.5(5)		0.44		2.0(5)		75Er01						
583.5(8)		0.20		incl		96Le01						
590(5)				2.0(5)		75Er01						
604(4)	$\langle 3^- \rangle$			2.5(7)		75Er01						
631.7(15)	$\langle 5^- \rangle$	0.08		3.0(8)		75Er01						
676(2)	$\langle 7^- \rangle$			25.2(31)		75Er01						
700(3)				4.0(16)		75Er01						
705.1(2) <sup>c</sup>	$\langle 17^+ \rangle$											
716.9(2) <sup>c</sup>	$\langle 15^+ \rangle$											
722.1(3) <sup>b</sup>	$\langle 25^+ \rangle$											
728.5(3) <sup>b</sup>	$\langle 23^+ \rangle$											
750(2)				1.7(4)		75Er01						
785.5(2) <sup>a</sup>	$\langle 23^- \rangle$											
788.0(2) <sup>a</sup>	21 <sup>-</sup>	0.17				96Le01						
801(3)	$\langle 11^- \rangle$			4.1(5)		75Er01						
815(3)				4.7(5)		75Er01						
857.3(10)		0.16				96Le01						
874.0(6)		0.45				96Le01						
901.6(8)		0.25				96Le01						
917.6(12)		0.15				96Le01						
927.4(2)	$\langle 19^+ \rangle$											

(continued)

**<sup>231</sup>Pa<sub>91</sub>**

$E^*$ [keV]	$2J^\pi$	$I_d$ (d,d')	$I_p$ (p,p')	$\sigma$ ( $\alpha$ ,t) $\mu\text{b/sr}$	$T_{1/2}$ or $\Gamma_{\text{cm}}$	Ref.	Branching ratios in percentage					
							$E_f^*$ : $2J_f^\pi$ :	0 3 <sup>-</sup>	9.2 1 <sup>-</sup>	58.6 7 <sup>-</sup>	77.7 5 <sup>-</sup>	84.2 5 <sup>+</sup>
930.1(4) <sup>c</sup>	$\langle 21^+ \rangle$											
945.8(6) <sup>c</sup>	[19 <sup>+</sup> ]	0.57				03Wu03						
967.9(6)		0.63				96Le01						
994.8(4) <sup>b</sup>	$\langle 29^+ \rangle$											
1019.6(4) <sup>b</sup>	$\langle 27^+ \rangle$	0.24				96Le01						
1048.4(6)		0.809				96Le01						
1057.1(2) <sup>a</sup>	$\langle 25^- \rangle$											
1075.6(3) <sup>a</sup>	$\langle 27^- \rangle$											
1086.4(6)		0.74				96Le01						
1136.8(5)		1.42				96Le01						
1158.5(10)		0.40				96Le01						
1190.0(15)		0.20				96Le01						
1196	23 <sup>+</sup>					03Wu03						
1221.3(8)		0.50				96Le01						
1309.0(4) <sup>b</sup>	$\langle 33^+ \rangle$											
1356.3(3) <sup>a</sup>	$\langle 29^- \rangle$											
1357.9(5) <sup>b</sup>	$\langle 31^+ \rangle$											
1399.2(4) <sup>a</sup>	$\langle 31^- \rangle$											
1661.6(5) <sup>b</sup>	$\langle 37^+ \rangle$											
1684.0(5) <sup>a</sup>	$\langle 33^- \rangle$											
1754.9(4) <sup>a</sup>	$\langle 35^- \rangle$											
2041.2(6) <sup>a</sup>	$\langle 37^- \rangle$											
2140.0(5) <sup>a</sup>	$\langle 39^- \rangle$											
	03Wu03	96Le01	96Le01	75Er01		Ref.						

Additional data on this isotope can be found in [03Wu03, 92De51, 80Ch30].

Three bands (ABF marked here a,b,c) were considered in [03Wu03],  $E^*$  are from [01Br31].

Data for this isotope are considered in vol. LB I/18C.

Energy levels and branching ratios [01Br31]. Part 2

**<sup>231</sup>Pa<sub>91</sub>**

$E^*$ [keV]	$2J^\pi$	Branching ratios in percentage										
		$E_f^*$ : $2J_f^\pi$ :	101 7 <sup>+</sup>	102 3 <sup>+</sup>	112 $\langle 9^+ \rangle$	168.6 11 <sup>-</sup>	171.5 $\langle 11^+ \rangle$	174.161 $\langle 5^- \rangle$	183.496 5 <sup>+</sup>	188.9 $\langle 13^+ \rangle$	193.5 $\langle 9^- \rangle$	300.7 $\langle 15^+ \rangle$
111.653(12) <sup>b</sup>	9 <sup>+</sup>		x									
168.6(2) <sup>a</sup>	11 <sup>-</sup>				x							
171.5(2) <sup>b</sup>	$\langle 11^+ \rangle$		x		x							
174.161(4)	$\langle 5^- \rangle$		19.8(5)									
183.4962(17)	5 <sup>+</sup>		26.9(13)	58(2)								
188.9(2) <sup>b</sup>	$\langle 13^+ \rangle$				100							
193.5(2) <sup>a</sup>	$\langle 9^- \rangle$		x									
218.240(13)	$\langle 7^- \rangle$		34(2)		26(1)		1.1(4)					
247.320(5)	7 <sup>+</sup>		10.7(5)	1.9(2)	26.4(9)				7.8(11)			

(continued)

 **$^{231}_{91}\text{Pa}$** 

$E^*$ [keV]	$2J^\pi$	Branching ratios in percentage										
		$E_f^*$ : $2J_f^\pi$ :	101 7 <sup>+</sup>	102 3 <sup>+</sup>	112 (9 <sup>+</sup> )	168.6 11 <sup>-</sup>	171.5 (11 <sup>+</sup> )	174.161 (5) <sup>-</sup>	183.496 5 <sup>+</sup>	188.9 (13 <sup>+</sup> )	193.5 (9 <sup>-</sup> )	300.7 (15 <sup>+</sup> )
273.8(2) <sup>c</sup>	(1 <sup>+</sup> )			19(2)								
300.7(2) <sup>b</sup>	(15 <sup>+</sup> )						x			x		
316.8(2) <sup>b</sup>	(17 <sup>+</sup> )									100		
320.209(18)	3 <sup>-</sup>			69.2(12)					7.6(3)			
328.7(2) <sup>a</sup>	15 <sup>-</sup>					85(4)				14.6(6)		
351.5(2) <sup>a</sup>	(13 <sup>-</sup> )					3.1(11)	x				88(25)	
351.84(4)	(5 <sup>-</sup> )		24(3)	28(3)								
391.7(2) <sup>c</sup>	(9 <sup>+</sup> )					28(4)						
409.0(2) <sup>c</sup>	(7 <sup>+</sup> )										40(10)	
487.5(3) <sup>b</sup>	(19 <sup>+</sup> )											x
525.2(2) <sup>c</sup>	(13 <sup>+</sup> )					74(7)						
543.3(2) <sup>c</sup>	(11 <sup>+</sup> )										100	
551.3(2) <sup>a</sup>	17 <sup>-</sup>											x

Energy levels and branching ratios [01Br31]. Part 3

 **$^{231}_{91}\text{Pa}$** 

$E^*$ [keV]	$2J^\pi$	Branching ratios in percentage										
		$E_f^*$ : $2J_f^\pi$ :	316.8 (17 <sup>+</sup> )	328.7 15 <sup>-</sup>	351.5 (13 <sup>-</sup> )	487.5 (19 <sup>+</sup> )	495.0 (21 <sup>+</sup> )	525.2 (13 <sup>+</sup> )	535.7 (19 <sup>-</sup> )	543.3 (11 <sup>+</sup> )	551.3 (17 <sup>-</sup> )	705.1 (17 <sup>+</sup> )
487.5(3) <sup>b</sup>	(19 <sup>+</sup> )		x									
495.0(3) <sup>b</sup>	(21 <sup>+</sup> )		100									
525.2(2) <sup>c</sup>	(13 <sup>+</sup> )			26(7)								
535.7(2) <sup>a</sup>	19 <sup>-</sup>		x	100								
551.3(2) <sup>a</sup>	17 <sup>-</sup>			x	100							
705.1(2) <sup>c</sup>	(17 <sup>+</sup> )			67(8)				33(8)				
716.9(2) <sup>c</sup>	(15 <sup>+</sup> )				74(8)					26(4)		
722.1(3) <sup>b</sup>	(25 <sup>+</sup> )						100					
728.5(3) <sup>b</sup>	(23 <sup>+</sup> )					x	x					
785.5(2) <sup>a</sup>	(23 <sup>-</sup> )						x		100			
788.0(2) <sup>a</sup>	21 <sup>-</sup>					x			x		100	
927.4(2)	(19 <sup>+</sup> )										70(8)	
930.1(4) <sup>c</sup>	(21 <sup>+</sup> )								57(7)			43(7)

Energy levels and branching ratios [01Br31]. Part 4

 **$^{231}_{91}\text{Pa}$** 

$E^*$	$2J^\pi$	Branching ratios in percentage									
[keV]	$E_f^*:$ $2J_f^\pi:$	716.9 $\langle 15^+ \rangle$	722.1 $\langle 25^+ \rangle$	728.5 $\langle 23^+ \rangle$	785.5 $\langle 23^- \rangle$	788.0 $\langle 21^- \rangle$	994.8 $\langle 29^+ \rangle$	1019.6 $\langle 27^+ \rangle$	1057.1 $\langle 25^- \rangle$	1075.6 $\langle 27^- \rangle$	1309.0 $\langle 33^+ \rangle$
927.4(2)	$\langle 19^+ \rangle$	30(8)									
994.8(4) <sup>b</sup>	$\langle 29^+ \rangle$		100								
1019.6(4) <sup>b</sup>	$\langle 27^+ \rangle$		x	x							
1057.1(2) <sup>a</sup>	$\langle 25^- \rangle$			x	51(7)	49(9)					
1075.6(3) <sup>a</sup>	$\langle 27^- \rangle$		x		100						
1309.0(4) <sup>b</sup>	$\langle 33^+ \rangle$						100				
1356.3(3) <sup>a</sup>	$\langle 29^- \rangle$								x	x	
1357.9(5) <sup>b</sup>	$\langle 31^+ \rangle$							100			
1399.2(4) <sup>a</sup>	$\langle 31^- \rangle$						x			x	
1661.6(5) <sup>b</sup>	$\langle 37^+ \rangle$										100
1754.9(4) <sup>a</sup>	$\langle 35^- \rangle$										x

Energy levels and branching ratios [01Br31]. Part 5

 **$^{231}_{91}\text{Pa}$** 

$E^*$ [keV]	$2J^\pi$	Branching ratios in percentage					
		$E_f^*:$ $2J_f^\pi:$	1356.3 $\langle 29^- \rangle$	1399.2 $\langle 31^- \rangle$	1661.6 $\langle 37^+ \rangle$	1684.0 $\langle 33^- \rangle$	1754.9 $\langle 35^- \rangle$
1684.0(5) <sup>a</sup>	$\langle 33^- \rangle$		100				
1754.9(4) <sup>a</sup>	$\langle 35^- \rangle$			x			
2041.2(6) <sup>a</sup>	$\langle 37^- \rangle$					100	
2140.0(5) <sup>a</sup>	$\langle 39^- \rangle$				x		x

Energy levels [91Sc08].

 **$^{232}_{91}\text{Pa}$** 

$E^*$ [keV]	$J^\pi$	$T_{1/2}$ or $\Gamma_{\text{cm}}$	Ref.
0	$\langle 2^- \rangle$	1.31(2) d	
18480(20)		306(20) keV 01Va18	01Va18 Ref.

Energy levels and branching ratios [90Ak02].

**<sup>233</sup>Pa**  
**91**

$E^*$	$2J^\pi$	$\sigma$ (t, $\alpha$ )	Nils.Conf.	$S_N$	Ref.	Branching ratios in percentage					
[keV]		$\mu\text{b/sr}$	$2J, 2K[Nn_z\Lambda]$	(t, $\alpha$ )		$E_f^*$ : $2J_f^\pi$ :	0.0 $3^-$	6.65 $1^-$	57.1 $7^-$	70.5 $5^-$	86.5 $5^+$
0.0	$3^-$	79	3,1-[530]	0.043	79Fl02						
6.65(5)	$1^-$					x					
57.10(2)	$7^-$	80	7,1-[530]	0.061	79Fl02	x					
70.5(1)	$5^-$					50(12)	50(8)				
86.48(1)	$5^+$					45(2)			55(4)		
94.66(5)	$3^+$					81(28)	18.9(14)				x
103.8(1)	$7^+$	58	7,3+[651]		77Th04				x		x
109.1(1)	$9^+$	incl	9,3+[651]		77Th04						
133.2(2)	$\langle 11^+ \rangle$										
163.3(2)	$\langle 11^- \rangle$	321	13,3+[651]		77Th04				x		
169.16(1)	$1^+$	incl	1,1+[400]		77Th04		63(6)	28(4)			
173(1)	$\langle 13^+ \rangle$										
179.6(10)	$\langle 9^- \rangle$									x	
201.62(5)	$3^+$	54	3,1+[400]	0.077	79Fl02		14(2)	58(4)		27(3)	0.8(3)
212.34(5)	$5^+$						33(2)		19(2)	x	
237.89(6)	$5^+$						7.8(9)		2.5(5)		29(2)
257.3(2)	$5^-$						22	1.5	x	11	43
279.74(6)	$\langle 7^+ \rangle$								2(1)	15(2)	47(5)
290(6)		8			77Th04						
300.49(6)	$7^+$									13(4)	41(8)
303.6(2)	$\langle 9^+ \rangle$										
306.0(2)	$\langle 7^- \rangle$								x		x
347(6)	$\langle 3^+ \rangle$	19		0.38	79Fl02						
355(2)	$\langle 9^- \rangle$										
366.1(2)	$9^+$										14(14)
411(10)		3			77Th04						
421(4)	$\langle 11^- \rangle$										
447.78(2)	$3^-$						25	39		7	7
450(2)											
454.40(7)	$3^+$	143	3,3+[402]	0.26	79Fl02						2.7
474(10)	$\langle 5^+ \rangle$	27	5,3+[402]	0.02	79Fl02						
523(10)		4			77Th04						
529(2)											
543(10)	$\langle 11^+ \rangle$	20		0.19	79Fl02						
553.88(6)	$1^+, 3^+$										1.3
569(10)	$\langle 7^+ \rangle$	36		0.20	79Fl02						
585.50(5)	$3^+$										x
589(4)	$\langle 13^+ \rangle$										
669.9(5)	$\langle 3^- \rangle$						x	15			
690(12)	$\langle 3^- \rangle$	9		0.006	79Fl02						
704(3)	$\langle 5^- \rangle$										
736(8)	$\langle 7^- \rangle$	21		0.004	79Fl02						
749(1)	$\langle 7^- \rangle$										
764.55(6)	$1^+, 3^+$						9.5	3.3			6.9
800(12)		2			77Th04						



(continued)

**<sup>233</sup>Pa<sub>91</sub>**

$E^*$	$2J^\pi$	$\sigma$ (t, $\alpha$ )	Nils.Conf.	$S_N$	Ref.	Branching ratios in percentage					
[keV]		$\mu\text{b/sr}$	$2J, 2K[Nn_z\Lambda]$	(t, $\alpha$ )		$E_f^*$ : $2J_f^\pi$ :	0.0 3 <sup>-</sup>	6.65 1 <sup>-</sup>	57.1 7 <sup>-</sup>	70.5 5 <sup>-</sup>	86.5 5 <sup>+</sup>
803(4)	$\langle 9^- \rangle$										
811.6(2)	3 <sup>+</sup>						1.7	7		7	19
833(12)		5			77Th04						
852(4)											
863(12)	$\langle 3^- \rangle$	6		0.006	79Fl02						
871(2)	$\langle 11^- \rangle$										
942(12)		7			77Th04						
980(8)		74			77Th04						
984.8(5)	$\langle 3^+ \rangle$						0.6	3.3			1.5
990(4)											
1018.7(5)	$\langle 3 \rangle$									13	
1044(12)		8			77Th04						
1065(8)	$\langle 5^+ \rangle$	38		0.035	79Fl02						
1143(3)											
1176	1 <sup>+</sup>			0.057	79Fl02						
1179(3)											
1233	$\langle 1^+, 3^- \rangle$										
1240(3)											
1267	1 <sup>+</sup>			0.019	79Fl02						
1274(5)											
1308	1 <sup>+</sup>			0.040	79Fl02						
1318(4)											
1358(4)											
1386	5 <sup>+</sup>			0.032	79Fl02						
1403(3)											
1417	5 <sup>+</sup>			0.024	79Fl02						
1486	$\langle 5^+, 11^- \rangle$										
1557											
1625											
1680											
		77Th04	77	79Fl02	Ref.						

Additional data on this isotope can be found in [00Us01].

$T_{1/2}$ =26.967(2) days and 35.7(10) ns are given in [90Ak02] for the ground state and the level at  $E^*$ =86.5 keV, respectively.

Spectroscopic information  $d\sigma/d\Omega$  on the (t, $\alpha$ ) reaction obtained in [77Th04] was compared there with DWBA.

Data for this isotope are considered in vol. LB I/18C.

Energy levels and branching ratios [90Ak02]. Part 2

 **$^{233}_{91}\text{Pa}$** 

$E^*$	$2J^\pi$	$E_f^*:$	Branching ratios in percentage					
[keV]		$2J_f^\pi:$	94.66 3 <sup>+</sup>	103.8 7 <sup>+</sup>	109.10 9 <sup>+</sup>	163.25 ⟨11 <sup>-</sup> ⟩	169.159 1 <sup>+</sup>	179.6 ⟨9 <sup>-</sup> ⟩
133.2(2)	⟨11 <sup>+</sup> ⟩				x			
163.3(2)	⟨11 <sup>-</sup> ⟩				x			
169.16(1)	1 <sup>+</sup>		9(3)					
212.34(5)	5 <sup>+</sup>		34(2)	14(3)				
237.89(6)	5 <sup>+</sup>		53(3)	8.3(9)				
257.3(2)	5 <sup>-</sup>		x	22				
279.74(6)	⟨7 <sup>+</sup> ⟩			17(3)	19(2)			
300.49(6)	7 <sup>+</sup>			18(3)	23(4)			
303.6(2)	⟨9 <sup>+</sup> ⟩			x	x	x		
366.1(2)	9 <sup>+</sup>			50(10)	≤47	36(14)		≤22
454.40(7)	3 <sup>+</sup>		70				12	
553.88(6)	1 <sup>+</sup> ,3 <sup>+</sup>		99					
585.50(5)	3 <sup>+</sup>		93					
764.55(6)	1 <sup>+</sup> ,3 <sup>+</sup>		54				12.7	
811.6(2)	3 <sup>+</sup>		12	3			6	
984.8(5)	⟨3 <sup>+</sup> ⟩		61	3.4			12	
1018.7(5)	⟨3⟩						8	

Energy levels and branching ratios [90Ak02]. Part 3

 **$^{233}_{91}\text{Pa}$** 

$E^*$	$2J^\pi$	$E_f^*:$	Branching ratios in percentage					
[keV]		$2J_f^\pi:$	201.62 3 <sup>+</sup>	212.34 5 <sup>+</sup>	237.89 5 <sup>+</sup>	257.30 5 <sup>-</sup>	553.88 1 <sup>+</sup> ,3 <sup>+</sup>	585.50 3 <sup>+</sup>
237.89(6)	5 <sup>+</sup>		x					
300.49(6)	7 <sup>+</sup>				5(3)			
306.0(2)	⟨7 <sup>-</sup> ⟩					x		
366.1(2)	9 <sup>+</sup>			≤37				
447.78(2)	3 <sup>-</sup>		x			22		
454.40(7)	3 <sup>+</sup>		7		8			
585.50(5)	3 <sup>+</sup>				6.6			
669.9(5)	⟨3 <sup>-</sup> ⟩					85		
764.55(6)	1 <sup>+</sup> ,3 <sup>+</sup>		5.6	1.9	0.5		2.7	3.0
811.6(2)	3 <sup>+</sup>		19	10	9		x	5
984.8(5)	⟨3 <sup>+</sup> ⟩		2.7				10	6
1018.7(5)	⟨3⟩		28	23				27

Energy levels and branching ratios [94Ak05].

 **$^{234}_{91}\text{Pa}$** 

$E^*$ [keV]	$J^\pi$	$T_{1/2}$ or $\Gamma_{\text{cm}}$	$E_f^*:$ $J_f^\pi:$	0.0 $4^+$	Branching ratios in percentage		
					73.92+X $\langle 0^- \rangle$	103.4+X $\langle 2^- \rangle$	166.7+X $\langle 1^+ \rangle$
0.0	$4^+$	6.70(5) h					
73.92(2)	$\langle 3^+ \rangle$			x			
73.92+X	$\langle 0^- \rangle$	1.17(3) m			x		
103.42+X	$\langle 2^- \rangle$	<0.5 ns			x		
166.30+X	$\langle 1^- \rangle$	$\leq 0.1$ ns			99(6)	0.74(12)	
166.72+X	$\langle 1^+ \rangle$	0.55(10) ns			36(3)	64(6)	
177.27+X					x	x	
186.73+X	$\langle 1^+ \rangle$				76(6)	21.6(11)	2.7(8)

Energy levels and branching ratios [03Br12].

 **$^{235}_{91}\text{Pa}$** 

$E^*$ [keV]	$2J^\pi$	$\sigma$ (t, $\alpha$ ) $\mu\text{b/sr}$	Nils.Conf. $2J, 2K[Nn_z\Lambda]$	Ref.	$E_f^*:$ $2J_f^\pi:$	Branching ratios in percentage		
						0 $\langle 3^- \rangle$	18.6 $\langle 1^+ \rangle$	51.7 $\langle 3^+ \rangle$
0	$\langle 3^- \rangle$	87	3,1-[530]	77Th04				
$\leq 10$	$\langle 1^- \rangle$					x		
18.6(3)	$\langle 1^+ \rangle$	226	1,1+[400]	77Th04				
51.7(3)	$\langle 3^+ \rangle$		7,1-[530]					
55(4)	$\langle 7^- \rangle$							
65(6)	$\langle 9^+ \rangle$	65	9,3+[651]	77Th04				
100(4)		52		77Th04				
132(4)	$\langle 13^+ \rangle$	99	13,3+[651]	77Th04				
162(6)		7		77Th04				
192(8)		13		77Th04				
252(8)		17		77Th04				
344.6(3)	$\langle 3^+ \rangle$	132	3,3+[402]	77Th04				100
378(10)	$\langle 5^+ \rangle$	17	5,3+[402]	77Th04				
468.8(3)	$\langle 1,3 \rangle$					17.7(11)	11(3)	72
484(12)		5		77Th04				
525(12)		21		77Th04				
570(12)		31		77Th04				
630(12)		26		77Th04				
649(12)		12		77Th04				
682(12)		11		77Th04				
727.1(3)	$\langle 1,3 \rangle$					62(3)	38(2)	
747.9(3)	$\langle 1,3 \rangle$					28(2)	30(2)	42(3)
751(8)	$\langle 11^- \rangle$	77	11,9-[514]	77Th04				
755.7(3)	$\langle 1,3 \rangle$						27(8)	73(4)
965(8)	$\langle 5^- \rangle$	59	5,1-[541]	77Th04				

 $T_{1/2}=24.44(11)$  min are given in [03Br12] for the ground state.Spectroscopic information  $d\sigma/d\Omega$  on the (t, $\alpha$ ) reaction was compared with DWBA [77Th04].

Data for this isotope are considered in vol. LB I/18C.

Energy levels and branching ratios [91Sc08].

 **$^{236}_{91}\text{Pa}$** 

$E^*$	$J^\pi$	$T_{1/2}$ or	$E_f^*:$	Branching ratios in percentage			
[keV]		$\Gamma_{\text{cm}}$	$J_f^\pi:$	0 1 <sup>(-)</sup>	31.54 110.76 $\langle 0^-, 1 \rangle$	110.76 $\langle 0^-, 1 \rangle$	227.42
0	1 <sup>(-)</sup>	9.1(1) m					
31.54(9)				100			
110.76(8)	$\langle 0^-, 1 \rangle$			100			
227.42(20)					100		
340.20(8)	$\langle 0^-, 1 \rangle$			35(4)	22(2)	30(4)	13(5)
580.81(12)	$\langle 0^-, 1 \rangle$			39(8)	61(17)		
678.11(8)	$\langle 0^-, 1 \rangle$			36(5)	55(8)	10(2)	

Energy levels [95Ak01, 06Ba41].

 **$^{237}_{91}\text{Pa}$** 

$E^*$	$2J^\pi$	$\sigma$ (t, $\alpha$ )	Nils.Conf.	Ref.
[keV]		$\mu\text{b/sr}$	$2J, 2K[Nn_z\Lambda]$	
0.0	$\langle 1^+ \rangle$	210	1,1+[400]	77Th04
35(2)	$\langle 3^+ \rangle$	51	3,1+[400]	77Th04
90(3)	$\langle 3^- \rangle$	121	3,1-[530]	77Th04
105(5)	$\langle 9^+ \rangle$	47	9,3+[651]	77Th04
147(6)	$\langle 7^- \rangle$	82	7,1-[530]	77Th04
158(6)	$\langle 13^+ \rangle$	145	13,3+[651]	77Th04
202(6)		7		77Th04
258(4)		30		77Th04
319(4)		9		77Th04
364(4)	$\langle 3^+ \rangle$	100	3,3+[402]	77Th04
393(6)	$\langle 5^+ \rangle$	22	5,3+[402]	77Th04
491(4)		9		77Th04
554(8)		16		77Th04
577(8)		23		77Th04
624(4)		82	$\langle 11, 9-[514] \rangle$	77Th04
686(8)		11		77Th04
714(8)		20		77Th04
741(8)		8		77Th04
972(8)		30		77Th04
1025(6)		66	$\langle 5, 1-[541] \rangle$	77Th04
1112(4)		32		77Th04

 $T_{1/2}$ =8.7(2) min are given in [95Ak01] for the ground state.Spectroscopic information  $d\sigma/d\Omega$  on (t, $\alpha$ ) reaction [77Th04] is compared with DWBA [06Ba41].