Special Feature

Neutron scattering lengths and cross sections

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The application of thermal neutron scattering to the study of the structure and dynamics of condensed matter requires a knowledge of the scattering lengths and the corresponding scattering and absorption cross sections of the elements. In some cases, values for the individual isotopes are needed as well. This information is required to obtain an absolute normalization of the scattered neutron distributions, to calculate unit-cell structure factors in neutron crystallography, and to correct for effects such as absorption, self-shielding, extinction, multiple scattering, incoherent scattering, and detector efficiency.

The development of modern neutron-optical techniques during the past 20 years has produced a dramatic increase in the accuracy with which scattering lengths can be measured (1–5). As in earlier versions of this work (6, 7), our aim has been to use the best measured values of the bound coherent and incoherent neutron scattering lengths (8), supplemented where necessary with available scattering and absorption cross section data (9, 10), to obtain as complete and consistent a set of neutron scattering lengths and cross sections as possible.

The results are summarized in Table 1. The trailing digits in parentheses give the standard errors calculated from the errors in the input data using the statistical theory of error propagation (11). For most nuclides the scattering lengths and scattering cross sections are independent of the incident neutron wave vector k in the thermal neutron region, while the absorption cross sections are inversely proportional to k (the so-called "1/v law"). The latter are, by convention, tabulated for k = 3.494 $Å^{-1}$, which corresponds to a wavelength λ = 1.798 Å, an energy E = 25.30 meV, or a velocity v = 2200 m/s. The only important exceptions are nuclides like ^{113}Cd which have an (n, γ) resonance at thermal neutron energies, in which case the scattering lengths and cross sections become strongly energy dependent. Such nuclides are indicated by a # symbol in Table 1. The scattering lengths of all the resonant rare-earth nuclides are tabulated as a function of energy in Ref. 12. The imaginary parts of the scattering lengths, which are appreciable only for strongly absorbing nuclides, were calculated from the measured absorption cross sections (9, 10) as described in Ref. 7 and are listed underneath the real parts in Table 1.

The basic relationships between the scattering lengths and the cross sections are summarized in the Appendix. In cases where the scattering lengths have not yet been measured directly, the available scattering cross section data (9, 10) were used to obtain the scattering lengths. Equations (12), (13), and (14) were used where necessary to fill in gaps in the table. For some elements, these relations indicated inconsistencies in the data. In such cases, appropriate adjustments in the values of some of the quantities were made. In almost all cases such adjustments were comparable with the stated errors. Finally, for some elements it was necessary to arbitrarily estimate the scattering lengths of one or two isotopes in order to be able to complete the table. Such estimates are indicated by the letter "E" and were usually made only for isotopes of low natural abundance where the estimated values have only a marginal effect on the final results.

Appendix: quantities and relations

We summarize here the basic relationships between the scattering lengths and cross sections of the elements and their isotopes that were used in the compilation of Table 1. More information can be found in Refs. 5 or 7. In general, the scattering of a neutron by a single bound nucleus is described within the Born approximation by the Fermi pseudopotential,

$$V(\mathbf{r}) = \frac{2\pi\hbar^2}{m} b\delta(\mathbf{r}), \qquad (1)$$

in which $\mathbf{r}$ is the position of the neutron relative to the nucleus, m the neutron mass, and b the bound scattering length which is in general complex:

$$b = b' - ib''. \qquad (2)$$

The effective scattering length that describes the interaction of a neutron with the entire atom or ion also includes contributions from various electromagnetic interactions (13) but we need not discuss these here.

The neutron has spin s and the nucleus spin $\mathbf{I}$ so that, if $I \neq 0$, the Fermi pseudopotential and, hence, the bound scattering length will in general be spin dependent. Since s = 1/2, the most general rotationally-invariant expression for *b* is

$$b = b_c + \frac{2b_i}{\sqrt{I(I+1)}} \mathbf{s}\cdot\mathbf{I}, \qquad (3)$$

in which the coefficients b_c and b_i are called the bound coherent and incoherent scattering lengths. If I = 0, then $b_i = 0$ by convention. The total scattering cross section is given by

$$\sigma_s = 4\pi\langle|b|^2\rangle, \quad (4)$$

in which the brackets denote a statistical average over the neutron and nuclear spins, and the absorption cross section is given by

$$\sigma_a = \frac{4\pi}{k}\langle b''\rangle, \quad (5)$$

where k is the incident-neutron wave vector. If the neutron or the nucleus is unpolarized then the total scattering cross section is of the form

$$\sigma_s = \sigma_c + \sigma_i, \quad (6)$$

in which σ_c and σ_i are called the bound coherent and incoherent scattering cross sections:

$$\sigma_c = 4\pi|b_c|^2, \sigma_i = 4\pi|b_i|^2, \quad (7)$$

and the absorption cross section is given by

$$\sigma_a = \frac{4\pi}{k} b_c'', \quad (8)$$

The absorption cross section is therefore uniquely determined by the imaginary part of the bound coherent scattering length. It is only when the neutron and the nucleus are both polarized that the imaginary part of the bound incoherent scattering length contributes to the value of σ_a.

Apart from some minor "local field" corrections (5, 14), the index of refraction n is given by the relation

$$n^2 = 1 - \frac{4\pi}{k^2}\rho\langle b\rangle, \quad (9)$$

where ρ is the number of atoms per unit volume. For unpolarized neutrons,

$$\langle b\rangle = b_c. \quad (10)$$

If the neutrons and the nuclei are both polarized then $\langle b\rangle$ depends on b_i as well as b_c. Equation (9) is the basic relation that enables one to determine scattering lengths (both magnitude and sign) from neutron optical measurements.

The coefficients b_c and b_i in the expression (3) for the bound scattering length depend on the particular isotope under consideration, and this provides an additional source of incoherence in the scattering of neutrons by a mixture of isotopes. If the brackets are now taken to denote an average over both the spin and the isotope distributions, then the expressions (10) for b_c, (4) for σ_s, and (5) for σ_a also apply to a mixture of isotopes. Hence, if c_l is the mole fraction of isotopes of type l, so that

$$\sum_l c_l = 1, \quad (11)$$

then:

$$b_c = \sum_l c_l b_{cl}, \quad (12)$$

$$\sigma_s = \sum_l c_l \sigma_{sl}, \quad (13)$$

$$\sigma_a = \sum_l c_l \sigma_{al}, \quad (14)$$

The bound coherent scattering cross section of the mixture is given, as before, by

$$\sigma_c = 4\pi|b_c|^2, \quad (15)$$

and the bound incoherent scattering cross section is defined as

$$\sigma_i = \sigma_s - \sigma_c. \quad (16)$$

Hence, it follows that

$$\sigma_i = 4\pi|b_i|^2 = \sigma_i(\text{spin}) + \sigma_i(\text{isotope}), \quad (17)$$

in which the contribution from spin incoherence is given by

$$\sigma_i(\text{spin}) = \sum_l c_l \sigma_{il} = 4\pi \sum_l c_l |b_{il}|^2, \quad (18)$$

and that from isotope incoherence is

$$\sigma_i(\text{isotope}) = 4\pi \sum_{l<l'} c_l c_{l'} |b_{cl} - b_{cl'}|^2. \quad (19)$$

Note that for a mixture of isotopes only the magnitude of b_i is defined by Eq. (17), and its sign is arbitrary. However, for each individual isotope, both the magnitude and sign (or complex phase) of b_i are defined in the expression (3).

Acknowledgments

The author is grateful to L. Koester, H. Rauch and E. Seymann, whose recent survey (8) of all measured neutron scattering lengths up to the end of December 1990 was of great help in ensuring that the present compilation was as up to date as possible. We also thank Professor Rauch for sending us information on some more recently measured values, Professor W. Waschkowski for keeping us abreast of the work at Munich, and Dr. K. Guckelsberger for his critique of the available He data.

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Table 1. **Neutron scattering lengths and cross sections of the elements and their isotopes.**

Column	Symbol	Unit	Quantity
1			element
2	Z		atomic number
3	A		mass number
4	$I(p)$		spin (parity) of the nuclear ground state
5	c	%	natural abundance (For radioisotopes the half-life is given instead.)
6	b_c	fm	bound coherent scattering length
7	b_i	fm	bound incoherent scattering length
8	s_c	barn[1]	bound coherent scattering cross section
9	s_i	barn	bound incoherent scattering cross section
10	s_s	barn	total bound scattering cross section
11	s_a	barn	absorption cross section for 2200 m/s neutrons[2]

(1) 1 barn = 100 fm^2
(2) E = 25.30 meV, k = 3.494 Å^{-1}, l = 1.798 Å

	Z	A	$I(\pi)$	c	b_c	b_i	σ_c	σ_i	σ_s	σ_a
H	1				−3.7390(11)		1.7568(10)	80.26(6)	82.02(6)	0.3326(7)
		1	1/2(+)	99.985	−3.7406(11)	25.274(9)	1.7583(10)	80.27(6)	82.03(6)	0.3326(7)
		2	1(+)	0.015	6.671(4)	4.04(3)	5.592(7)	2.05(3)	7.64(3)	0.000519(7)
		3	1/2(+)	(12.32 a)	4.792(27)	−1.04(17)	2.89(3)	0.14(4)	3.03(5)	0
He	2				3.26(3)		1.34(2)	0	1.34(2)	0.00747(1)
		3	1/2(+)	0.00014	5.74(7)	−2.5(6)	4.42(10)	1.6(4)	6.0(4)	5333.(7.)
					−1.483(2)i	+2.568(3)i				
		4	0(+)	99.99986	3.26(3)	0	1.34(2)	0	1.34(2)	0
Li	3				−1.90(2)		0.454(10)	0.92(3)	1.37(3)	70.5(3)
		6	1(+)	7.5	2.00(11)	−1.89(10)	0.51(5)	0.46(5)	0.97(7)	940.(4.)
					−0.261(1)i	+0.26(1)i				
		7	3/2(−)	92.5	−2.22(2)	−2.49(5)	0.619(11)	0.78(3)	1.40(3)	0.0454(3)
Be	4	9	3/2(−)	100	7.79(1)	0.12(3)	7.63(2)	0.0018(9)	7.63(2)	0.0076(8)
B	5				5.30(4)		3.54(5)	1.70(12)	5.24(11)	767.(8.)
					−0.213(2)i					
		10	3(+)	20.0	−0.1(3)	−4.7(3)	0.144(8)	3.0(4)	3.1(4)	3835.(9.)
					−1.066(3)i	+1.231(3)i				
		11	3/2(−)	80.0	6.65(4)	−1.3(2)	5.56(7)	0.21(7)	5.77(10)	0.0055(33)
C	6				6.6460(12)		5.550(2)	0.001(4)	5.551(3)	0.00350(7)
		12	0(+)	98.90	6.6511(16)	0	5.559(3)	0	5.559(3)	0.00353(7)
		13	1/2(−)	1.10	6.19(9)	−0.52(9)	4.81(14)	0.034(11)	4.84(14)	0.00137(4)
N	7				9.36(2)		11.01(5)	0.50(12)	11.51(11)	1.90(3)
		14	1(+)	99.63	9.37(2)	2.0(2)	11.03(5)	0.5(1)	11.53(11)	1.91(3)
		15	1/2(−)	0.37	6.44(3)	−0.02(2)	5.21(5)	0.00005(10)	5.21(5)	0.000024(8)
O	8				5.803(4)		4.232(6)	0.000(8)	4.232(6)	0.00019(2)
		16	0(+)	99.762	5.803(4)	0	4.232(6)	0	4.232(6)	0.00010(2)
		17	5/2(+)	0.038	5.78(15)	0.18(6)	4.20(22)	0.004(3)	4.20(22)	0.236(10)

	Z	A	I(π)	c	b_c	b_i	σ_c	σ_i	σ_s	σ_a
		18	0(+)	0.200	5.84(7)	0	4.29(10)	0	4.29(10)	0.00016(1)
F	9	19	1/2(+)	100	5.654(10)	−0.082(9)	4.017(14)	0.0008(2)	4.018(14)	0.0096(5)
Ne	10				4.566(6)		2.620(7)	0.008(9)	2.628(6)	0.039(4)
		20	0(+)	90.51	4.631(6)	0	2.695(7)	0	2.695(7)	0.036(4)
		21	3/2(+)	0.27	6.66(19)	±0.6(1)	5.6(3)	0.05(2)	5.7(3)	0.67(11)
		22	0(+)	9.22	3.87(1)	0	1.88(1)	0	1.88(1)	0.046(6)
Na	11	23	3/2(+)	100	3.63(2)	3.59(3)	1.66(2)	1.62(3)	3.28(4)	0.530(5)
Mg	12				5.375(4)		3.631(5)	0.08(6)	3.71(4)	0.063(3)
		24	0(+)	78.99	5.66(3)	0	4.03(4)	0	4.03(4)	0.050(5)
		25	5/2(+)	10.00	3.62(14)	1.48(10)	1.65(13)	0.28(4)	1.93(14)	0.19(3)
		26	0(+)	11.01	4.89(15)	0	3.00(18)	0	3.00(18)	0.0382(8)
Al	13	27	5/2(+)	100	3.449(5)	0.256(10)	1.495(4)	0.0082(6)	1.503(4)	0.231(3)
Si	14				4.1491(10)		2.1633(10)	0.004(8)	2.167(8)	0.171(3)
		28	0(+)	92.23	4.107(6)	0	2.120(6)	0	2.120(6)	0.177(3)
		29	1/2(+)	4.67	4.70(10)	0.09(9)	2.78(12)	0.001(2)	2.78(12)	0.101(14)
		30	0(+)	3.10	4.58(8)	0	2.64(9)	0	2.64(9)	0.107(2)
P	15	31	1/2(+)	100	5.13(1)	0.2(2)	3.307(13)	0.005(10)	3.312(16)	0.172(6)
S	16				2.847(1)		1.0186(7)	0.007(5)	1.026(5)	0.53(1)
		32	0(+)	95.02	2.804(2)	0	0.9880(14)	0	0.9880(14)	0.54(4)
		33	3/2(+)	0.75	4.74(19)	1.5(1.5)	2.8(2)	0.3(6)	3.1(6)	0.54(4)
		34	0(+)	4.21	3.48(3)	0	1.52(3)	0	1.52(3)	0.227(5)
		36	0(+)	0.02	3.(1.) E	0	1.1(8)	0	1.1(8)	0.15(3)
Cl	17				9.5770(8)		11.526(2)	5.3(5)	16.8(5)	33.5(3)
		35	3/2(+)	75.77	11.65(2)	6.1(4)	17.06(6)	4.7(6)	21.8(6)	44.1(4)
		37	3/2(+)	24.23	3.08(6)	0.1(1)	1.19(5)	0.001(3)	1.19(5)	0.433(6)
Ar	18				1.909(6)		0.458(3)	0.225(5)	0.683(4)	0.675(9)
		36	0(+)	0.337	24.90(7)	0	77.9(4)	0	77.9(4)	5.2(5)
		38	0(+)	0.063	3.5(3.5)	0	1.5(3.1)	0	1.5(3.1)	0.8(2)
		40	0(+)	99.600	1.830(6)	0	0.421(3)	0	0.421(3)	0.660(9)
K	19				3.67(2)		1.69(2)	0.27(11)	1.96(11)	2.1(1)
		39	3/2(+)	93.258	3.74(2)	1.4(3)	1.76(2)	0.25(11)	2.01(11)	2.1(1)
		40	4(−)	0.012	3.(1.) E		1.1(8)	0.5(5) E	1.6(9)	35.(8.)
		41	3/2(+)	6.730	2.69(8)	1.5(1.5)	0.91(5)	0.3(6)	1.2(6)	1.46(3)
Ca	20				4.70(2)		2.78(2)	0.05(3)	2.83(2)	0.43(2)
		40	0(+)	96.941	4.80(2)	0	2.90(2)	0	2.90(2)	0.41(2)
		42	0(+)	0.647	3.36(10)	0	1.42(8)	0	1.42(8)	0.68(7)
		43	7/2(−)	0.135	−1.56(9)		0.31(4)	0.5(5) E	0.8(5)	6.2(6)
		44	0(+)	2.086	1.42(6)	0	0.25(2)	0	0.25(2)	0.88(5)
		46	0(+)	0.004	3.6(2)	0	1.6(2)	0	1.6(2)	0.74(7)
		48	0(+)	0.187	0.39(9)	0	0.019(9)	0	0.019(9)	1.09(14)
Sc	21	45	7/2(−)	100	12.29(11)	−6.0(3)	19.0(3)	4.5(5)	23.5(6)	27.5(2)
Ti	22				−3.438(2)		1.485(2)	2.87(3)	4.35(3)	6.09(13)
		46	0(+)	8.2	4.93(6)	0	3.05(7)	0	3.05(7)	0.59(18)
		47	5/2(−)	7.4	3.63(12)	−3.5(2)	1.66(11)	1.5(2)	3.2(2)	1.7(2)
		48	0(+)	73.8	−6.08(2)	0	4.65(3)	0	4.65(3)	7.84(25)

Z	A	I(π)	c	b_c	b_i	σ_c	σ_i	σ_s	σ_a
	49	7/2(–)	5.4	1.04(5)	5.1(2)	0.14(1)	3.3(3)	3.4(3)	2.2(3)
	50	0(+)	5.2	6.18(8)	0	4.80(12)	0	4.80(12)	0.179(3)
V 23				–0.3824(12)		0.01838(12)	5.08(6)	5.10(6)	5.08(4)
	50	6(+)	0.250	7.6(6)		7.3(1.1)	0.5(5) E	7.8(1.0)	60.(40.)
	51	7/2(–)	99.750	–0.402(2)	6.35(4)	0.0203(2)	5.07(6)	5.09(6)	4.9(1)
Cr 24				3.635(7)		1.660(6)	1.83(2)	3.49(2)	3.05(8)
	50	0(+)	4.35	–4.50(5)	0	2.54(6)	0	2.54(6)	15.8(2)
	52	0(+)	83.79	4.920(10)	0	3.042(12)	0	3.042(12)	0.76(6)
	53	3/2(–)	9.50	–4.20(3)	6.87(10)	2.22(3)	5.93(17)	8.15(17)	18.1(1.5)
	54	0(+)	2.36	4.55(10)	0	2.60(11)	0	2.60(11)	0.36(4)
Mn 25	55	5/2(–)	100	–3.73(2)	1.79(4)	1.75(2)	0.40(2)	2.15(3)	13.3(2)
Fe 26				9.45(2)		11.22(5)	0.40(11)	11.62(10)	2.56(3)
	54	0(+)	5.8	4.2(1)	0	2.2(1)	0	2.2(1)	2.25(18)
	56	0(+)	91.7	9.94(3)	0	12.42(7)	0	12.42(7)	2.59(14)
	57	1/2(–)	2.2	2.3(1)		0.66(6)	0.3(3) E	1.0(3)	2.48(30)
	58	0(+)	0.3	15.(7.)	0	28.(26.)	0	28.(26.)	1.28(5)
Co 27	59	7/2(–)	100	2.49(2)	–6.2(2)	0.779(13)	4.8(3)	5.6(3)	37.18(6)
Ni 28				10.3(1)		13.3(3)	5.2(4)	18.5(3)	4.49(16)
	58	0(+)	68.27	14.4(1)	0	26.1(4)	0	26.1(4)	4.6(3)
	60	0(+)	26.10	2.8(1)	0	0.99(7)	0	0.99(7)	2.9(2)
	61	3/2(–)	1.13	7.60(6)	±3.9(3)	7.26(11)	1.9(3)	9.2(3)	2.5(8)
	62	0(+)	3.59	–8.7(2)	0	9.5(4)	0	9.5(4)	14.5(3)
	64	0(+)	0.91	–0.37(7)	0	0.017(7)	0	0.017(7)	1.52(3)
Cu 29				7.718(4)		7.485(8)	0.55(3)	8.03(3)	3.78(2)
	63	3/2(–)	69.17	6.43(15)	0.22(2)	5.2(2)	0.006(1)	5.2(2)	4.50(2)
	65	3/2(–)	30.83	10.61(19)	1.79(10)	14.1(5)	0.40(4)	14.5(5)	2.17(3)
Zn 30				5.680(5)		4.054(7)	0.077(7)	4.131(10)	1.11(2)
	64	0(+)	48.6	5.22(4)	0	3.42(5)	0	3.42(5)	0.93(9)
	66	0(+)	27.9	5.97(5)	0	4.48(8)	0	4.48(8)	0.62(6)
	67	5/2(–)	4.1	7.56(8)	–1.50(7)	7.18(15)	0.28(3)	7.46(15)	6.8(8)
	68	0(+)	18.8	6.03(3)	0	4.57(5)	0	4.57(5)	1.1(1)
	70	0(+)	0.6	6.(1.) E	0	4.5(1.5)	0	4.5(1.5)	0.092(5)
Ga 31				7.288(2)		6.675(4)	0.16(3)	6.83(3)	2.75(3)
	69	3/2(–)	60.1	7.88(2)	–0.85(5)	7.80(4)	0.091(11)	7.89(4)	2.18(5)
	71	3/2(–)	39.9	6.40(3)	–0.82(4)	5.15(5)	0.084(8)	5.23(5)	3.61(10)
Ge 32				8.185(20)		8.42(4)	0.18(7)	8.60(6)	2.20(4)
	70	0(+)	20.5	10.0(1)	0	12.6(3)	0	12.6(3)	3.0(2)
	72	0(+)	27.4	8.51(10)	0	9.1(2)	0	9.1(2)	0.8(2)
	73	9/2(+)	7.8	5.02(4)	3.4(3)	3.17(5)	1.5(3)	4.7(3)	15.1(4)
	74	0(+)	36.5	7.58(10)	0	7.2(2)	0	7.2(2)	0.4(2)
	76	0(+)	7.8	8.2(1.5)	0	8.(3.)	0	8.(3.)	0.16(2)
As 33	75	3/2(–)	100	6.58(1)	–0.69(6)	5.44(2)	0.060(10)	5.50(2)	4.5(1)
Se 34				7.970(9)		7.98(2)	0.32(6)	8.30(6)	11.7(2)
	74	0(+)	0.9	0.8(3.0)	0	0.1(6)	0	0.1(6)	51.8(1.2)
	76	0(+)	9.0	12.2(1)	0	18.7(3)	0	18.7(3)	85.(7.)
	77	1/2(–)	7.6	8.25(8)	±0.6(1.6)	8.6(2)	0.05(26)	8.65(16)	42.(4.)
	78	0(+)	23.5	8.24(9)	0	8.5(2)	0	8.5(2)	0.43(2)

Z	A	I(π)	c	b_c	b_i	σ_c	σ_i	σ_s	σ_a
	80	0(+)	49.6	7.48(3)	0	7.03(6)	0	7.03(6)	0.61(5)
	82	0(+)	9.4	6.34(8)	0	5.05(13)	0	5.05(13)	0.044(3)
Br 35				6.795(15)		5.80(3)	0.10(9)	5.90(9)	6.9(2)
	79	3/2(–)	50.69	6.80(7)	–1.1(2)	5.81(12)	0.15(6)	5.96(13)	11.0(7)
	81	3/2(–)	49.31	6.79(7)	0.6(1)	5.79(12)	0.05(2)	5.84(12)	2.7(2)
Kr 36				7.81(2)		7.67(4)	0.01(14)	7.68(13)	25.(1.)
	78	0(+)	0.35		0		0		6.4(9)
	80	0(+)	2.25		0		0		11.8(5)
	82	0(+)	11.6		0		0		29.(20.)
	83	9/2(+)	11.5						185.(30.)
	84	0(+)	57.0		0		0		0.113(15)
	86	0(+)	17.3	8.1(2)	0	8.2(4)	0	8.2(4)	0.003(2)
Rb 37				7.09(2)		6.32(4)	0.5(4)	6.8(4)	0.38(1)
	85	5/2(–)	72.17	7.03(10)		6.2(2)	0.5(5) E	6.7(5)	0.48(1)
	87	3/2(–)	27.83	7.23(12)		6.6(2)	0.5(5) E	7.1(5)	0.12(3)
Sr 38				7.02(2)		6.19(4)	0.06(11)	6.25(10)	1.28(6)
	84	0(+)	0.56	7.(1.) E	0	6.(2.)	0	6.(2.)	0.87(7)
	86	0(+)	9.86	5.67(5)	0	4.04(7)	0	4.04(7)	1.04(7)
	87	9/2(+)	7.00	7.40(7)		6.88(13)	0.5(5) E	7.4(5)	16.(3.)
	88	0(+)	82.58	7.15(6)	0	6.42(11)	0	6.42(11)	0.058(4)
Y 39	89	1/2(–)	100	7.75(2)	1.1(3)	7.55(4)	0.15(8)	7.70(9)	1.28(2)
Zr 40				7.16(3)		6.44(5)	0.02(15)	6.46(14)	0.185(3)
	90	0(+)	51.45	6.4(1)	0	5.1(2)	0	5.1(2)	0.011(5)
	91	5/2(+)	11.32	8.7(1)	–1.08(15)	9.5(2)	0.15(4)	9.7(2)	1.17(10)
	92	0(+)	17.19	7.4(2)	0	6.9(4)	0	6.9(4)	0.22(6)
	94	0(+)	17.28	8.2(2)	0	8.4(4)	0	8.4(4)	0.0499(24)
	96	0(+)	2.76	5.5(1)	0	3.8(1)	0	3.8(1)	0.0229(10)
Nb 41	93	9/2(+)	100	7.054(3)	–0.139(10)	6.253(5)	0.0024(3)	6.255(5)	1.15(5)
Mo 42				6.715(20)		5.67(3)	0.04(5)	5.71(4)	2.48(4)
	92	0(+)	14.84	6.91(8)	0	6.00(14)	0	6.00(14)	0.019(2)
	94	0(+)	9.25	6.80(7)	0	5.81(12)	0	5.81(12)	0.015(2)
	95	5/2(+)	15.92	6.91(6)		6.00(10)	0.5(5) E	6.5(5)	13.1(3)
	96	0(+)	16.68	6.20(6)	0	4.83(9)	0	4.83(9)	0.5(2)
	97	5/2(+)	9.55	7.24(8)		6.59(15)	0.5(5) E	7.1(5)	2.5(2)
	98	0(+)	24.13	6.58(7)	0	5.44(12)	0	5.44(12)	0.127(6)
	100	0(+)	9.63	6.73(7)	0	5.69(12)	0	5.69(12)	0.4(2)
Tc 43	99	9/2(+)	(2.13×10^5 a)	6.8(3)		5.8(5)	0.5(5) E	6.3(7)	20.(1.)
Ru 44				7.03(3)		6.21(5)	0.4(1)	6.6(1)	2.56(13)
	96	0(+)	5.5		0		0		0.28(2)
	98	0(+)	1.9		0		0		< 8.
	99	5/2(+)	12.7						6.9(1.0)
	100	0(+)	12.6		0		0		4.8(6)
	101	5/2(+)	17.0						3.3(9)
	102	0(+)	31.6		0		0		1.17(7)
	104	0(+)	18.7		0		0		0.31(2)
Rh 45	103	1/2(–)	100	5.88(4)		4.34(6)	0.3(3) E	4.6(3)	144.8(7)
Pd 46				5.91(6)		4.39(9)	0.093(9)	4.48(9)	6.9(4)

Z	A	$I(\pi)$	c	b_c	b_i	σ_c	σ_i	σ_s	σ_a
	102	0(+)	1.02	7.7(7) E	0	7.5(1.4)	0	7.5(1.4)	3.4(3)
	104	0(+)	11.14	7.7(7) E	0	7.5(1.4)	0	7.5(1.4)	0.6(3)
	105	5/2(+)	22.33	5.5(3)	−2.6(1.6)	3.8(4)	0.8(1.0)	4.6(1.1)	20.(3.)
	106	0(+)	27.33	6.4(4)	0	5.1(6)	0	5.1(6)	0.304(29)
	108	0(+)	26.46	4.1(3)	0	2.1(3)	0	2.1(3)	8.5(5)
	110	0(+)	11.72	7.7(7) E	0	7.5(1.4)	0	7.5(1.4)	0.226(31)
Ag 47				5.922(7)		4.407(10)	0.58(3)	4.99(3)	63.3(4)
	107	1/2(−)	51.83	7.555(11)	1.00(13)	7.17(2)	0.13(3)	7.30(4)	37.6(1.2)
	109	1/2(−)	48.17	4.165(11)	−1.60(13)	2.18(1)	0.32(5)	2.50(5)	91.0(1.0)
Cd 48				4.87(5)		3.04(6)	3.46(13)	6.50(12)	2520.(50.)
				−0.70(1)*i*					
	106	0(+)	1.25	5.(2.) E	0	3.1(2.5)	0	3.1(2.5)	1.
	108	0(+)	0.89	5.4(1)	0	3.7(1)	0	3.7(1)	1.1(3)
	110	0(+)	12.51	5.9(1)	0	4.4(1)	0	4.4(1)	11.(1.)
	111	1/2(+)	12.81	6.5(1)		5.3(2)	0.3(3) E	5.6(4)	24.(3.)
	112	0(+)	24.13	6.4(1)	0	5.1(2)	0	5.1(2)	2.2(5)
#	113	1/2(+)	12.22	−8.0(2)		12.1(4)	0.3(3) E	12.4(5)	20600.(400.)
				−5.73(11)*i*					
	114	0(+)	28.72	7.5(1)	0	7.1(2)	0	7.1(2)	0.34(2)
	116	0(+)	7.47	6.3(1)	0	5.0(2)	0	5.0(2)	0.075(13)
In 49				4.065(20)		2.08(2)	0.54(11)	2.62(11)	193.8(1.5)
				−0.0539(4)*i*					
	113	9/2(+)	4.3	5.39(6)	±0.017(1)	3.65(8)	0.000037(5)	3.65(8)	12.0(1.1)
	115	9/2(+)	95.7	4.01(2)	−2.1(2)	2.02(2)	0.55(11)	2.57(11)	202.(2.)
				−0.0562(6)*i*					
Sn 50				6.225(2)		4.870(3)	0.022(5)	4.892(6)	0.626(9)
	112	0(+)	1.0	6.(1.) E	0	4.5(1.5)	0	4.5(1.5)	1.00(11)
	114	0(+)	0.7	6.2(3)	0	4.8(5)	0	4.8(5)	0.114(30)
	115	1/2(+)	0.4	6.(1.) E		4.5(1.5)	0.3(3) E	4.8(1.5)	30.(7.)
	116	0(+)	14.7	5.93(5)	0	4.42(7)	0	4.42(7)	0.14(3)
	117	1/2(+)	7.7	6.48(5)		5.28(8)	0.3(3) E	5.6(3)	2.3(5)
	118	0(+)	24.3	6.07(5)	0	4.63(8)	0	4.63(8)	0.22(5)
	119	1/2(+)	8.6	6.12(5)		4.71(8)	0.3(3) E	5.0(3)	2.2(5)
	120	0(+)	32.4	6.49(5)	0	5.29(8)	0	5.29(8)	0.14(3)
	122	0(+)	4.6	5.74(5)	0	4.14(7)	0	4.14(7)	0.18(2)
	124	0(+)	5.6	5.97(5)	0	4.48(8)	0	4.48(8)	0.133(5)
Sb 51				5.57(3)		3.90(4)	0.00(7)	3.90(6)	4.91(5)
	121	5/2(+)	57.3	5.71(6)	−0.05(15)	4.10(9)	0.0003(19)	4.10(9)	5.75(12)
	123	7/2(+)	42.7	5.38(7)	−0.10(15)	3.64(9)	0.001(4)	3.64(9)	3.8(2)
Te 52				5.80(3)		4.23(4)	0.09(6)	4.32(5)	4.7(1)
	120	0(+)	0.096	5.3(5)	0	3.5(7)	0	3.5(7)	2.3(3)
	122	0(+)	2.60	3.8(2)	0	1.8(2)	0	1.8(2)	3.4(5)
	123	1/2(+)	0.908	−0.05(25)	−2.04(9)	0.002(3)	0.52(5)	0.52(5)	418.(30.)
				−0.116(8)*i*					
	124	0(+)	4.816	7.96(10)	0	8.0(2)	0	8.0(2)	6.8(1.3)
	125	1/2(+)	7.14	5.02(8)	−0.26(13)	3.17(10)	0.008(8)	3.18(10)	1.55(16)
	126	0(+)	18.95	5.56(7)	0	3.88(10)	0	3.88(10)	1.04(15)
	128	0(+)	31.69	5.89(7)	0	4.36(10)	0	4.36(10)	0.215(8)
	130	0(+)	33.80	6.02(7)	0	4.55(11)	0	4.55(11)	0.29(6)
I 53	127	5/2(+)	100	5.28(2)	1.58(15)	3.50(3)	0.31(6)	3.81(7)	6.15(6)
Xe 54				4.92(3)		3.04(4)			23.9(1.2)

Z		A	I(π)	c	b_c	b_i	σ_c	σ_i	σ_s	σ_a
		124	0(+)	0.10		0		0		165.(20.)
		126	0(+)	0.09		0		0		3.5(8)
		128	0(+)	1.91		0		0		< 8.
		129	1/2(+)	26.4						21.(5.)
		130	0(+)	4.1		0		0		< 26.
		131	3/2(+)	21.2						85.(10.)
		132	0(+)	26.9		0		0		0.45(6)
		134	0(+)	10.4		0		0		0.265(20)
		136	0(+)	8.9		0		0		0.26(2)
Cs	55	133	7/2(+)	100	5.42(2)	1.29(15)	3.69(3)	0.21(5)	3.90(6)	29.0(1.5)
Ba	56				5.07(3)		3.23(4)	0.15(11)	3.38(10)	1.1(1)
		130	0(+)	0.11	−3.6(6)	0	1.6(5)	0	1.6(5)	30.(5.)
		132	0(+)	0.10	7.8(3)	0	7.6(6)	0	7.6(6)	7.0(8)
		134	0(+)	2.42	5.7(1)	0	4.08(14)	0	4.08(14)	2.0(1.6)
		135	3/2(+)	6.59	4.67(10)		2.74(12)	0.5(5) E	3.2(5)	5.8(9)
		136	0(+)	7.85	4.91(8)	0	3.03(10)	0	3.03(10)	0.68(17)
		137	3/2(+)	11.23	6.83(10)		5.86(17)	0.5(5) E	6.4(5)	3.6(2)
		138	0(+)	71.70	4.84(8)	0	2.94(10)	0	2.94(10)	0.27(14)
La	57				8.24(4)		8.53(8)	1.13(19)	9.66(17)	8.97(4)
		138	5(+)	0.09	8.(2.) E		8.(4.)	0.5(5) E	8.5(4.0)	57.(6.)
		139	7/2(+)	99.91	8.24(4)	3.0(2)	8.53(8)	1.13(15)	9.66(17)	8.93(4)
Ce	58				4.84(2)		2.94(2)	0.00(10)	2.94(10)	0.63(4)
		136	0(+)	0.19	5.80(9)	0	4.23(13)	0	4.23(13)	7.3(1.5)
		138	0(+)	0.25	6.70(9)	0	5.64(15)	0	5.64(15)	1.1(3)
		140	0(+)	88.48	4.84(9)	0	2.94(11)	0	2.94(11)	0.57(4)
		142	0(+)	11.08	4.75(9)	0	2.84(11)	0	2.84(11)	0.95(5)
Pr	59	141	5/2(+)	100	4.58(5)	−0.35(3)	2.64(6)	0.015(3)	2.66(6)	11.5(3)
Nd	60				7.69(5)		7.43(10)	9.2(8)	16.6(8)	50.5(1.2)
		142	0(+)	27.16	7.7(3)	0	7.5(6)	0	7.5(6)	18.7(7)
		143	7/2(−)	12.18	14.(2.) E	±21.(1.)	25.(7.)	55.(7.)	80.(2.)	334.(10.)
		144	0(+)	23.80	2.8(3)	0	1.0(2)	0	1.0(2)	3.6(3)
		145	7/2(−)	8.29	14.(2.) E		25.(7.)	5.(5.) E	30.(9.)	42.(2.)
		146	0(+)	17.19	8.7(2)	0	9.5(4)	0	9.5(4)	1.4(1)
		148	0(+)	5.75	5.7(3)	0	4.1(4)	0	4.1(4)	2.5(2)
		150	0(+)	5.63	5.3(2)	0	3.5(3)	0	3.5(3)	1.2(2)
Pm	61	147	7/2(+)	(2.62 a)	12.6(4)	±3.2(2.5)	20.0(1.3)	1.3(2.0)	21.3(1.5)	168.4(3.5)
Sm	62				0.80(2) −1.65(2)*i*		0.422(9)	39.(3.)	39.(3.)	5922.(56.)
		144	0(+)	3.1	−3.(4.) E	0	1.(3.)	0	1.(3.)	0.7(3)
		147	7/2(−)	15.1	14.(3.)	±11.(7.)	25.(11.)	14.(19.)	39.(16.)	57.(3.)
		148	0(+)	11.3	−3.(4.) E	0	1.(3.)	0	1.(3.)	2.4(6)
	#	149	7/2(−)	13.9	−19.2(1) −11.7(1)*i*	±31.4(6) −10.3(1)*i*	63.5(6)	137.(5.)	200.(5.)	42080.(400.)
		150	0(+)	7.4	14.(3.)	0	25.(11.)	0	25.(11.)	104.(4.)
		152	0(+)	26.6	−5.0(6)	0	3.1(8)	0	3.1(8)	206.(6.)
		154	0(+)	22.6	9.3(1.0)	0	11.(2.)	0	11.(2.)	8.4(5)
Eu	63				7.22(2) −1.26(1)*i*		6.75(4)	2.5(4)	9.2(4)	4530.(40.)
	#	151	5/2(+)	47.8	6.13(14) −2.53(3)*i*	±4.5(4) −2.14(2)*i*	5.5(2)	3.1(4)	8.6(4)	9100.(100.)

Z	A	I(π)	c	b_c	b_i	σ_c	σ_i	σ_s	σ_a
	153	5/2(+)	52.2	8.22(12)	±3.2(9)	8.5(2)	1.3(7)	9.8(7)	312.(7.)
Gd 64				6.5(5)		29.3(8)	151.(2.)	180.(2.)	49700.(125.)
				−13.82(3)*i*					
	152	0(+)	0.2	10.(3.) E	0	13.(8.)	0	13.(8.)	735.(20.)
	154	0(+)	2.1	10.(3.) E	0	13.(8.)	0	13.(8.)	85.(12.)
#	155	3/2(−)	14.8	6.0(1)	±5.(5.) E	40.8(4)	25.(6.)	66.(6.)	61100.(400.)
				−17.0(1)*i*	−13.16(9)*i*				
	156	0(+)	20.6	6.3(4)	0	5.0(6)	0	5.0(6)	1.5(1.2)
#	157	3/2(−)	15.7	−1.14(2)	±5.(5.) E	650.(4.)	394.(7.)	1044.(8.)	259000.(700.)
				−71.9(2)*i*	−55.8(2)*i*				
	158	0(+)	24.8	9.(2.)	0	10.(5.)	0	10.(5.)	2.2(2)
	160	0(+)	21.8	9.15(5)	0	10.52(11)	0	10.52(11)	0.77(2)
Tb 65	159	3/2(+)	100	7.38(3)	−0.17(7)	6.84(6)	0.004(3)	6.84(6)	23.4(4)
Dy 66				16.9(2)		35.9(8)	54.4(1.2)	90.3(9)	994.(13.)
				−0.276(4)*i*					
	156	0(+)	0.06	6.1(5)	0	4.7(8)	0	4.7(8)	33.(3.)
	158	0(+)	0.10	6.(4.) E	0	5.(6.)	0	5.(6.)	43.(6.)
	160	0(+)	2.34	6.7(4)	0	5.6(7)	0	5.6(7)	56.(5.)
	161	5/2(+)	19.0	10.3(4)	±4.9(8)	13.3(1.0)	3.(1.)	16.(1.)	600.(25.)
	162	0(+)	25.5	−1.4(5)	0	0.25(18)	0	0.25(18)	194.(10.)
	163	5/2(−)	24.9	5.0(4)	1.3(3)	3.1(5)	0.21(10)	3.3(5)	124.(7.)
	164	0(+)	28.1	49.4(2)	0	307.(3.)	0	307.(3.)	2840.(40.)
				−0.79(1)*i*					
Ho 67	165	7/2(−)	100	8.01(8)	−1.70(8)	8.06(16)	0.36(3)	8.42(16)	64.7(1.2)
Er 68				7.79(2)		7.63(4)	1.1(3)	8.7(3)	159.(4.)
	162	0(+)	0.14	8.8(2)	0	9.7(4)	0	9.7(4)	19.(2.)
	164	0(+)	1.56	8.2(2)	0	8.4(4)	0	8.4(4)	13.(2.)
	166	0(+)	33.4	10.6(2)	0	14.1(5)	0	14.1(5)	19.6(1.5)
	167	7/2(+)	22.9	3.0(3)	1.0(3)	1.1(2)	0.13(8)	1.2(2)	659.(16.)
	168	0(+)	27.1	7.4(4)	0	6.9(7)	0	6.9(7)	2.74(8)
	170	0(+)	14.9	9.6(5)	0	11.6(1.2)	0	11.6(1.2)	5.8(3)
Tm 69	169	1/2(+)	100	7.07(3)	0.9(3)	6.28(5)	0.10(7)	6.38(9)	100.(2.)
Yb 70				12.43(3)		19.42(9)	4.0(2)	23.4(2)	34.8(8)
	168	0(+)	0.14	−4.07(2)	0	2.13(2)	0	2.13(2)	2230.(40.)
				−0.62(1)*i*					
	170	0(+)	3.06	6.77(10)	0	5.8(2)	0	5.8(2)	11.4(1.0)
	171	1/2(−)	14.3	9.66(10)	−5.59(17)	11.7(2)	3.9(2)	15.6(3)	48.6(2.5)
	172	0(+)	21.9	9.43(10)	0	11.2(2)	0	11.2(2)	0.8(4)
	173	5/2(−)	16.1	9.56(7)	−5.3(2)	11.5(2)	3.5(3)	15.0(4)	17.1(1.3)
	174	0(+)	31.8	19.3(1)	0	46.8(5)	0	46.8(5)	69.4(5.0)
	176	0(+)	12.7	8.72(10)	0	9.6(2)	0	9.6(2)	2.85(5)
Lu 71				7.21(3)		6.53(5)	0.7(4)	7.2(4)	74.(2.)
	175	7/2(+)	97.39	7.24(3)	±2.2(7)	6.59(5)	0.6(4)	7.2(4)	21.(3.)
#	176	7(−)	2.61	6.1(1)	±3.0(4)	4.7(2)	1.2(3)	5.9(4)	2065.(35.)
				−0.57(1)*i*	+0.61(1)*i*				
Hf 72				7.77(14)		7.6(3)	2.6(5)	10.2(4)	104.1(5)
	174	0(+)	0.2	10.9(1.1)	0	15.(3.)	0	15.(3.)	561.(35.)
	176	0(+)	5.2	6.61(18)	0	5.5(3)	0	5.5(3)	23.5(3.1)
	177	7/2(−)	18.6	0.8(1.0) E	±0.9(1.3)	0.1(2)	0.1(3)	0.2(2)	373.(10.)
	178	0(+)	27.1	5.9(2)	0	4.4(3)	0	4.4(3)	84.(4.)

Z		A	I(π)	c	b_c	b_i	σ_c	σ_i	σ_s	σ_a
		179	9/2(+)	13.7	7.46(16)	±1.06(8)	7.0(3)	0.14(2)	7.1(3)	41.(3.)
		180	0(+)	35.2	13.2(3)	0	21.9(1.0)	0	21.9(1.0)	13.04(7)
Ta	73				6.91(7)		6.00(12)	0.01(17)	6.01(12)	20.6(5)
	#	180	9(–)	0.012	7.(2.) E		6.2(3.5)	0.5(5) E	7.(4.)	563.(60.)
		181	7/2(+)	99.988	6.91(7)	–0.29(3)	6.00(12)	0.011(2)	6.01(12)	20.5(5)
W	74				4.86(2)		2.97(2)	1.63(6)	4.60(6)	18.3(2)
		180	0(+)	0.1	5.(3.) E	0	3.(4.)	0	3.(4.)	30.(20.)
		182	0(+)	26.3	6.97(4)	0	6.10(7)	0	6.10(7)	20.7(5)
		183	1/2(–)	14.3	6.53(4)		5.36(7)	0.3(3) E	5.7(3)	10.1(3)
		184	0(+)	30.7	7.48(6)	0	7.03(11)	0	7.03(11)	1.7(1)
		186	0(+)	28.6	–0.72(4)	0	0.065(7)	0	0.065(7)	37.9(6)
Re	75				9.2(2)		10.6(5)	0.9(6)	11.5(3)	89.7(1.0)
		185	5/2(+)	37.40	9.0(3)	±2.0(1.8)	10.2(7)	0.5(9)	10.7(6)	112.(2.)
		187	5/2(+)	62.60	9.3(3)	±2.8(1.1)	10.9(7)	1.0(8)	11.9(4)	76.4(1.0)
Os	76				10.7(2)		14.4(5)	0.3(8)	14.7(6)	16.0(4)
		184	0(+)	0.02	10.(2.) E	0	13.(5.)	0	13.(5.)	3000.(150.)
		186	0(+)	1.58	11.6(1.7)	0	17.(5.)	0	17.(5.)	80.(13.)
		187	1/2(–)	1.6	10.(2.) E		13.(5.)	0.3(3) E	13.(5.)	320.(10.)
		188	0(+)	13.3	7.6(3)	0	7.3(6)	0	7.3(6)	4.7(5)
		189	3/2(–)	16.1	10.7(3)		14.4(8)	0.5(5) E	14.9(9)	25.(4.)
		190	0(+)	26.4	11.0(3)	0	15.2(8)	0	15.2(8)	13.1(3)
		192	0(+)	41.0	11.5(4)	0	16.6(1.2)	0	16.6(1.2)	2.0(1)
Ir	77				10.6(3)		14.1(8)	0.(3.)	14.(3.)	425.(2.)
		191	3/2(+)	37.3						954.(10.)
		193	3/2(+)	62.7						111.(5.)
Pt	78				9.60(1)		11.58(2)	0.13(11)	11.71(11)	10.3(3)
		190	0(+)	0.01	9.0(1.0)	0	10.(2.)	0	10.(2.)	152.(4.)
		192	0(+)	0.79	9.9(5)	0	12.3(1.2)	0	12.3(1.2)	10.0(2.5)
		194	0(+)	32.9	10.55(8)	0	14.0(2)	0	14.0(2)	1.44(19)
		195	1/2(–)	33.8	8.83(11)	–1.00(17)	9.8(2)	0.13(4)	9.9(2)	27.5(1.2)
		196	0(+)	25.3	9.89(8)	0	12.3(2)	0	12.3(2)	0.72(4)
		198	0(+)	7.2	7.8(1)	0	7.6(2)	0	7.6(2)	3.66(19)
Au	79	197	3/2(+)	100	7.63(6)	–1.84(10)	7.32(12)	0.43(5)	7.75(13)	98.65(9)
Hg	80				12.692(15)		20.24(5)	6.6(1)	26.8(1)	372.3(4.0)
		196	0(+)	0.2	30.3(1.0)	0	115.(8.)	0	115.(8.)	3080.(180.)
		198	0(+)	10.1		0		0		2.0(3)
		199	1/2(–)	17.0	16.9(4)	±15.5(8)	36.(2.)	30.(3.)	66.(2.)	2150.(48.)
		200	0(+)	23.1		0		0		< 60.
		201	3/2(–)	13.2						7.8(2.0)
		202	0(+)	29.6		0		0		4.89(5)
		204	0(+)	6.8		0		0		0.43(10)

Z	A	I(π)	c	b_c	b_i	σ_c	σ_i	σ_s	σ_a
Tl 81				8.776(5)		9.678(11)	0.21(15)	9.89(15)	3.43(6)
	203	1/2(+)	29.524	6.99(16)	1.06(14)	6.14(28)	0.14(4)	6.28(28)	11.4(2)
	205	1/2(+)	70.476	9.52(7)	−0.242(17)	11.39(17)	0.007(1)	11.40(17)	0.104(17)
Pb 82				9.405(3)		11.115(7)	0.0030(7)	11.118(7)	0.171(2)
	204	0(+)	1.4	9.90(10)	0	12.3(2)	0	12.3(2)	0.65(7)
	206	0(+)	24.1	9.22(5)	0	10.68(12)	0	10.68(12)	0.0300(8)
	207	1/2(−)	22.1	9.28(4)	0.14(6)	10.82(9)	0.002(2)	10.82(9)	0.699(10)
	208	0(+)	52.4	9.50(2)	0	11.34(5)	0	11.34(5)	0.00048(3)
Bi 83	209	9/2(−)	100	8.532(2)	0.259(15)	9.148(4)	0.0084(10)	9.156(4)	0.0338(7)
Po 84									
At 85									
Rn 86									
Fr 87									
Ra 88	226	0(+)	(1.60×10^3 a)	10.0(1.0)	0	13.(3.)	0	13.(3.)	12.8(1.5)
Ac 89									
Th 90	232	0(+)	100	10.31(3)	0	13.36(8)	0	13.36(8)	7.37(6)
Pa 91	231	3/2(−)	(3.28×10^4 a)	9.1(3)		10.4(7)	0.1(3.3)	10.5(3.2)	200.6(2.3)
U 92				8.417(5)		8.903(11)	0.005(16)	8.908(11)	7.57(2)
	233	5/2(+)	(1.59×10^5 a)	10.1(2)	±1.(3.)	12.8(5)	0.1(6)	12.9(3)	574.7(1.0)
	234	0(+)	0.005	12.4(3)	0	19.3(9)	0	19.3(9)	100.1(1.3)
	235	7/2(−)	0.720	10.47(4)	±1.3(6)	13.78(11)	0.2(2)	14.0(2)	680.9(1.1)
	238	0(+)	99.275	8.402(5)	0	8.871(11)	0	8.871(11)	2.68(2)
Np 93	237	5/2(+)	(2.14×10^6 a)	10.55(10)		14.0(3)	0.5(5) E	14.5(6)	175.9(2.9)
Pu 94									
	238	0(+)	(87.74 a)	14.1(5)	0	25.0(1.8)	0	25.0(1.8)	558.(7.)
	239	1/2(+)	(2.41×10^4 a)	7.7(1)	±1.3(1.9)	7.5(2)	0.2(6)	7.7(6)	1017.3(2.1)
	240	0(+)	(6.56×10^3 a)	3.5(1)	0	1.54(9)	0	1.54(9)	289.6(1.4)
	242	0(+)	(3.76×10^5 a)	8.1(1)	0	8.2(2)	0	8.2(2)	18.5(5)
Am 95	243	5/2(−)	(7.37×10^3 a)	8.3(2)	±2.(7.)	8.7(4)	0.3(2.6)	9.0(2.6)	75.3(1.8)
Cm 96									
	244	0(+)	(18.10 a)	9.5(3)	0	11.3(7)	0	11.3(7)	16.2(1.2)
	246	0(+)	(4.7×10^3 a)	9.3(2)	0	10.9(5)	0	10.9(5)	1.36(17)
	248	0(+)	(3.5×10^5 a)	7.7(2)	0	7.5(4)	0	7.5(4)	3.00(26)