Atomic Data and Nuclear Data Tables 111–112 (2016) 1–28

Contents lists available at ScienceDirect

Atomic Data and Nuclear Data Tables

journal homepage: www.elsevier.com/locate/adt

Table of nuclear electric quadrupole moments

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ARTICLE INFO

Article history:
Received 14 May 2015
Received in revised form
18 December 2015
Accepted 18 December 2015
Available online 11 April 2016

Keywords:
Nuclear electric quadrupole moments

ABSTRACT

This Table is a compilation of experimental measurements of static electric quadrupole moments of ground states and excited states of atomic nuclei throughout the periodic table. To aid identification of the states, their excitation energy, half-life, spin and parity are given, along with a brief indication of the method and any reference standard used in the particular measurement. Experimental data from all quadrupole moment measurements actually provide a value of the product of the moment and the electric field gradient [EFG] acting at the nucleus. Knowledge of the EFG is thus necessary to extract the quadrupole moment. A single recommended moment value is given for each state, based, for each element, wherever possible, upon a standard reference moment for a nuclear state of that element studied in a situation in which the electric field gradient has been well calculated. For several elements one or more subsidiary EFG/moment reference is required and their use is specified.

The literature search covers the period to mid-2015.

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http://dx.doi.org/10.1016/j.adt.2015.12.002
0092-640X/

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1. Introduction and motivation

The electric quadrupole moment is a feature of atomic nuclei which finds relevance in a wide range of fields of research and more general measurement. Although the quadrupole moment is most obviously of value in the study of nuclei themselves, being a measure of the deviation of the nuclear charge distribution from a spherical shape, measurement of nuclear quadrupole interactions forms a vital investigatory tool in many areas of condensed matter physics and, aiding into the elucidation of structures of complex molecules and their wave-functions, extending into many areas of chemical, biological and medical science.

Establishing an accepted value of the quadrupole moment of any nucleus faces a fundamental problem. The difficulty lies in the fact that what can actually be measured is the interaction energy of the quadrupole moment, eQ, with its surroundings, usually written as $h\nu_Q = e^2qQ$. This interaction involves the product of the moment with the electric field gradient [EFG], eq, acting at the nucleus. The situation can be contrasted to the challenge of measuring the nuclear magnetic dipole moment, μ, which similarly involves its product with the magnetic field B acting at the nucleus, $h\nu_M = \mu B$. In the latter case it is a relatively simple matter to apply a known magnetic field, generated by a suitable arrangement of coils carrying a precisely measured current, which can be varied at the will of the experimenter. The nuclear magnetic moment can be extracted from this product, and hence measured, by a wide range of methods.

However it is not possible to generate EFGs in the laboratory which are sufficiently large to produce measurable energy differences. Given the small scale of nuclear quadrupole moments, of order 1 barn [100 fm^2], to provide an energy splitting between levels of order 10 MHz requires an EFG of order 10^{17} V cm^{-2}. However, such large gradients are to be found at nuclei when in atoms, ions or molecules and also in a wide range of non-cubic solids. This does not solve the problem of extracting the quadrupole moment since difficulty in calculation of the EFG from first principles has been a serious barrier to separation of the nuclear quadrupole moment from the measured product.

This is not the place to enter into a history of multi-electron electric field distribution theory, however until the advent of more powerful computers only the simplest atoms or ions, with few electrons, were open to accurate calculation. For this reason the study of quadrupole hyperfine interactions in muonic atoms, in which the muon wave-function [and hence charge distribution and EFG] at the nucleus can be accurately predicted, was early seen as a fruitful way to establish reliable values of quadrupole moments, especially in heavier elements where the interaction can be readily resolved. For multi-electron atoms and ions, many delicate features of the calculation were beyond the power of computation until the past two decades or so. Prior to this, the best EFG estimates involved approximations and corrections related to the distortion of inner closed electron shells, collectively associated with the name Sternheimer shielding [or anti-shielding] factors, which could be uncertain to 10% or more. Thus, although experimentally the nuclear quadrupole interaction could be measured to very much better precision, the nuclear quadrupole moments extracted from the measurements were hard to pin down.

In recent years multi-electron computation has advanced to the extent that it is now possible to make calculations of EFGs in most atoms and ions and also in many molecules. The results show admirable self-consistency and are proving reliable to a degree comparable to that of the best muonic atom results. First in 1992 and again in 2001 and 2008, Pyykkö, one of the pioneers in such calculations, published a listing of recommended values of the quadrupole moments of selected, usually stable, nuclear states in the majority of elements, including those most commonly used in applications beyond the realm of nuclear structure physics. Adopting such a set of standard values allows measurements using the standard isotope to be used to calibrate EFGs in other environments and, by extension, to allow moments of other isotopes, and excited states in all isotopes, to be related to the single reference moment. The modern calculations include all effects previously grouped under the name of shielding.

There exist in the literature many excellent experimental results giving rise to values of nuclear quadrupole moments. Each measurement required the authors to specify the EFG at the nucleus in their particular experimental system. The published Q values depend upon the individual choice of EFG and can thus be difficult to compare consistently without considerable effort. This is especially true if the experiments were made many years apart, during which the reference value(s) adopted may have changed. Existing tabulations do not always specify adopted standards and where they do, the standard values can change over the years. Only recently has it been possible, with the aid of much improved EFG calculations, to prepare a tabulation in which the adopted standards are likely to prove stable over at least the medium term, trustworthy in many cases to a few percent or better.

This Table presents a listing of measured quadrupole moments normalised, as far as possible, to a set of identified reference moments, one or more for each element, which have been derived from measurement in a situation in which the EFG has been calculated either by a modern computation or in a simpler system such as a muonic atom. There are still some 17 elements, He, Si, P, Ar, Ag, Cd, Te, Ce, Tm, W, Pt, Tl, Po, At, Cm, Bk and Cf in the sequence to Einsteinium at $Z = 99$ for which no such basic reference standard has been adopted. For the majority of the remaining elements the reference values chosen by Pyykkö in his most recent listing have been adopted. The few exceptions are noted in the Table. Nevertheless it is frequently not possible to normalise all measurements to the adopted reference for an element. This arises most often in connection with excited state measurements when an equivalent measurement on the reference (usually stable) isotope in the same conditions is not possible. In such cases a secondary standard efg has often been adopted. These are briefly specified in the Table in the heading for each element. Further discussion of the primary and secondary reference EFG's, emphasizing where their adoption has led to major (>5%) change in the moment value, with several larger than 25%, is given in [1]. Major uncertainty reductions are also listed there.

In contrast to the forgoing discussion there do exist methods of measurement of the quadrupole moment which are free of uncertainty of estimation of an associated EFG. These involve calculation of field gradients provided by free electric charges and thus nothing more than Coulomb's law. They include electron scattering [ES] and re-orientation of the angular distribution during Coulomb excitation [CER] both of which have been extensively used in the study of short lived excited nuclear states. Calculation of the electromagnetic interaction of the charged projectile with the nucleus is straightforward in principle and the quadrupole moment can be readily extracted, although the experiments have limited accuracy. Results based on these methods are not directly related to, or dependent upon, the value of the adopted standard quadrupole moment for that element.

The most recent entries in this tabulation were published in mid-2015.

2. Policies

2.1. Signs

Signs are given when the sign can be determined from experimental data. Where the sign is not given by the measurement, no sign is given in the Table, although it can sometimes be inferred either from systematics or from the magnitude of the result.

2.2. Results and uncertainties

Experimental values and their associated errors are as given by the authors subject to a policy of limiting significant figures. Numerical errors with digits above 15 have, in most cases, been rounded to 2 and errors with first digit 2 or greater rounded down if the second digit is 4 or lower, otherwise rounded up. Results have also been rounded to give no more significant figures than the rounded error would allow. Thus a published value 0.953(65) has been rounded to 0.95(7) and 0.25(16) rounded to 0.3(2).

2.3. Electric quadrupole moments

These are listed in units of barns ($1 \text{ b} = 10^{-28} \text{ m}^2$). As explained in the introduction, with modern computations of the EFG, corrections relating shielding caused by polarisation of atomic electrons, known as Sternheimer Corrections, are no longer needed. Where there is more than one reference isotope this is possible without causing any confusion since moment ratios are frequently determined to far greater precision than their individual values. Reference to original publication is given, both in the form of the Nuclear Structure Reference listing [2] maintained at the National Nuclear Data Center, Brookhaven National Laboratory, and the journal reference (see separate listing at the end of the moment entries). A listing of journal abbreviations is given in Table 1.

Reference moments and EFG's

Justification of the reference values should be sought in the reference(s) given, usually Pyykkö [3], or, for the secondary standards, the measurements in which they have been used.

Recommended values

The Table gives, for each listed state, identified by energy [in keV], half-life and spin, a single value for the quadrupole moment. The method involved in its measurement is identified by one of the abbreviations listed in Table 1. Entries have been normalised to the given value of the reference isotope moment wherever possible, so values will in general differ from those in the original publications. Where several experimental results exist for the same state, attempts to make valid weighted averages have been avoided since frequently there exist non-statistical differences between experiments which cannot be properly taken into account. Most often one of the more recent results, with a relatively small estimated uncertainty, has been chosen. Readers who require a more extended listing of all results on a given state should consult the extended Tables [4,5].

Acknowledgments

The author gratefully acknowledges help and advice from Pekka Pyykkö and assistance from the staff of the National Nuclear Data Center, Brookhaven National Laboratory, in particular Joann B. Totans and Jagdish Tuli. This work builds upon earlier tabulations, notably those by Gladys Fuller [6] and Pramila Raghavan [7]. Research sponsored by the IAEA Nuclear Data Section, Vienna International Centre, 1400 Vienna, Austria.

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Explanation of Tables

Table 1. **Table of nuclear electric quadrupole moments**

Element	Identifies the element for the following isotopes and specifies the reference isotope(s) for that element. Also, in the first row for each element, the system in which the EFG which has been calculated to obtain the reference moment(s) is given briefly. Secondary standards are listed in subsequent rows and identified by Letters A, B, C.... For more details on the EFG calculations see [2] above.
Nucleus	Identifies the nucleus by mass number *A* and atomic number *Z*, with its chemical symbol. This is given once for each nucleus. Nuclei are grouped by element in increasing sequence of atomic number and by increasing mass number for each element.
E(level)	Gives the energy of the state on which the measurement is made, rounded to the nearest kilovolt, 0 being the ground state. Where placement of the level with respect to the ground state is unknown, this is denoted be addition of an offset *x* or *y*.
$T_{1/2}$	Gives the half-life $T_{1/2}$ the state: Units y = years, d = days, h = hours, m = minutes, s = seconds, ms = milliseconds (10^{-3} s), μs = microseconds (10^{-6} s), ns = nanoseconds (10^{-9} s), ps = picoseconds (10^{-12} s) and fs = femtoseconds (10^{-15} s).
I^π	Gives the spin (I) and parity (π) of the state. Uncertain values are given in brackets. Where the measurement was made on unresolved states, the average spin is given as I_{av}.
Q (b)	Gives the measured nuclear electric quadrupole moment Q in units of the barn (1 barn = 10^{-28} m^2). No sign is given if it was not determined by the experiment. The uncertainty in the result is given in brackets, subject to the policy declared in the introduction. Thus +1.27(10) means a value of +1.27 barns with uncertainty 0.10 barns.
Ref. Std.	In this column the reference standard upon which the listed result depends is given. There is no entry when the method used does not depend upon an adopted standard (i.e. a Coulomb Excitation Reorientation (CER) measurement).
Method	The method used in the measurement is briefly identified here. A list of abbreviations used is given below. In view of the great proliferation of specialised methods, this method description is limited and for detailed information reference should be made to the original publication. Re-evaluation of the published result, where it involves re-normalisation to the adopted value of the reference standard by the tabulator, is not indicated specifically.
References	1. The NSR keynumber reference is given in the main table. These can be further identified by reference to the Brookhaven National Nuclear Data Center website www.nndc.bnl.gov/nsr. 2. The original journal or other publication reference is given in the listing at the end of the Table.

Experimental method abbreviations

AB	Atomic beam magnetic resonance
AB/MS	Atomic beam and molecular spectroscopy
ABLDF	Atomic beam with laser double resonance detection
ABLFS	Atomic beam with laser fluorescence spectroscopy
ABLS	Atomic beam laser spectroscopy
β-NMR	NMR of in-beam polarised nuclei with beta asymmetry detection
β-NQR	Nuclear quadrupole resonance with beta detection
β-RadOP	Beta-ray detection of optical pumping
B(E2)	Value based on measured E2 transition probability
CER	Coulomb excitation reorientation
CERP	Precession of coulomb excitation reorientation
CFBLS	Collinear fast beam laser spectroscopy
CFBLS/β-NMR	Collinear fast beam laser spectroscopy: NMR with beta detection
CLS	Resonance cell laser spectroscopy
EPR	Electron paramagnetic resonance
ES	Electron scattering
IPAC	Integral perturbed angular correlation
LEMS	Level mixing spectroscopy
LRFS	Laser resonance fluorescence spectroscopy
LRIS	Laser resonance ionisation spectroscopy
LS	Laser spectroscopy
MA	Microwave absorption in gases
MAPON	Modulated adiabatic passage NMR on oriented nuclei
MB	Molecular beam magnetic resonance
ME	Mossbauer effect
MS	Molecular spectroscopy
Mu-X	Muonic X-ray hyperfine structure
NMR/ON	Nuclear magnetic resonance on oriented nuclei
NO/ME	Mossbauer effect on oriented nuclei
NO/S	Static nuclear orientation with gamma detection
NQR	Nuclear quadrupole resonance
NSLR	Nuclear spin-lattice relaxation
O	Optical spectroscopy
OD	Optical double resonance
OP/RD	Optical pumping with radiative detection
PAC	Perturbed angular correlation
Pi-X	Pionic X-ray Hyperfine Structure
Q	Quadrupole resonance
QI-NMR/ON	Quadrupole interaction resolved NMR on oriented nuclei
QIR	Quadrupole Interaction deduced from Relaxation Time
R	Re-evaluated data, or (for revised reference standard) adjusted by tabulator
RIMS/LS	Resonant ionisation mass spectrometry/laser spectroscopy
TDPAC	Time-dependent perturbed angular correlation
TDPAD	Time-dependent perturbed angular distribution
TF	Transient field
TFLD	Tilted foil time-differential perturbed gamma angular distribution
TLS	Trap laser spectroscopy

Literature reference abbreviations

ADNDT	Atomic Data and Nuclear Data Tables
AECL	Atomic Energy Commission, Chalk River Laboratories, Report
ARHMI	Annual Report, Hahn–Meitner Institute, Berlin
AuJP	Australian Journal of Physics
BAPS	Bulletin of the American Physical Society
Bk88 NFFS	Nuclei Far From Stability, AIP Conference 164, Rosseau Lake, Ont. Canada 1988
CERN EP	CERN EP Division Report
CPL	Chemical Physics Letters
CzJP	Czech Journal of Physics
Eur Phys J	European Physics Journal
HP Ac	Helvetica Physica Acta
HFI	Hyperfine Interactions
IoP Conf	Institute of Physics Conference Series
IAN	Izv. Akad. Nauk. SSSR Ser Fiz (trans. Bull. Acad. Sci. USSR, Phys. Ser.)
J Phys	Journal of Physics (London)
J Phys Radium	Journal de Physique et el Radium (Paris)
JCP	Journal of Chemical Physics
JINC	Journal of Inorganic and Nuclear Chemistry
JPCR	Journal of Physical and Chemical Reference Data
JPJS	Journal of the Physical Society of Japan
JPPa	Journal de Physique (Paris)
LNPP	Leningrad Nuclear Physics Institute preprint
Mol Phys	Molecular Physics
NIM	Nuclear Instruments and Methods
NIMPR	Nuclear Instruments and Methods in Physics Research
NP	Nuclear Physics

ORNL	Oak Ridge National Laboratory Report
Ospk	Opt. Spektrosk. (trans Optics and Spectroscopy (USSR))
PCNeugart	R. Neugart, private communication
Phca	Physica
PhMg	Philosophical Magazine
PL	Physics Letters
PR	Physical Review
Prep	Physics Reports
PRL	Physical Review Letters
PS	Physica Scripta
RIKEN	Report of RIKEN Laboratory, Japan
Sol St Comm	Solid State Communications
STMP	Springer Texts in Modern Physics
Th 68 Cass.	B.R.Casserberg, Thesis, Princeton, (1968)
UCRL	University of California Lawrence Berkeley Report
UkrF	Ukrainskii Fiz. Zh.
YadF	Yadern Fys. (trans Soviet Journal of Nuclear Physics)
ZNat	Zeitschrift fur Naturforschung
ZP	Zeitschrift fur Physik

Table 1
Table of nuclear electric quadrupole moments.

Element	Nucleus	E (level) keV	$T_{1/2}$	I^{π}	$Q\,(b)$	Ref. Std.	Method	Reference
Hydrogen	*Efg at the deuterium nucleus calculated for HD and D_2*							
Reference isotope	1 H 2	0	Stable	1+	+0.00286(2)		MB, R	1979Bi14
Lithium	*Efg at the ^{7}Li nucleus calculated for the LiH molecule*							
	3 Li 6	0	Stable	1+	−0.000806(6)	[7Li]	MB	2005Bo45/1998Ce04
Reference isotope	3 Li 7	0	Stable	3/2−	−0.0400(3)		MB	2008Py02
	3 Li 8	0	842 ms	2+	+0.0314(2)	[7Li]	β-NMR	2005Bo45
	3 Li 9	0	178 ms	3/2−	−0.0304(2)	[7Li]	β-NMR	2011AV08
	3 Li 11	0	8.5 ms	3/2−	(−)0.0339(5)	[7Li]	NQR	2014Vo01
Beryllium	*Calculation of the quadrupole coupling constant for the $^3P_2$ state of the Be atom*							
Reference isotope	4 Be 9	0	Stable	3/2−	+0.0529(4)		AB	1991Su05
Boron	*Calculation of the quadrupole coupling constant of the $^2P_{3/2}$ ground state of the B atom*							
	5 B 8	0	0.77s	2+	+0.0643(14)	[11B]	β-NQR	2006Su13
	5 B 10	0	Stable	3+	+0.0845(2)	[11B]	AB	2008Py02/1970Ne21
Reference isotope	5 B 11	0	Stable	3/2−	+0.04059(10)		AB	2008Py02/1970Ne21
	5 B 12	0	20.4 ms	1+	0.0132(3)	[11B]	β-NMR	1992Mi18
	5 B 13	0	17.4 ms	3/2−	(+)0.0365(8)	[11B]	β-NMR	2004Na38
	5 B 14	0	13.8 ms	2−	0.0297(8)	[11B]	β-NMR	1996Iz01
	5 B 15	0	10.3 ms	3/2−	0.0379(11)	[11B]	β-NMR	1996Iz01
	5 B 17	0	5.1 ms	(3/2−)	0.0385(15)	[11B]	β-NMR	2003Og03
Carbon	*Calculation of the quadrupole coupling constant of the $^3P_2$ state of the C atom*							
Reference isotope	6 C 11	0	20.4 m	3/2−	0.0333(2)		AB	2008Py02/1969Sc34
	6 C 12	4438	45 fs	2+	+0.06(3)	[11C]	CER	1983Ve01
Nitrogen	*Calculation of the quadrupole coupling constant of the $^1P_1$ state of the N^+ ion*							
	7 N 12	0	11.0 ms	1+	+0.100(9)	[14N]	β-NMR	1998Mi10
Reference isotope	7 N 14	0	Stable	1+	+0.02044(3)		AB/MS	2008Py02/1997To06
	7 N 16	0	7.13 s	2−	(−)0.018(2)	[14N]	β-NMR	2001Ma42
	7 N 18	0	624 ms	1−	+0.027(4)	[14N]	LMR	1999Ne01
					(+)0.0123(12)	[14N]	β-NMR	1999Og03
Oxygen	*Calculation of the quadrupole coupling constant of the $^3P_2$ state of the O atom*							
	8 O 13	0	8..6 ms	3/2−	0.0111(8)	[17O]	β-NQR	1999Ma46
Reference isotope	8 O 17	0	Stable	5/2+	−0.0256(2)		R/EPR	2008Py02/1969Sc34
	8 O 18	1982	2.07 ps	2+	−0.036(9)	[17O]	CER	1983Gr28
	8 O 19	0	27 s	5/2+	0.00362(13)	[17O]	β-NMR	1999Mi16
Fluorine	*Calculation of the quadrupole coupling constant of the F_2 molecule*							
	9 F 17	0	64.5 s	5/2+	0.076(4)	[19F 197 keV]	β-NMR	1974Mi21
	9 F 18	1121	153 ns	5+	0.071(6)	[19F 197 keV]	β-NMR	1974Mi21
Reference isomer	9 F 19	197	88.5 ns	5/2+	−0.0942(9)		PAC	2008Py02
	9 F 20	0	11 s	2+	0.056(4)	[19F 197 keV]	β-NMR	1974Mi21
	9 F 21	0	4.16 s	5/2+	0.011(2)	[19F 197 keV]	β-NMR	1999Mb13
	9 F 22	0	4.2 s	4+	0.003(2)	[19F 197 keV]	β-NMR	2010Mi13
Neon	*Calculation of the quadrupole coupling constant of the $^3P_2$ state of the Ne atom*							
	10 Ne 20	1634	0.7 ps	2+	−0.23(3)	[21Ne]	CER	1981Sp07
Reference isotope	10 Ne 21	0	Stable	3/2+	+0.102(8)		O/AB	2008Py02/1972Du06
	10 Ne 22	1275	3.6 ps	2+	−0.19(4)	[21Ne]	CER	1981Sp07
	10 Ne 23	0	37.6 s	5/2+	0.145(13)	[21Ne]	CFBLS	2005Ge06
Sodium	*Muonic atom HFS measurements*							
	11 Na 20	0	0.446 s	2+	+0.101(8)	[23Na]	β-NMR	2009Mi04
	11 Na 21	0	22.5 s	3/2+	0.138(11)	[23Na]	β-NMR	2009Mi04
	11 Na 22	0	2.60 y	3+	+0.180(11)	[23Na]	ABLS	1998Ga44
Reference isotope	11 Na 23	0	Stable	3/2+	+0.104(1)		O	2008Py02/2006Da14
	11 Na 25	0	60 s	5/2+	0.0015(3)	[23Na]	β-NMR	2004Og13
	11 Na 26	0	1.07 s	3+	−0.0053(2)	[23Na]	CFBLS/β-NMR	2000Ke09
	11 Na 27	0	0.29 s	5/2+	−0.0071(3)	[23Na]	CFBLS/β-NMR	2000Ke09
	11 Na 28	0	30.5 ms	1+	+0.389(11)	[23Na]	CFBLS/β-NMR	2000Ke09
	11 Na 29	0	43 ms	3/2+	+0.085(3)	[23Na]	CFBLS/β-NMR	2000Ke09
Magnesium	*Calculation of the quadrupole coupling constant of the $^3P_1$ state of the Mg atom*							
	12 Mg 23	0	11.3 s	3/2+	0.114(3)	[25Mg]	β-NMR	1999Mb13
	12 Mg 24	1369	1.45 ps	2+	−0.29(3)		CER	1990Gr11
Reference isotope	12 Mg 25	0	Stable	5/2+	+0.199(2)		AB	2008Py02
	12 Mg 26	1809	476 fs	2+	−0.21(2)		CER	1991He09
Aluminium	*Calculation of the quadrupole coupling constant of the $^3P_{3/2}$ state of the Al atom*							
	13 Al 25	0	7.18 s	5/2+	0.24(2)	[27Al]	β-NQR	2007Ma94
	13 Al 26	0	7×10^5 y	5+	+0.26(3)	[27Al]	ABLS	1997Le19
Reference isotope	13 Al 27	0	Stable	5/2+	+0.1466(10)		AB	2008Py02/1968Ma23
	13 Al 28	0	2.24 m	3+	0.172(12)	[27Al]	β-NMR	1978St31

(*continued on next page*)

Table 1 (*continued*)

Element	Nucleus	E (level) keV	$T_{1/2}$	I^{π}	Q (b)	Ref. Std.	Method	Reference
	13 Al 31	0	644 ms	(5/2+)	0.134(2)	[27Al]	β-NQR	2009De25
	13 Al 32	0	33 ms	1+	0.025(2)	[27Al]	β-NQR	2007Ka68
	13 Al 33	0	44 ms	(5/2+)	0.132(16)	[27Al]	β-NMR	2012Sh22
Silicon	*There is no adopted reference efg for Si.*							
	A. Efg at Si in Al_2O_3 estimated from band structure calculations							
	14 Si 27	0	4.1 s	5/2+	0.063(14)	A	β-NQR	1999Mb13
	14 Si 28	1779	0.49 ps	2+	+0.16(3)		CER	1981Sp07
	14 Si 30	2235	0.25 ps	2+	−0.05(6)		CER	1981Sp07
Phosphorus	*There is no adopted reference efg for P.*							
	A. Calculated efg at P site in $\alpha - Al_2O_3$							
	15 P 28	0	270 ms	3+	0.137(14)	A	β-NQR	2012Zh36
Sulphur	*Calculation of the quadrupole coupling constant of the S^- ion*							
	A. Efg at S site in FeS_2							
	16 S 32	2230	0.16 ps	2+	−0.16(2)		CER	1982Ve09
Reference isotope	16 S 33	0	Stable	3/2+	−0.0678(13)		MA	2008Py02
	16 S 34	2128	0.32 ps	2+	+0.04(3)		CER	1981Sp07
Reference isotope	16 S 35	0	87.4 d	3/2+	+0.0471(9)		MA	2008Py02
	16 S 43	320	415 ns	7/2−	0.23(3)	A	TDPAD	2012Ch16
Chlorine	*Calculation of the quadrupole interaction at Cl in the HCl molecule*							
Reference isotope	17 Cl 35	0	Stable	3/2+	−0.0817(8)		AB	2008Py02
	17 Cl 36	0	3.0×10^5 y	2+	−0.178(4)	[35Cl]	MA	1972St38
Reference isotope	17 Cl 37	0	Stable	3/2+	−0.0644(6)		AB	2008Py02
Argon	*Calculation of the quadrupole coupling constant in the Ar atom*							
	18 Ar 35	0	1.78s	3/2+	−0.084(15)	[37Ar]	CFBLS/β-NMR	1996Kl04
	18 Ar 36	1970	0.28 ps	2+	+0.11(6)		CER	1971Na06
Reference isotope	18 Ar 37	0	35.0 d	3/2+	+0.076(9)	Calc B value	CFBLS/β-NMR	1996Kl04
	18 Ar 39	0	269 y	7/2−	−0.12(3)	[37Ar]	CFBLS	2008Bl01
	18 Ar 40	1461	1.12 ps	2+	+0.01(4)		CER	1971Na05
	18 Ar 41	0	1.82 h	7/2−	−0.042(4)	[37Ar]	CFBLS	2008Bl01
	18 Ar 43	0	5.37 m	5/2−	+0.142(14)	[37Ar]	CFBLS	2008Bl01
Potassium	*Calculation of the quadrupole coupling constant of the $^4F_{9/2}$ state of the K atom*							
	19 K 37	0	1.22 s	3/2+	+0.106(4)	[39K]	β-NQR	2008Mi07
Reference isotope	19 K 39	0	Stable	3/2+	+0.0585(6)		AB	2008Py02/1998Ke05
Reference isotope	19 K 40	0	1.3×10^9 y	4−	−0.073(1)		AB	2008Py02/1998Ke05
Reference isotope	19 K 41	0	Stable	3/2+	+0.0711(7)		AB	2008Py02/1998Ke05
Calcium	*Calculation of the quadrupole coupling constant of the $^1D_2$ state of the Ca atom*							
	20 Ca 39	0	0.86 s	3/2+	0.036(7)	calc efg	β-NMR	1999MaZI
Reference isotope	20 Ca 41	0	1.0×10^5 y	7/2−	−0.0665(18)		AB	2008Py02
	20 Ca 42	1525	1.1 ps	2+	−0.19(8)		CER	1973To07
Reference isotope	20 Ca 43	0	Stable	7/2−	−0.0408(8)		AB	2008Py02
	20 Ca 44	1157	3.0 ps	2+	−0.14(7)		CER	1973To07
	20 Ca 45	0	165 d	7/2−	+0.038(12)	[41Ca]	ABLFS	1983Ar25
Scandium	*Calculation of the quadrupole coupling constants in ScF, ScCl and ScBr molecules*							
	21 Sc 41	0	0.59 s	7/2−	−0.145(3)	[45Sc]	β-NQR	2002Mi37
	21 Sc 43	0	3.89 h	7/2−	−0.27(5)	[45Sc]	CLS	2011Av01
		3123	473 ns	19/2−	0.199(14)	[45Sc]	TDPAD	1981Da06
	21 Sc 44	0	3.89 h	2+	+0.10(5)	[45Sc]	CLS	2011Av01
		68	153 ns	1−	0.21(2)	[45Sc]	TDPAC	1973Ha61
		271	58.6 h	6+	−0.19(2)	[45Sc]	CLS	2011Av01
Reference isotope	21 Sc 45	0	Stable	7/2−	−0.220(2)		MS	2008Py02
		12.4	318 ms	3/2+	+0.28(5)	[45Sc]	CLS	2011Av01
	21 Sc 46	0	83.81 d	4+	+0.119(6)	[45Sc]	AB	1962Pe21
	21 Sc 47	0	3.42 d	7/2−	−0.22(3)	[45Sc]	AB	1966Co13
Titanium	*Calculation of the quadrupole coupling constants in states of the Ti^+ ion*							
	22 Ti 43	3066	560 ns	19/2−	0.33(8)	[47Ti]	TDPAD	1981Da06
	22 Ti 45	0	3.09 h	7/2−	0.015(15)	[47Ti][49Ti]	AB	1966Co19
	22 Ti 46	889	5.36 ps	2+	−0.21(6)		CER	1975To06
Reference isotope	22 Ti 47	0	Stable	5/2−	+0.302(10)		AB	2008Py02
	22 Ti 48	984	4.29 ps	2+	−0.177(8)		ES	1972Li12
Reference isotope	22 Ti 49	0	Stable	7/2−	+0.247(11)		AB	2008Py02
	22 Ti 50	1554	1.12 ps	2+	+0.08(16)		CER	1975To06
Vanadium	*Calculation of the quadrupole coupling constants in states of the V atom*							
	A. Calculated efg in 3d/4s excited states of the V atom							
Reference isotope	23 V 50	0	1.5×10^{17} y	6+	+0.21(4)		ABLDF	2008Py02/1979Er04
	23 V 51	0	Stable	7/2−	−0.043(5)	A	LRFS	1989Un01

(*continued on next page*)

Table 1 (*continued*)

Element	Nucleus	E (level) keV	$T_{1/2}$	I^{π}	Q (b)	Ref. Std.	Method	Reference
Chromium	*Calculation of the quadrupole coupling constants in states of the Cr atom*							
	24 Cr 50	783	9.2 ps	2+	−0.36(7)		CER	1975To06
	24 Cr 52	1434	0.707 ps	2+	−0.08(2)		ES	1989Ra17(1)
Reference isotope	24 Cr 53	0	Stable	3/2−	−0.15(5)		AB	2008Py02
	24 Cr 54	835	8.0 ps	2+	−0.21(8)		CER	1975To06
Manganese	*Calculation of the quadrupole coupling constant for the ^6D states of the Mn atom*							
	25 Mn 50	229	1.75 m	5+	+0.83(12)	[Mn55]	TLS	2010Ch15
	25 Mn 51	0	Stable	5/2−	0.41(8)	[Mn55]	AB	1971Jo10
	25 Mn 52	0	5.80 d	6+	+0.50(7)	[Mn55]	NMR/ON	1970Ni11
	25 Mn 53	0	3.7×10^6 y	7/2−	+0.17(3)	[Mn55]	TLS	2010Ch15
	25 Mn 54	0	312 d	3+	+0.37(3)	[Mn55]	TLS	2010Ch15
Reference isotope	25 Mn 55	0	Stable	5/2−	+0.330(10)		AB	2008Py02
	25 Mn 56	0	2.58 h	3+	+0.48(15)	[Mn55]	TLS	2010Ch15
Iron	*Efg calculations in many Fe compounds*							
	26 Fe 54	1408	0.80 ps	2+	−0.05(14)		CER	1981Le02
		6527	367 ns	10+	+0.30(4)	[57Fe 14 keV]	TDPAD/TF	1984Ha07
	26 Fe 56	847	6.9 ps	2+	−0.23(3)		CER	1971Th14
Reference isomer	26 Fe 57	14	98 ns	3/2−	+0.160(8)		ME	2008Py02/1995Du17
	26 Fe 58	811	6.7 ps	2+	−0.27(5)		CER	1981Le02
	26 Fe 61	861	245 ns	(9/2+)	0.44(6)	[57Fe 14 keV]	TDPAD	2007Ve05
Cobalt	*Calculation of the quadrupole coupling constants in states of the Co atom*							
	27 Co 56	0	78.8 d	4+	+0.25(9)	[59Co]	MAPON	1988Ba87
	27 Co 57	0	271 d	7/2−	+0.54(10)	[59Co]	NMR/ON	1972Ni01
	27 Co 58	0	70.8 d	2+	+0.23(3)	[59Co]	NMR/ON	1972Ni01
Reference isotope	27 Co 59	0	Stable	7/2−	+0.42(3)		AB	2008Py02
	27 Co 60	0	5.271 y	5+	+0.46(6)	[59Co]	NMR/ON	1972Ni01
Nickel	*Calculation of the quadrupole coupling constants in states of the Ni atom*							
	28 Ni 58	1454	0.644 ps	2+	−0.10(6)		CER	1974Le13
	28 Ni 60	1332	0.713 ps	2+	−0.10(2)		ES	1972Li12
Reference isotope	28 Ni 61	0	Stable	3/2−	+0.162(15)		AB	2008Py02/1968Ch10
		67	5.34 ns	5/2−	−0.20(3)	[61Ni]	ME	1971Go31
	28 Ni 62	1173	1.43 ps	2+	+0.05(12)		CER	1974Le13
	28 Ni 64	1346	0.85 ps	2+	+0.4(2)		CER	1971ChZK
Copper	*Muonic atom X-ray hyperfine structure*							
	29 Cu 58	0	3.2 s	1+	−0.16(3)	[65Cu]	CLS	2011Vi03
	29 Cu 59	0	81.5 s	3/2−	−0.20(2)	[65Cu]	CLS	2011Vi03
	29 Cu 60	0	23.4 m	2+	+0.121(13)	[65Cu]	CLS	2011Vi03
	29 Cu 61	0	3.41 h	3/2−	−0.221(10)	[65Cu]	CLS	2011Vi03
	29 Cu 62	0	9.73 m	1+	−0.022(4)	[65Cu]	CLS	2011Vi03
Reference isotope	29 Cu 63	0	Stable	3/2−	−0.220(15)		Mu-X	2008Py02/1982Ef01
	29 Cu 64	0	12.7 h	1+	+0.075(9)	[65Cu]	CLS	2010Vi07
Reference isotope	29 Cu 65	0	Stable	3/2−	−0.204(14)		Mu-X	2008Py02/1982Ef01
	29 Cu 66	0	5.1 m	1+	+0.059(14)	[65Cu]	CLS	2010Vi07
		1154	0.60 ms	6−	(+)0.195(13)	[63Cu,65Cu]	TDPAD	2011Lo01
	29 Cu 67	0	61.83 h	3/2−	−0.182(8)	[65Cu]	CLS	2010Vi07
	29 Cu 68	0	31.1 s	1+	−0.086(14)	[65Cu]	CLS	2010Vi07
		637	3.75 m	6−	−0.46(2)	[65Cu]	CLS	2010Vi07
	29 Cu 69	0	2.85 m	3/2−	−0.154(17)	[65Cu]	CLS	2010Vi07
	29 Cu 70	0	44.5 s	6−	−0.298(15)	[65Cu]	CLS	2010Vi07
		101	33 s	3−	−0.14(4)	[65Cu]	CLS	2010Vi07
		242	6.6 s	1+	−0.12(3)	[65Cu]	CLS	2010Vi07
	29 Cu 71	0	19.5 s	3/2−	−0.200(17)	[65Cu]	CLS	2010Vi07
	29 Cu 72	0	6.62 s	2−	+0.08(2)	[65Cu]	CLS	2010Vi07
	29 Cu 73	0	4.2 s	3/2−	−0.210(10)	[65Cu]	CLS	2010Vi07
	29 Cu 74	0	1.63 s	2−	+0.27(3)	[65Cu]	CLS	2010Vi07
	29 Cu 75	0	1.22 s	5/2−	−0.281(17)	[65Cu]	CLS	2010Vi07
Zinc	*Calculation of the quadrupole coupling constants in states of the Zn atom*							
	30 Zn 63	0	38.1 m	3/2−	+0.29(3)	[67Zn]	OD	1969La05
	30 Zn 64	992	1.85 ps	2+	−0.14(2)		ES	1981Ko06/1976Ne06
	30 Zn 65	0	244.1 d	5/2−	−0.023(2)	[67Zn]	OD	1964By01
	30 Zn 66	1039	1.56 ps	2+	−0.081(13)		ES	1981Ko06/1976Ne06
Reference isotope	30 Zn 67	0	Stable	5/2−	+0.150(15)		AB	2008Py02/1969La05
		604	333 ns	9/2+	+0.54(5)	[67Zn]	NQR	1976Ch37/1979Ka44
	30 Zn 68	1077	1.61 ps	2+	−0.106(16)		ES	1981Ko06/1976Ne06
	30 Zn 69	439	13.72 h	9/2+	−0.45(7)	[67Zn]	NO/S	1983Oe01
	30 Zn 70	885	3.2 ps	2+	−0.24(3)		ES	1981Ko06/1976Ne06
Gallium	*Calculation of the quadrupole coupling constants in GaF, GaCl and GaBr molecules*							
	31 Ga 63	0	32.4 s	3/2−	+0.212(4)	[69Ga]	CLS	2012Pr11
	31 Ga 66	1464	57 ns	7−	+0.78(4)	[69Ga][71Ga]	TDPAD	1985Ra33

(*continued on next page*)

Table 1 (*continued*)

Element	Nucleus	E (level) keV	$T_{1/2}$	I^{π}	$Q(b)$	Ref. Std.	Method	Reference
	31 Ga 67	0	78.3 h	3/2−	+0.197(2)	[69Ga][71Ga]	AB	1968Eh02/2001Py02
	31 Ga 68	0	68.1 m	1+	−0.0277(14)	[69Ga][71Ga]	AB	1972St38
		1230	64 ns	7−	+0.72(2)	[69Ga][71Ga]	TDPAD	1985Ra33
Reference isotope	31 Ga 69	0	Stable	3/2−	+0.171(2)		MS	2008Py02
	31 Ga 70	0	21.1 m	1+	+0.105(7)	[69Ga]	CLS	2012Pr11
Reference isotope	31 Ga 71	0	Stable	3/2−	+0.107(1)		MS	2008Py02
	31 Ga 72	0	14.1 h	3−	+0.530(6)	[69Ga][71Ga]	AB	1968Eh02/2001Py02
	31 Ga 73	0	4.86 h	3/2−	+0.209(2)	[71Ga]	CLS	2010Ch16
	31 Ga 74	0	8.12 m	3− or 4−	+0.55(4) or +0.60(4)	[71Ga]	LRS	2011Ma45
	31 Ga 75	0	126 s	3/2−	−0.285(17)	[71Ga]	CLS	2010Ch16
	31 Ga 76	0	32.6 s	(2+)	+0.33(2)	[71Ga]	LRS	2011Ma45
	31 Ga 77	0	13.2 s	3/2−	−0.208(13)	[71Ga]	CLS	2010Ch16
	31 Ga 78	0	5.1 s	(2+)	+0.33(2)	[71Ga]	LRS	2011Ma45
	31 Ga 79	0	2.85 s	3/2−	+0.158(10)	[71Ga]	CLS	2010Ch16
	31 Ga 80	0?	0.2–1.7 s	(3−)	+0.38(2)	[71Ga]	CLS	2010Ch50
		0?	0.2–1.7 s	(6−)	+0.48(3)	[71Ga]	CLS	2010Ch50
	31 Ga 81	0	1.22 s	5/2−	−0.048(8)	[71Ga]	CLS	2010Ch16
Germanium	*Calculation of the quadrupole coupling constants in GeO, GeS molecules*							
	A. Efg of Ge in Zn single crystal							
	32 Ge 67	752	146 ns	9/2+	0.92(9)	[73Ge]	TDPAD	1993Co17/1981Vi05
	32 Ge 69	0	39.0 h	5/2−	+0.027(5)	[73Ge]	AB	1970Ol02
		398	2.8 ms	9/2+	0.75(8)	[73Ge]	TDPAD	1993Co17/1981Vi05
	32 Ge 70	1039	1.32 ps	2+	+0.03(6)		CER	1980Le16/2000To12
	32 Ge 71	175	84 ns	5/2+	0.18(4)	A	TDPAD	1993Co17/1981Vi05
		199	20.2 ms	9/2+	0.34(5)		QIR	1975Ri03/1976Br41
	32 Ge 72	834	3.29 ps	2+	−0.13(6)		CER	1980Le16/2000To12
Reference isotope	32 Ge 73	0	Stable	9/2+	−0.196(1)		MS	2008Py02/1999Ke17
		13	2.86 ms	5/2+	0.70(8)	A	TDPAC	1993Co17/1981Vi05
	32 Ge 74	596	12.5 ps	2+	−0.19(2)		CER	2000To12
		1204	4.9 ps	2+	−0.26(6)		CER	2000To12
	32 Ge 76	563	18.6 ps	2+	−0.19(6)		CER	1980Le16/2000To12
Arsenic	*Muonic atom X-ray hyperfine structure*							
	33 As 70	0	53 m	4+	+0.09(2)	[75As]	AB	1980Ho02
	33 As 71	0	65.3 h	5/2−	−0.021(6)	[75As]	NO/S	1988Wh03
	33 As 72	0	26 h	2−	−0.08(2)	[75As]	AB	1980Ho02
	33 As 73	66	5.0 ns	5/2−	+0.356(12)	[75As]	TDPAC	1992Sc21
Reference isotope	33 As 75	0	Stable	3/2−	+0.314(6)		Mu-X	2008Py02/1982Ef01
Selenium	*Calculation of the quadrupole coupling constant in Se metal*							
	34 Se 74	635	7.08 ps	2+	−0.36(7)		CER	1978Le22
	34 Se 75	0	118.5 d	5/2+	1.1(2)	[77Se]	MA	1955Aa06
	34 Se 76	559	12.3 ps	2+	−0.34(7)		CER	1977Le11
Reference isotope	34 Se 77	250	9.56 ns	5/2−	+0.76(5)		TDPAC	2008Py02/1983Un02
	34 Se 78	614	8.6 ps	2+	−0.26(9)		CER	1977Le11
	34 Se 79	0	$<6.5 \times 10^4$ y	7/2+	+0.8(2)	[77Se]	MA	1989Ra17(2)
	34 Se 80	666	8.0 ps	2+	−0.31(7)		CER	1977Le11
	34 Se 82	654	11.3 ps	2+	−0.22(7)		CER	1977Le11
Bromine	*Calculation of the quadrupole coupling constants in states of the Br atom and in HBr*							
	35 Br 76	0	16.1 h	1−	+0.255(4)	[79Br]	AB	1960Li11
	35 Br 77	0	57 h	3/2−	+0.50(2)	[79Br]	MAPON	1998Se09
Reference isotope	35 Br 79	0	Stable	3/2−	+0.313(3)		AB/MS	2008Py02/2001Bi17
	35 Br 80	0	17.6 m	1+	+0.185(3)	[79Br]	AB	1964Wh05
		37	7.4 ns	2−	0.164(6)	[79Br]	AB	1978Ta24
		86	4.42 h	5−	+0.710(10)	[79Br]	AB	1964Wh05
Reference isotope	35 Br 81	0	Stable	3/2−	+0.262(3)	[79Br]	AB/MS	2008Py02/2001Bi17
	35 Br 82	0	35.3 h	5−	+0.707(10)	[79Br]	AB	1959Ga12
Krypton	*Calculation of the quadrupole coupling constants in* KrH^+							
	36 Kr 75	0	4.3 m	5/2+	+1.137(13)	[83Kr]	CFBLS	1995Ke04
	36 Kr 77	0	74.4 m	5/2+	+0.948(10)	[83Kr]	CFBLS	1995Ke04
	36 Kr 79	130	50 s	7/2+	+0.404(5)	[83Kr]	CFBLS	1995Ke04
		147	77.7 ns	5/2−	+0.45(3)	[83Kr]	TDPAD	1978HaXP
	36 Kr 81	0	2.3×10^5 y	7/2+	+0.644(4)	[83Kr]	LRFS	1993Ca41
Reference isotope	36 Kr 83	0	Stable	9/2+	+0.259(1)		MS	2008Py02
		9	147 ns	7/2+	+0.507(3)	[83Kr]	ME	1977Ho33
	36 Kr 84	3236	1.84 ms	8+	+0.36(4)	[83Kr]	LEMS	2006Sc22
	36 Kr 85	0	10.76 y	9/2+	+0.443(3)	[83Kr]	LRFS	1993Ca41
	36 Kr 87	0	76.3 m	5/2+	−0.300(3)	[83Kr]	CFBLS	1995Ke04
	36 Kr 89	0	3.15 m	3/2+	+0.166(2)	[83Kr]	CFBLS	1995Ke04
	36 Kr 91	0	8.57 s	5/2+	+0.303(6)	[83Kr]	CFBLS	1995Ke04
	36 Kr 94	666	8.7 ps	2+	−0.5(3)		CER	2012 Al03

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Table 1 (*continued*)

Element	Nucleus	E (level) keV	$T_{1/2}$	I^{π}	Q (b)	Ref. Std.	Method	Reference
Rubidium	*Calculation of the quadrupole coupling constants in RbF*							
	37 Rb 76	0	39 s	1(−)	+0.46(20)	[85Rb]	ABLS	1981Th04
	37 Rb 77	0	3.8 m	3/2−	+0.84(17)	[85Rb]	ABLS	1981Th04
	37 Rb 78	103	6.3 m	4−	+0.99(20)	[85Rb]	ABLS	1981Th04
	37 Rb 79	0	23 m	5/2+	−0.12(4)	[85Rb]	ABLS	1981Th04
	37 Rb 80	0	30 s	1+	+0.42(8)	[85Rb]	ABLS	1981Th04
	37 Rb 81	0	4.58 h	3/2−	+0.48(10)	[85Rb]	ABLS	1981Th04
		86	32 m	9/2+	−0.90(19)	[85Rb]	ABLS	1981Th04
	37 Rb 82	0	1.25 m	1+	+0.23(10)	[85Rb]	ABLS	1981Th04
		∼100	6.47 h	5−	+1.22(27)	[85Rb]	ABLS	1981Th04
	37 Rb 83	0	86.2 d	5/2−	+0.24(5)	[85Rb]	ABLS	1981Th04
	37 Rb 84	0	33 d	2−	−0.02(4)	[85Rb]	ABLS	1981Th04
		465	20.4 m	6−	+0.70(36)	[85Rb]	ABLS	1981Th04
Reference isotope	37 Rb 85	0	Stable	5/2−	+0.276(1)		MS	2008Py02
		514	1.02 ms	9/2+	−0.9(3)	[85Rb]	OPD	1991Ma21
	37 Rb 86	0	18.65 d	2−	+0.23(6)	[85Rb]	ABLS	1981Th04
		556	1.02 m	(6−)	+0.45(14)	[85Rb]	ABLS	1981Th04
Reference isotope	37 Rb 87	0	4.9×10^{10} y	3/2−	+0.1335(5)		MS	2008Py02
	37 Rb 88	0	17.7 m	2−	−0.01(11)	[85Rb]	ABLS	1981Th04
	37 Rb 89	0	15.2 m	3/2−	+0.17(3)	[85Rb]	ABLS	1981Th04
	37 Rb 90	107	4.26 m	3−	+0.25(7)	[85Rb]	ABLS	1981Th04
	37 Rb 91	0	58 s	3/2(−)	+0.19(5)	[85Rb]	ABLS	1981Th04
	37 Rb 93	0	5.85 s	5/2−	+0.21(6)	[85Rb]	ABLS	1981Th04
	37 Rb 94	0	2.73 s	3(−)	+0.20(7)	[85Rb]	ABLS	1981Th04
	37 Rb 95	0	0.38 s	5/2−	+0.26(9)	[85Rb]	ABLS	1981Th04
	37 Rb 96	0	0.20 s	2+	+0.30(9)	[85Rb]	ABLS	1981Th04
	37 Rb 97	0	0.17 s	3/2−	+0.70)15)	[85Rb]	ABLS	1981Th04
Strontium	*Calculation of the quadrupole coupling constants in the 4d $^2D_{5/2}$ and $^5P_{9/2}$ states of the Sr^+ ion*							
	38 Sr 77	0	9 s	5/2+	+1.27(5)	[87Sr]	CFBLS	1992Li11
	38 Sr 79	0	2.25 m	(3/2−)	+0.661(6)	[87Sr]	CFBLS	1990Bu12
	38 Sr 83	0	32.4 h	7/2+	+0.708(11)	[87Sr]	CFBLS	1990Bu12
	38 Sr 85	0	64.8 d	9/2+	+0.263(14)	[87Sr]	CFBLS	1990Bu12
Reference isotope	38 Sr 87	0	Stable	9/2+	+0.305(2)		AB	2008Py02/2006Sa21
	38 Sr 89	0	50.5 d	5/2+	−0.253(8)	[87Sr]	CFBLS	1990Bu12
	38 Sr 91	0	9.5 h	5/2+	+0.042(10)	[87Sr]	CFBLS	1990Bu12
	38 Sr 93	0	7.4 m	5/2+	+0.240(10)	[87Sr]	CFBLS	1990Bu12
	38 Sr 99	0	0.269 s	3/2+	+0.76(4)	[87Sr]	CFBLS	1991Li05
Yttrium	*Calculation of the quadrupole coupling constants in the 4d 5s² 2D states of the Y atom*							
	39 Y 87	381	13.4 h	9/2+	−0.50(6)	[90Y]	CLS	2007Ch07
	39 Y 88	0	106 d	4−	+0.16(3)	[90Y]	CLS	2007Ch07
		675	14 ms	8+	+0.06(6)	[90Y]	CLS	2007Ch07
	39 Y 89	909	16.1 s	9/2+	−0.43(6)	[90Y]	CLS	2007Ch07
Reference isotope	39 Y 90	0	64.1 h	2−	−0.125(11)		AB	2008Py02/1998Bi20
		682	3.19 h	7+	−0.65(8)	[90Y]	CLS	2007Ch07
	39 Y 92	0	3.54 h	2−	0.00(2)	[90Y]	CLS	2007Ch07
	39 Y 93	758	0.82 s	9/2+	−0.64(8)	[90Y]	CLS	2007Ch07
	39 Y 94	0	18.7 m	2−	−0.03(3)	[90Y]	CLS	2007Ch07
	39 Y 96	1140	9.6 s	8+	−0.98(11)	[90Y]	CLS	2007Ch07
	39 Y 97	668	1.17 s	9/2+	−0.76(8)	[90Y]	CLS	2007Ch07
		3522	142 ms	(27/2)	−1.21(14)	[90Y]	CLS	2007Bi14
	39 Y 98	410	2.0 s	4 or 5	+1.7(2) or +1.8(2)	[90Y]	CLS	2007Bi14
	39 Y 99	0	1.47 s	5/2+	+1.55(17)	[90Y]	CLS	2007Bi14
	39 Y 100	(143)	0.94 s	4	+1.85(20)	[90Y]	CLS	2007Bi14/2010Ba31
	39 Y 101	0	0.45 s	5/2+	+1.53(17)	[90Y]	CLS	2007Bi14
	39 Y 102	0 + x	0.3 s	2 or 3	+1.17(13) or +1.36(16)	[90Y]	CLS	2007Bi14
Zirconium	*Calculation of the quadrupole coupling constants in the ZrO and ZrS molecules*							
	40 Zr 87	0	1.68 h	9/2+	+0.42(5)	[91Zr]	CLS	2003Th03
	40 Zr 88	2889	1.32 ms	8+	+0.44(3)	[91Zr]	TDPAD/TFLD	1985Ra09/1986Be06
	40 Zr 89	0	78.4 h	9/2+	+0.28(10)	[91Zr]	CLS	2003Th03
	40 Zr 90	3589	134 ns	8+	−0.44(3)	[91Zr]	TDPAD/TFLD	1985Ra09/1986Be06
Reference isotope	40 Zr 91	0	Stable	5/2+	−0.176(3)		MS	2008Py02/2000Ke03
		3167	3.6 ms	21/2+	0.71(4)	[91Zr]	TDPAD	1985Ra09
	40 Zr 95	0	64.0 d	5/2+	+0.22(2)	[5−90mZr calc]	MAPON	1998Se01
	40 Zr 101	0	2.4s	3/2+	+0.81(6)	[91Zr]	CLS	2002Ca37
Niobium	*Muonic atom X-ray hyperfine structure*							
	41 Nb 90	0	14.6 h	8+	+0.01(4)	[93Nb]	CLS	2009Ch25
		125	18.8 s	4−	−0.26(4)	[93Nb]	CLS	2009Ch25
	41 Nb 91	0	680 y	9/2+	−0.25(3)	[93Nb]	CLS	2009Ch25
	41 Nb 92	0	3.5×10^{7} y	7+	−0.35(3)	[93Nb]	CLS	2009Ch25
Reference isotope	41 Nb 93	0	Stable	9/2+	−0.32(2)		Mu-X	2008Py02/1973Po15
	41 Nb 99	0	15 s	9/2+	−0.41(14)	[93Nb]	CLS	2009Ch25

(*continued on next page*)

Table 1 (*continued*)

Element	Nucleus	E (level) keV	$T_{1/2}$	I^{π}	Q (b)	Ref. Std.	Method	Reference
	41 Nb 101	0	7.1 s	5/2+	+1.05(7)	[93Nb]	CLS	2009Ch25
	41 Nb 103	0	1.5 s	5/2+	+1.08(9)	[93Nb]	CLS	2009Ch25
Molybdenum	*Estimation of the quadrupole coupling constant in states of the Mo atom*							
	A. Normalised to Q of 92Mo 2760 keV state estimated from B(E2)							
	42 Mo 90	2875	1.1 ms	8+	0.61(3)	A	TDPAD	1985Ra09
	42 Mo 92	2760	190 ns	8+	(−)0.36	From B(E2)	Not measured	1991Ha04
	42 Mo 94	871	2.9 ps	2+	−0.13(8) or +0.01(8)		CER	1976Pa13
		2956	98 ns	8+	0.50(1)	A	TDPAD	1985Ra09
Reference isotope	42 Mo 95	0	Stable	5/2+	−0.022(1))		AB	2008Py02/1982BuZE
	42 Mo 96	778	3.7 ps	2+	−0.20(8) or +0.04(8)		CER	1976Pa13
Reference isotope	42 Mo 97	0	Stable	5/2+	+0.255(13)		AB	2008Py02/1982BuZE
	42 Mo 98	787	3.5 ps	2+	−0.26(9)		CER	1979Pa11
	42 Mo 100	536	10.3 ps	2+	−0.25(7)		CER	2011Wr01
Technetium	*Estimation of the quadrupole coupling constant in states of the Tc atom*							
Reference isotope	43 Tc 99	0	2.1×10^5 y	9/2+	−0.129(6)		AB	2008Py02/1982BuZE
Ruthenium	*Calculated hyperfine structure in the 5F multiplet of the Ru atom*							
	44 Ru 93	2082	2.4 ms	21/2+	+0.04(1)	[99Ru]	TDPAD	1991Ha04
	44 Ru 96	833	2.7 ps	2+	−0.15(8)		CER	1998Hi01
	44 Ru 98	653	5.9 ps	2+	−0.21(8) or −0.01(9)		CER	1998Hi01
Reference isotope	44 Ru 99	0	Stable	5/2+	+0.079(4)		AB	2008Py02/1982BuZE
		90	20.5 ns	3/2+	+0.231(13)	[99Ru]	ME	1976Ki02
	44 Ru 100	540	12 ps	2+	−0.44(4) or −0.27(7)		CER	1998Hi01
Reference isotope	44 Ru 101	0	Stable	5/2+	+0.46(2)		AB	2008Py02/1982BuZE
	44 Ru 102	475	18 ps	2+	−0.63(4) or −0.34(3)		CER	1998Hi01
	44 Ru 103	0	39.4 d	3/2+	+0.62(2)	[99Ru 90 keV]	NO/S	1986Gr26
	44 Ru 104	358	58 ps	2+	−0.78(7) or −0.20(12)		CER	1998Hi01
Rhodium	*Calculation of the quadrupole coupling constants in Rh intermetallic compounds*							
Reference isotope	45 Rh 100	74	214 ns	(2)+	0.153 (18)		PAC	2008Py02/1996Bl15
	45 Rh 103	295	6.7 ps	3/2−	−0.3(2)		CERP	1976Ge19
		357	73 ps	5/2−	−0.4(2)		CERP	1976Ge19
Palladium	*Muonic atom X-ray hyperfine structure*							
	46 Pd 102	556	11.3 ps	2+	−0.20(15)		CERP	1977Fa11
	46 Pd 104	556	9.7 ps	2+	−0.46(11)		CERP	1977Fa11
Reference isotope	46 Pd 105	0	Stable	5/2+	+0.660(11)		Mu-X	2008Py02/1978Vu01
	46 Pd 106	512	12 ps	2+	−0.51(7)		ES	1973Ho05
	46 Pd 108	434	23 ps	2+	−0.58(4)		ES	1978Ar07
	46 Pd 110	374	46 ps	2+	−0.47(3)		ES	1976Li19
Silver	*Calculation of the quadrupole coupling constant in the Ag atom*							
	47 Ag 101	0	11.4 m	9/2+	+0.35(5)	[110Ag 118 keV]	CLS	1989Di12
	47 Ag 103	0	1.10 h	7/2+	+0.84(9)	[110Ag 118 keV]	CLS	1989Di12
	47 Ag 104	0	69 m	5+	+1.06(11)	[110Ag 118 keV]	CLS	1989Di12
	47 Ag 105	25	7.2 m	7/2+	+0.85(11)	[110Ag 118 keV]	CLS	1989Di12
	47 Ag 106	90	8.5 d	6+	1.11(11)	[110Ag 118 keV]	CLS	1989Di12
	47 Ag 107	93	44.3 s	7/2+	0.98(11)	[110Ag 118 keV]	LMR	1986Be01/1984Be53
	47 Ag 108	110	418 y	6+	+1.32(7)	[110Ag 118 keV]	O	1984Be53
	47 Ag 109	88	39.8 s	7/2+	(+)1.02(12)	[110Ag 118 keV]	LMR	1986Be01/1984Be53
		311	5.9 ps	3/2−	−0.7(3)		CER	1972Th16
		415	35 ps	5/2−	−0.3(3)		CER	1972Th16
	47 Ag 110	0	24.4 s	1+	0.24(12)		QIR	1981Do17
Reference isomer		118	252 d	6+	+1.44(10)		O	1984Be53
Cadmium	*There is no adopted reference efg for Cd.*							
	A. Efg in $^2P_{5/2}$ state of the Cd ion							
	B. For the efg used to obtain Q(109Cd)/Q(109Cd 463 keV) see 1969La06/1978Sp09							
	48 Cd 102	2718	56 ns	8+	0.76(9)	[efg Cd in Cd]	TDPAD	1992Al17
	48 Cd 103	0	7.3 m	5/2+	−0.7(6)	A	CLS	1987Bu01
	48 Cd 105	0	56 m	5/2+	+0.37(4)	A	OD	1969La06
		2517	4.5 ms	21/2+	+1.02(10)	B	TDPAC	1978Sp09
	48 Cd 106	633	7.3 ps	2+	−0.28(8)		CER	1976Es02
	48 Cd 107	0	6.50 h	5/2+	+0.60(2)	A	CLS	2013Yo02
		846	70 ns	11/2−	−0.94(10)	B	TDPAC	1978Sp09
		2679	56 ns	21/2+	+1.05(11)	B	TDPAC	1978Sp09
	48 Cd 108	633	6.8 ps	2+	−0.45(8)		CER	1976Es02
	48 Cd 109	0	453 d	5/2+	+0.60(3)	A	CLS	2013Yo02
		463	10.9 ms	11/2−	[−0.92(9)]	Systematic extrapolation	Not measured	1978Sp09
	48 Cd 110	658	5.0 ps	2+	−0.40(4)		ES	1977Gi13
	48 Cd 111	245	84 ns	5/2+	+0.74(7)	B	TDPAC	1978Sp09
		396	48.6 m	11/2−	−0.75(3)	A	CLS	2013Yo02
	48 Cd 112	617	6.2 ps	2+	−0.37(4)		ES	1977Gi13

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Table 1 (*continued*)

Element	Nucleus	E (level) keV	$T_{1/2}$	I^{π}	$Q\,(b)$	Ref. Std.	Method	Reference
	48 Cd 113	264	14 y	11/2−	−0.61(3)	A	CLS	2013Yo02
	48 Cd 114	558	9.0 ps	2+	−0.348(12)		ES	1981Ko06
	48 Cd 115	173	44.8 d	11/2−	−0.48(2)	A	CLS	2013Yo02
	48 Cd 116	514	15 ps	2+	−0.42(4)		ES	1977Gi13
	48 Cd 117	136	3.36 h	11/2−	−0.320(13)	A	CLS	2013Yo02
	48 Cd 119	147	2.20 m	11/2−	−0.135(6)	A	CLS	2013Yo02
	48 Cd 121	215	8.3 s	11/2−	+0.009(6)	A	CLS	2013Yo02
	48 Cd 123	317	1.82 s	11/2−	+0.135(7)	A	CLS	2013Yo02
	48 Cd 125	0	0.68 s	3/2+	+0.209(10)	A	CLS	2013Yo02
		x	0.48 s	11/2−	+0.269(13)	A	CLS	2013Yo02
	48 Cd 127	0	0.37 s	3/2+	+0.239(11)	A	CLS	2013Yo02
		x	–	11/2−	+0.34(2)	A	CLS	2013Yo02
	48 Cd 129	0	0.27 s	3/2+	+0.132(9)	A	CLS	2013Yo02
		x	–	11/2−	+0.57(3)	A	CLS	2013Yo02
Indium	*Calculated electric quadrupole interactions in indium halides*							
	49 In 104	0	1.7 m	5+	+0.63(10)	[115In]	CFBLS	1987Eb02
	49 In 105	0	5.07 m	9/2+	+0.79(5)	[115In]	CFBLS	1987Eb02
	49 In 106	0	6.2 m	7+	+0.92(6)	[115In]	CFBLS	1987Eb02
	49 In 107	0	32.4 min	9/2+	+0.77(5)	[115In]	CFBLS	1987Eb02
	49 In 108	0	58 m	7+	+0.955(7)	[115In]	CFBLS	1987Eb02
		29	40 m	2+	'+0.444(13)	[115In]	CFBLS	1987Eb02
	49 In 109	0	4.2 h	9/2+	+0.80(3)	[115In]	CFBLS	1987Eb02
	49 In 110	0*	69.1 m	2+	+0.32(2)	[113In]	AB	1968CaZX
		0*	4.9 h	7+	+0.95(2)	[115In]	CFBLS	1987Eb02
	49 In 111	0	2.83 d	9/2+	+0.76(2)	[115In]	CFBLS	1987Eb02
	49 In 112	0*	14.4 m	1+	+0.082(5)	[113In]	AB	1968CaZX
		157	20.9 m	4+	+0.679(10)	[115In]	CFBLS	1987Eb02
		351	0.69 ms	7+	1.00(3)	[117In 660 keV]	TDPAD	1993Io02
		614	2.82 ms	8−	0.092(3)	[117In 660 keV]	TDPAD	1993Io02
Reference isotope	49 In 113	0	Stable	9/2+	0.759(8)		AB/MS	2008Py02
	49 In 114	190	49.5 d	5+	+0.703(11)	[115In]	CFBLS	1987Eb02
Reference isotope	49 In 115	0	4.4×10^{14} y	9/2+	0.770(8)		AB/MS	2008Py02
		829	5.78 ns	3/2+	−0.59(4)	[117In 660 keV]	TDPAC	1973Ha61
	49 In 116	0	14.1 s	1+	0.11(1)	[115In]	NSLR	1982Gr17
		127	54.2 m	5+	+0.762(11)	[115In]	CFBLS	1987Eb02
		290	2.18 s	8−	+0.295(9)	[115In]	CFBLS	1987Eb02
	49 In 117	0	42 m	9/2+	+0.788(10)	[115In]	CFBLS	1987Eb02
		660	53.6 ns	3/2+	−0.57(4)	[115In]	TDPAC	1972Ra27
	49 In 118	∼60	4.45 m	5+	+0.757(8)	[115In]	CFBLS	1987Eb02
		∼200	8.5 s	8−	+0.419(7)	[115In]	CFBLS	1987Eb02
	49 In 119	0	2.4 m	9/2+	+0.812(7)	[115In]	CFBLS	1987Eb02
		654	130 ns	3/2+	0.59(4)	[115In]	TDPAC	1980HaYW
	49 In 120	(0)	44.4 s	5+	+0.770(16)	[115In]	CFBLS	1987Eb02
		(0)	47.3 s	8−	+0.504(10)	[115In]	CFBLS	1987Eb02
	49 In 121	0	23.1 s	9/2+	+0.774(10)	[115In]	CFBLS	1987Eb02
	49 In 122	0 + x	9.2 s	5+	+0.77(2)	[115In]	CFBLS	1987Eb02
		∼220	10.5s	8−	+0.56(2)	[115In]	CFBLS	1987Eb02
	49 In 123	0	6.68 s	9/2+	+0.720(9)	[115In]	CFBLS	1987Eb02
	49 In 124	0	3.09 s	3+	+0.58(7)	[115In]	CFBLS	1987Eb02
		190	3.7 s	8−	+0.631(9)	[115In]	CFBLS	1987Eb02
	49 In 125	0	2.50 s	9/2+	+0.68(3)	[115In]	CFBLS	1987Eb02
	49 In 126	(0)	1.60 s	3+	+0.47(5)	[115In]	CFBLS	1987Eb02
		(0)	1.64 s	8−	+0.649(11)	[115In]	CFBLS	1987Eb02
	49 In 127	0	1.22 s	9/2+	+0.56(3)	[115In]	CFBLS	1987Eb02
Tin	*There is no adopted reference efg for Sn.*							
	A–relative to 119Sn 24 keV *– calculation of the quadrupole coupling constants in many molecular tin compounds.*							
	B–relative to 117Sn 315 keV *– calculation of quadrupole interaction in 5p6s $^{3}P_{1}$ state of tin atom. Calculation is accurate only to* +/ − *10%–20%.*							
	C–relative to 116Sn 3548 keV *10+ moment estimated from theory. Accuracy estimated at 10%.*							
	D–relative to 118Sn 3106 keV *10+ moment estimated from theory. Accuracy estimated at 10%.*							
	50 Sn 109	0	18.0 m	5/2+	+0.33(11)	B	ABLFS	1987Eb01
	50 Sn 110	2480	5.6 ns	6+	0.30(4)	D	TDPAD	1989Vo17
	50 Sn 111	0	35 m	7/2+	+0.20(10)	B	ABLFS	1987Eb01
	50 Sn 112	1257	0.35 ps	2+	−0.09(10)		CER	1975Gr30
		2550	13.7 ns	6+	(−)0.25(5)	C	TDPAD	1975Vi03
	50 Sn 113	739	82 ns	11/2−	(−)0.41(4)	C	TDPAD	1975Di02
	50 Sn 114	3088	765 ns	7−	(−)0.32(3)	C	TDPAD	1975Di02
	50 Sn 115	613	3.26 ps	7/2+	(−)0.26(3)	D	TDPAD	1976Be59
		714	159 µs	11/2−	0.38(6)		QIR	1975Ri03
	50 Sn 116	1294	0.36 ps	2+	−0.17(4)		ES	1976Li19
		2366	370 ns	5−	(−)0.26(3)	C	TDPAD	1975Di02
		3548	904 ns	10+	[(−)0.41(4)]	C	Not measured	1975Di02
	50 Sn 117	315	13.6 d	11/2−	−0.42(5)	B	ABLFS	1986An24
	50 Sn 118	1230	0.46 ps	2+	−0.14(10)		CER	1975Gr30

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Table 1 (*continued*)

Element	Nucleus	E (level) keV	$T_{1/2}$	I^{π}	Q (b)	Ref. Std.	Method	Reference
		2321	21.7 ns	5−	(−)0.22(3)	C	TDPAD	1975Di02
		2575	217 ns	7−	0.32(3)	D	TDPAD	1976Be59
		3106	2.65 ms	10+	[0.41(4)]	D	Not measured	1976Be59
Reference Isotope	50 Sn 119	24	17.8 ns	3/2+	−0.132(1)		ME	2008Py02/2008Ba56
		90	293.1 d	11/2−	−0.29(3)	A	ME	1972Be79
	50 Sn 120	1171	0.64 ps	2+	+0.02(7)		CER	1975Gr30
		2285	5.53 ns	5−	0.046(2)	A	TDPAC	1970Wo02
	50 Sn 121	0	27.1 h	3/2+	−0.02(2)	B	ABLFS	1986An24
		6.3	55 y	11/2−	−0.14(3)	B	ABLFS	1986An24
	50 Sn 122	1140	0.76 ps	2+	−0.13(10)		CER	1975Gr30
	50 Sn 123	0	129 d	11/2−	+0.03(4)	B	ABLFS	1986An24
	50 Sn 124	1132	0.97 ps	2+	+0.03(13)		CER	1975Gr30
	50 Sn 125	0	9.62 d	11/2−	+0.2(2)	B	ABLFS	2005Le34
		28	9.5 m	3/2+	+0.86(8)	B	ABLFS	2004Le13
	50 Sn 126	1141	1.0 ps	2+	0.0(2)		CER	2011Al35
	50 Sn 127	0	2.1 h	11/2−	+0.32(14)	B	ABLFS	2005Le34
		5	4.13 m	3/2+	+0.65(7)	B	ABLFS	2004Le13
	50 Sn 128	2492	2.7 µs	10+	−0.1(3)		CER	2011Al35
	50 Sn 129	0	2.23 m	3/2+	+0.05(12)	B	ABLFS	2004Le13
		35	6.9 m	11/2−	−0.20(19)	B	ABLFS	2005Le34
	50 Sn 130	1947	1.7 m	7−	−0.39(12)	B	ABLFS	2005Le34
	50 Sn 131	0	56 s	3/2+	−0.04(9)	B	ABLFS	2004Le13
		242	58.4 s	11/2−	0.0(2)	B	ABLFS	2005Le34
Antimony	*Calculated efg's in SbN, SbP, SbF and SbCl molecues*							2008Py02
	51 Sb 112	796	536 ns	8−	1.06(2)	[121Sb]	TDPAD	1982Ma29
	51 Sb 114	496	219 ms	8−	1.02(16)	[121Sb]	QIR, R	1982Ma29
	51 Sb 115	2796	152 ns	19/2−	0.79(4)	[121Sb]	TDPAD	1983Se04
	51 Sb 116	1844	11.9 ns	7+	2.5(6)	[121Sb]	TDPAD(ampl)	1992Io01
	51 Sb 117	0	2.80 h	5/2+	0.2(12)	[121Sb]	AB	1974Ek01
		3131	340 ms	(25/2)+	1.14(5)	[121Sb]	QIR,R	1982Ma29
		3231	290 ns	23/2−	3.7(4)	[121Sb]	TDPAD	1988Io01
	51 Sb 118	51	20.6 ms	(3)+	0.9(2)	[121Sb]	TDPAD	1982Ma29
		270	13.4 ns	3−	0.39(8)	[121Sb]	TDPAD(ampl)	1985Di07
		927	22.8 ns	7+	2.6(5)	[121Sb]	TDPAD(ampl)	1988Io01
	51 Sb 119	2554	128 ns	19/2−	3.18(13)	[121Sb]	TDPAD	1991Io02
	51 Sb 120	78	247 ns	3+	0.63(2)	[121Sb]	TDPAD	1982Ma29
Reference Isotope	51 Sb 121	0	Stable	5/2+	−0.543(11)		O	2008Py02/1978Bu24
		37	3.5 ns	7/2+	−0.727(16)	[121Sb]	ME	1970St13
	51 Sb 122	0	2.68 d	2−	+1.28(8)	[121Sb]	O	1960Fe08
		61	1.86 ms	3+	0.63(2)	[121Sb]	TDPAD	1982Ma29
Reference Isotope	51 Sb 123	0	Stable	7/2+	−0.692(14)		O	2008Py02/1978Bu24
	51 Sb 124	0	60.2 d	3−	+2.8(2)	[121Sb]	NO/S	1985He16
Tellurium	*There is no adopted reference efg for Te.*							
	A. Efg in the lased state of the Te atom calculated by semi-empirical methods							
	52 Te 122	564	7.52 ps	2+	−0.57(5)		CER	1976Bo12
	52 Te 124	603	6.25 ps	2+	−0.45(5)		CER	1976Bo12
	52 Te 125	36	1.48 ns	3/2+	−0.31(2)	[129I]	ME	1977La03
		145	58 d	11/2−	0.0(2)	A	CLS	2006Si40
		321	695 ps	9/2−	0.12(+5,−9)	[125Te 36 keV]	IPAC	1976Va28
	52 Te 126	666	4.41 ps	2+	−0.23(5)		CER	1976Bo12
	52 Te 127	88	109 d	11/2−	0.17(12)	A	CLS	2006Si40
	52 Te 128	743	3.2 ps	2+	−0.22(5)		CER	1976Bo12
	52 Te 129	0	69.5 m	3/2+	0.055(13)	[129I]	NO/ME	1987Be36
		106	33.5 d	11/2−	0.40(3)	A	CLS	2006Si40
	52 Te 130	840	2.3 ps	2+	−0.12(5)		CER	1976Bo12
	52 Te 131	182	30 h	11/2−	0.25(14)	A	CLS	2006Si40
	52 Te 133	0	12.5 m	3/2+	0.23(9)	A	CLS	2006Si40
		334	55.4 m	11/2−	0.28(14)	A	CLS	2006Si40
	52 Te 135	0	19 s	7/2−	0.29(9)	A	CLS	2006Si40
Iodine	*Calculated efg's in atomic I and in HI*							2008Py02
	53 I 125	0	60.2 d	5/2+	−0.761(17)	[127I]	MA	1958Fl39
Reference isotope	53 I 127	0	Stable	5/2+	−0.696(12)		AB	1976Fu06
		58	1.95 ns	7/2+	−0.624(11)	[127I]	ME	1964Pe15
	53 I 129	0	1.6×10^{7} y	7/2+	−0.488(8)	[127I]	Q,MA	1953Li16
		28	16.8 ns	5/2+	−0.604(10)	[127I]	ME	1972Ro41
	53 I 131	0	8.04 d	7/2+	−0.34(2)	[127I]	AB	1960Li13
		1797	5.9 ns	(15/2)−	0.66(6)	[129I 28 keV]	TDPAC	1973Ha61
	53 I 132	0	2.28 h	4+	0.08(1)	[127I]	AB	1960Wh06
		50	1.12 ns	3+	0.20(6)	[129I]	IPAC	1979Oo01
		278	1.42 ns	1+	−0.150(5)	[129I]	TDPAC	1979Oo01
	53 I 133	0	20.9 h	7/2+	−0.23(1)	[127I]	AB	1961Al20

(*continued on next page*)

Table 1 (*continued*)

Element	Nucleus	E (level) keV	$T_{1/2}$	I^{π}	Q (b)	Ref. Std.	Method	Reference
Xenon	*Calculated efg in XeH$^+$ and XeD$^+$*							
	A–Q estimated from B(E2)							
	B–Efg estimated from systematics in Te metal							
	54 Xe 117	0	1.02 m	5/2+	+1.14((4)	[131Xe]	CLS	1990NeZY
	54 Xe 119	0	5.8 m	5/2+	+1.29(5)	[131Xe]	CLS	1990NeZY
	54 Xe 121	0	39 m	5/2+	+1.31(5)	[131Xe]	CLS	1990NeZY
	54 Xe 123	180 + x	5.2 ms	7/2(−)	1.4(3)	[125Xe 296 keV]	TDPAD	1982Ze05
		201 + x	17 ns	9/2−	1.1(6)	[125Xe 296 keV]	TDPAD(ampl)	1982Ze05
	54 Xe 125	253	57 s	9/2−	+0.417(15)	[131Xe]	CLS	1990NeZY
		296	140 ns	7/2+	1.40(15)	A	Not measured	1982Ze05
	54 Xe 127	297	1.15 m	9/2−	+0.68(2)	[131Xe]	CLS	1990NeZY
	54 Xe 129	40	0.98 ns	3/2+	−0.393(10)	[131Xe]	ME	1964Pe06
		236	8.89 d	11/2−	+0.63(2)	[131Xe]	CLS	1990NeZY
Reference isotope	54 Xe 131	0	Stable	3/2+	−0.114(1)		CLS	1989Bo03
		164	11.8 d	11/2−	+0.72(3)	[131Xe]	CLS	1990NeZY
	54 Xe 132	2214	90 ns	7−	0.010(5)	B	TDPAD	1987Le31
	54 Xe 133	0	5.24 d	3/2+	+0.140(5)	[131Xe]	CLS	1990NeZY
		233	2.19 d	11/2−	+0.76(5)	[131Xe]	CLS	1990NeZY
	54 Xe 135	0	9.10 h	3/2+	+0.210(7)	[131Xe]	CLS	1990NeZY
		527	15.3 m	11/2−	+0.61(2)	[131Xe]	CLS	1990NeZY
	54 Xe 137	0	3.82 m	7/2−	−0.47(2)	[131Xe]	CLS	1989Bo03
	54 Xe 139	0	39.7 s	3/2−	+0.39(2)	[131Xe]	CLS	1989Bo03
	54 Xe 141	0	1.73 s	5/2+	−0.57(2)	[131Xe]	CLS	1989Bo03
	54 Xe 143	0	0.30 s	5/2−	+0.91(3)	[131Xe]	CLS	1989Bo03
Caesium	*Calculated efg in CsF molecule.*							2008Py02
	A–estimated efg at Cs in Ga metal							
	55 Cs 118	(0)	14 s	2	+1.31(17)	[133Cs]	ABLS	1987Co19
	55 Cs 119	(0)	36 s	9/2+	+2.65(17)	[133Cs]	ABLS	1981Th06
		(0)	28 s	3/2+	+0.85(12)	[133Cs]	ABLS	1981Th06
	55 Cs 120	0	64 s	2+	+1.36(7)	[133Cs]	ABLS	1981Th06
	55 Cs 121	0	2.27 m	3/2+	+0.79(4)	[133Cs]	ABLS	1981Th06
		∼36	2.02 m	9/2+	+2.53(13)	[133Cs]	ABLS	1981Th06
	55 Cs 122	(0)	21 s	1+	−0.179(10)	[133Cs]	ABLS	1981Th06
		(0)	4.2 m	8−	+3.09(8)	[133Cs]	ABLS	1981Th06
	55 Cs 124	0	30.8 s	1+	−0.69(4)	[133Cs]	ABLS	1981Th06
	55 Cs 126	0	1.64 m	1+	−0.64(3)	[133Cs]	ABLS	1981Th06
	55 Cs 127	66	24.9 ns	5/2(+)	0.58(12)	A	TDPAC	1999Co22
	55 Cs 128	0	3.62 m	1+	−0.54(3)	[133Cs]	ABLS	1981Th06
	55 Cs 130	0	29.9 m	1+	−0.056(6)	[133Cs]	ABLS	1981Th06
		0 + x	3.7 m	5(−)	+1.36(8)	[133Cs]	ABLS	1981Th06
	55 Cs 131	0	9.69 d	5/2+	+0.59(2)	[133Cs]	ABLS	1975Ac01
		134	8.7 ns	5/2+	0.20(2)	[133Cs 81 keV]	TDPAC	2000De13
	55 Cs 132	0	6.47 d	2(−)	+0.48(2)	[133Cs]	ABLS	1975Ac01
Reference isotope	55 Cs 133	0	Stable	7/2+	−0.00343(10)		MB	1998Pe18
		81	6.31 ns	5/2+	0.30(2)	[133Cs]	ME	1977Ca30
	55 Cs 134	0	2.06 y	4+	+0.37(2)	[133Cs]	ABLS	1975Ac01
		139	2.90 h	8−	+0.92(8)	[133Cs]	ABLS	1981Th06
	55 Cs 135	0	3×10^6 y	7/2+	+0.048(3)	[133Cs]	ABLS	1975Ac01
		1633	53 m	19/2−	+0.83(7)	[133Cs]	ABLS	1981Th06
	55 Cs 136	0	13.2 d	5+	+0.213(15)	[133Cs]	ABLS	1975Ac01
		0 + x	19 s	8−	+0.70(3)	[133Cs]	ABLS	1981Th06
	55 Cs 137	0	30.17 y	7/2+	+0.048(2)	[133Cs]	ABLS	1975Ac01
	55 Cs 138	0	32.2 m	3−	+0.112(17)	[133Cs]	ABLS	1981Th06
		80	2.9 m	6−	−0.37(5)	[133Cs]	ABLS	1981Th06
	55 Cs 139	0	9.4 m	7/2+	−0.063(14)	[133Cs]	ABLS	1979Bo01
	55 Cs 140	0	65 s	1−	−0.094(15)	[133Cs]	ABLS	1981Th06
	55 Cs 141	0	25.1 s	7/2+	−0.42(7)	[133Cs]	ABLS	1981Th06
	55 Cs 143	0	1.78 s	3/2+	+0.44(3)	[133Cs]	ABLS	1981Th06
	55 Cs 144	0	1.00 s	1	+0.29(2)	[133Cs]	ABLS	1981Th06
	55 Cs 145	0	0.59 s	3/2+	+0.58(6)	[133Cs]	ABLS	1981Th06
	55 Cs 146	0	0.34 s	1	+0.21(3)	[133Cs]	ABLS	1987Co19
Barium	*Efg calculations in the 6p $^2P_{3/2}$ state of the Ba II spectrum*							2008Py02
	56 Ba 121	0	30 s	5/2(+)	+1.96(13)	[135Ba]	CLS	1988We14
	56 Ba 123	0	2.7 m	5/2+	+1.63(13)	[135Ba]	CLS	1988We14
	56 Ba 127	80	1.9 s	7/2(−)	+1.78(14)	[135Ba]	CLS	1992Da06
	56 Ba 129	8.4	2.16h	7/2+	+1.75(14)	[135Ba]	CLS	1979Be25
	56 Ba 130	357	37 ps	2+	−1.02(15) or −0.09(15)		CER	1989Bu07
		2476	9.54 ms	8−	+2.40(6)	[135Ba]	CLS	2002Mo31
	56 Ba 131	188	14.6 m	9/2−	+1.60(14)	[135Ba]	CLS	1983Mu12
	56 Ba 133	288	38.9 h	11/2−	+0.96(6)	[135Ba]	CLS	1979Be25
	56 Ba 134	605	5.1 ps	2+	−0.26(12) or +0.15(12)		CER	1989Bu07
Reference isotope	56 Ba 135	0	Stable	3/2+	+0.160(3)		CFBLS	1984We15
		268	28.7 h	11/2−	+1.03(15)	[135Ba]	CLS	1979Be25
	56 Ba 136	819	1.93 ps	2+	−0.19(6) or +0.07(7)		CER	1986Ro15

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Table 1 (*continued*)

Element	Nucleus	E (level) keV	$T_{1/2}$	I^{π}	$Q\,(b)$	Ref. Std.	Method	Reference
Reference isotope	56 Ba 137	0	Stable	3/2+	+0.245(4)		CFBLS	1984We15
		662	2.55 m	11/2−	+0.85(10)	[135Ba]	CLS	1983Mu12
	56 Ba 138	1436	0.206 ps	2+	−0.14(6) or +0.08(6)		CER	1989Bu07
	56 Ba 139	0	84.6 m	7/2−	−0.573(13)	[135Ba]	CFBLS	1988We07
	56 Ba 140	602	7.2 ps	2+	−0.5(3)		CER	2012Ba40
	56 Ba 141	0	18.7 m	3/2−	+0.454(10)	[135Ba]	CFBLS	1988We07
	56 Ba 143	0	14.5 s	5/2(+)	−0.88(2)	[135Ba]	CFBLS	1988We07
	56 Ba 145	0	4.31 s	5/2(−)	+1.22(2)	[135Ba]	CFBLS	1988We07
Lanthanum	*Calculated efg's in La halides*							2008Py02
	57 La 135	0	19.5 h	5/2+	−0.4(4)	[139La]	CLS	2003Ii03
	57 La 137	0	6×10^{4} y	7/2+	+0.21(4)	[139La]	CLS	2003Ii03
	57 La 138	0	1.1×10^{11} y	5+	+0.39(3)	[139La]	CLS	2003Ii03
Reference isotope	57 La 139	0	Stable	7/2+	+0.200(6)		MB	2007Ja16
	57 La 140	0	40.3 h	3−	+0.084(13)	[139La]	NO/S	1966Bl05
Cerium	*There is no adopted efg calculation for cerium.*							
	A. Normalised to nuclear model estimate of Q 138Ce 3538 keV.							
	58 Ce 129	108	60 ns	9/2−	1.32(13)	A	TDPAD	1998Io01
	58 Ce 130	2454	109 ns	7−	1.8(2)	A	TDPAD	1999Io02
	58 Ce 131	162	88 ns	9/2−	0.92(10)	A	TDPAD	1998Io01
	58 Ce 134	3209	308 ns	10+	+1.32(12)	A	TDPAD	1983Da29
	58 Ce 136	3095	2.2 ms	10+	+1.11(11)	A	TDPAD	1983Da29
	58 Ce 138	3538	82 ns	10+	Estimated +0.77 eb		Not measured	1983Da29
	58 Ce 140	2084	3.4 ns	4+	0.35(7)	[139La]	TDPAC	1973KlZV
	58 Ce 142	641	5.7 ps	2+	−0.16(5) or −0.37(5)		CER	1988Ve08/1989Sp07
Praseodymium	*EFG calculated in the Pr atom with estimated Sternheimer correction.*							
	N.B. Deviation from standard adopted by Pyykkö (2008Py02) who gives Q ^{141}Pr *− 0.059(4) b.*							
Reference isotope	59 Pr 141	0	Stable	5/2+	−0.077(6)		CLS	1994Ii01
	59 Pr 142	0	19.2 h	2−	0.039(17)	[141Pr]	AB	1962Ca10
	59 Pr 143	0	13.57 d	7/2+	+0.77(16)	[141Pr]	CLS	1994Ii01
Neodymium	*Efg calculated in the Nd ion with estimated Sternheimer correction. N.B. Deviation from standard adopted by Pyykkö (2008Py02) who gives Q* ^{143}Nd *−0.63(6) b.*							
	60 Nd 135	0	12.4 m	9/2−	+1.9(5)	[143Nd]	CLS	1992Le09
	60 Nd 139	0	30 m	3/2+	+0.28(9)	[143Nd]	CLS	1992Le09
	60 Nd 141	0	2.49 h	3/2+	+0.32(13)	[143Nd]	CLS	1992Le09
Reference isotope	60 Nd 143	0	Stable	7/2−	−0.61(2)		AB	1992Au04
	60 Nd 144	697	4.51 ps	2+	−0.15(6) or −0.28(6)		CER	1989Sp07
	60 Nd 145	0	Stable	7/2−	−0.314(12)	[143Nd]	AB	1992Au04
	60 Nd 146	454	27.5 ps	2+	−0.78(9)		CER	1970Ge08
	60 Nd 147	0	11.0 d	5/2−	+0.9(3)	[143Nd]	AB	1970PiZR
	60 Nd 148	302	78 ps	2+	−1.46(13)		CER	1970Ge08
	60 Nd 149	0	1.73 h	5/2−	+1.3(3)	[143Nd]	AB	1970PiZR
	60 Nd 150	130	2142 ps	2+	−2.0(5)		CER	1970Ge08
Promethium	*Empirical efg estimate in Pm atom*							
	61 Pm 145	0	17.7 y	5/2+	+0.23(8)	[147Pm]	CLS	1992Al03
Reference isotope	61 Pm 147	0	2.623 y	7/2+	+0.74(20)		O	1966Re04
	61 Pm 148	0	5.37 d	1−	+0.2(2)	[147Pm]	AB	1963Bu14
	61 Pm 151	0	28.4 h	5/2 +	2.2(9)	[147Pm]	AB	1963Bu14
Samarium	*Muonic atom X-ray hyperfine structure*							
	62 Sm 140	3172	19.4 ns	10+	1.7(5)	[154Sm 82]	TDPAD	1985Be23
	62 Sm 141	176	22.6 m	11/2−	+1.6(5)	[147Sm]	CLS	1992Le09
	62 Sm 142	2372	170 ns	7−	+1.1(3)	[154Sm 82]	TDPAD	1985Be23/1986Da22
	62 Sm 143	0	8.83 m	3/2+	+0.4(2)	[147Sm]	CLS	1992Le09
	62 Sm 145	0	340 d	7/2−	−0.60(7)	[147Sm]	LRFS	1990En01
Reference isotope	62 Sm 147	0	1.1×10^{11} y	7/2−	−0.26(3)		Mu-X	2008Py02/1981Ba28
		121	0.78 ns	5/2−	−0.5(2)	[147Sm]	ME	1971Pa04
	62 Sm 148	550	7.3 ps	2+	−1.0(3)		CER	1989Ra17(1)
	62 Sm 149	0	$>2 \times 10^{15}$ y	7/2−	+0.078(8)	[147Sm]	AB	1972Ch55/1992Le09
		23	7.6 ns	5/2−	+1.01(9)	[147Sm]	Mu-X	1981Ba28
	62 Sm 150	334	49 ps	2+	−1.3(2)		CER	1973Gr06
	62 Sm 151	0	90 y	5/2−	+0.71(7)	[147Sm]	LRFS	1990En01
Reference isotope	62 Sm 152	122	1.40 ns	2+	−1.666(16)		Mu-X	1979Po05
	62 Sm 153	0	46.8 h	3/2+	+1.30(12)	[147Sm]	LRFS	1990En01
Reference isotope	62 Sm 154	82	3.01 ns	2+	−1.87(4)		Mu-X	1979Po05
	62 Sm 155	0	22.4 m	3/2−	1.13(13)	[147Sm]	AB	1976Fu06
Europium	*Muonic atom X-ray hyperfine structure*							
	63 Eu 140	0 + x	1.54 s	1(+)	+0.31(4)	[153Eu]	CLS	1985Ah02
	63 Eu 141	0	40 s	5/2+	+0.85(4)	[153Eu]	CLS	1985Ah02
	63 Eu 142	0	2.4 s	1+	+0.12(5)	[153Eu]	CLS	1985Ah02
		180	73 s	8−	+1.41(6)	[153Eu]	CLS	1985Ah02

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Table 1 (*continued*)

Element	Nucleus	*E* (level) keV	$T_{1/2}$	I^{π}	*Q* (*b*)	Ref. Std.	Method	Reference
	63 Eu 143	0	2.6 m	5/2+	+0.51(3)	[153Eu]	CLS	1985Ah02
	63 Eu 144	0	10 s	1+	+0.10(3)	[153Eu]	CLS	1985Ah02
	63 Eu 145	0	5.93 d	5/2+	+0.29(2)	[153Eu]	CLS	1985Ah02
	63 Eu 146	0	4.59 d	4−	−0.18(6)	[153Eu]	CLS	1985Ah02
	63 Eu 147	0	24.1 d	5/2+	+0.55(3)	[153Eu]	CLS	1985Ah02
	63 Eu 148	0	54.5 d	5−	+0.35(6)	[153Eu]	CLS	1985Ah02
	63 Eu 149	0	93.1 d	5/2+	+0.75(2)	[153Eu]	CLS	1985Ah02
	63 Eu 150	0	35.8 y	5(−)	+1.13(5)	[153Eu]	CLS	1985Ah02
	63 Eu 151	0	Stable	5/2+	+0.903(10)	[153Eu]	Mu-X	1984Ta04
		22	9.5 ns	7/2+	+1.28(2)		Mu-X	1984Ta05
	63 Eu 152	0	13.54 y	3−	+2.72(3)	[153Eu]	CLS	1986Al33
Reference isotope	63 Eu 153	0	Stable	5/2+	+2.41(2)		Mu-X	1984Ta04
		83	0.80 ns	7/2+	+0.44(2)		Mu-X	1984Ta05
		103	3.9 ns	3/2+	+1.253(12)	[153Eu]	ME	1973Ar19
	63 Eu 154	0	8.6 y	3−	+2.85(10)	[153Eu]	CLS	1986Al33
	63 Eu 155	0	4.68 y	5/2+	+2.5(3)	[153Eu]	CLS	1990Al34
	63 Eu 157	0	15.2 h	5/2+	+2.6(3)	[153Eu]	CLS	1990Al34
	63 Eu 158	0	45.9 m	1(−)	+0.66(14)	[153Eu]	CLS	1990Al34
	63 Eu 159	0	18.1 m	5/2+	+2.7(3)	[153Eu]	CLS	1990Al34
Gadolinium	*Muonic atom X-ray hyperfine structure*							
	64 Gd 144	3433	130 ns	10+	−1.40(6)	[155Gd]	TDPAD	1982Ha20/1985Da20
	64 Gd 147	997	22.2 ns	13/2+	−0.70(8)	[155Gd]	TDPAD	1982Ha20/1985Da20
		3582	27 ns	27/2−	−1.21(9)	[155Gd]	TDPAD	1982Ha20/1985Da20
		8587	510 ns	49/2+	−3.00(18)	[155Gd]	TDPAD	1982Ha20/1985Da20
	64 Gd 148	2695	16.5 ns	9−	0.96(5)	[155Gd]	TDPAD	1982Ha20
	64 Gd 154	123	1.17 ns	2+	−1.82(4)		Mu-X	1983La08
Reference isotope	64 Gd 155	0	Stable	3/2−	+1.27(3)		Mu-X	1983La08
		87	6.35 ns	5/2+	+0.110(8)	[155Gd]	ME	1974Ar23
		105	1.18 ns	3/2+	+1.27(5)	[155Gd]	ME	1974Ar23
	64 Gd 156	89	2.21 ns	2+	−1.93(4)		Mu-X	1983La08
Reference isotope	64 Gd 157	0	Stable	3/2−	+1.35(3)		Mu-X	1983La08
		64	0.46 ms	5/2+	+2.43(7)	[157Gd]	ME	1974Ar23
	64 Gd 158	80	2.52 ns	2+	−2.01(4)		Mu-X	1983La08
	64 Gd 160	75	2.70 ns	2+	−2.08(4)		Mu-X	1983La08
Terbium	*Muonic atom X-ray hyperfine structure*							
	A. Efg estimate at Tb in yttrium ethylsulphate							
	65 Tb 148	0	60 m	2−	−0.3(2)	[159Tb]	CLS	1990Al36
	65 Tb 150	0 + x	3.48 h	2(−)	0.00(13)	[159Tb]	CLS	1990Al36
	65 Tb 152	0	17.5 h	2−	+0.34(13)	[159Tb]	CLS	1990Al36
	65 Tb 153	0	2.34 d	5/2+	+1.08(14)	[159Tb]	CLS	1990Al36
	65 Tb 154	0 + x	9.4 h	3−	+2.4(13)	[159Tb]	NO/S	1983Be03
	65 Tb 155	0	5.32 d	3/2+	+1.41(6)	[159Tb]	CLS	1990Al36
	65 Tb 156	0	5.35 d	3−	+2.3(8)	[159Tb]	NO/S	1979Ri17/1983Be03
	65 Tb 157	0	99 y	3/2+	+1.40(8)	[159Tb]	CLS	1990Al36
	65 Tb 158	0	150 y	3−	+2.7(5)	A	EPR/NO/S	1968Ea04
Reference isotope	65 Tb 159	0	Stable	3/2+	+1.432(8)		Mu-X	1984Ta04
	65 Tb 160	0	72.1 d	3−	+3.85(5)	[159Tb]	NMR/ON	1987Ma42
	65 Tb 161	0	6.9 d	3/2+	+1.3(6)	[159Tb]	NO/S	1983Ri15
Dysprosium	*Muonic atom X-ray hyperfine structure*							
	A. Unpublished results from Neugart, PC to Raghavan (1987). No information on interaction analysis.							
	B. Analysis of perturbation of TDPAC in liquid sources							
	66 Dy 147	751	59 s	(11/2−)	+0.67(10)	A	CLS	1989Ra17
	66 Dy 149	0	4.23 m	7/2−	−0.62(5)	A	CLS	1989Ra17
	66 Dy 151	0	17 m	7/2−	−0.30(5)	A	CLS	1989Ra17
	66 Dy 153	0	6.3 h	7/2−	−0.15(9)	[163Dy]	AB	1973Ek01
	66 Dy 155	0	10.0 h	3/2−	+0.96(2)	[163Dy]	AB	1973Ek01
	66 Dy 157	0	8.1 h	3/2−	+1.29(2)	[163Dy]	AB	1973Ek01
	66 Dy 159	0	144 d	3/2−	+1.37(2)	A	CLS	1989Ra17
	66 Dy 160	87	1.96 ns	2+	1.8(4)	B	TDPAC	1970Wa25
	66 Dy 161	0	Stable	5/2+	+2.51(2)	[163Dy]	AB	1974Fe05
		26	29 ns	5/2−	+2.51(2)	[161Dy]	ME	1973St23
		44	0.78 ns	7/2+	+0.53(13)	[161Dy]	ME	1973Sy01
		75	3.2 ns	3/2−	+1.45(6)	[161Dy]	ME	1973St23
Reference isotope	66 Dy 163	0	Stable	5/2−	+2.65(2)		Mu-X	1984Ta04
	66 Dy 164	73	2.39 ns	2+	−2.08(15)	[161Dy]	ME	1968Mu01
	66 Dy 165	0	2.33 h	7/2+	+3.48(7)	[161Dy]	AB	1968 Ra03
Holmium	*Pionic atom X-ray hyperfine structure*							
	67 Ho 152	0	161.8 s	2−	+0.1(2)	[165Ho]	LRIS	1989Al27
		160	49.5 s	9+	−1.3(8)	[165Ho]	LRIS	1989Al27
	67 Ho 153	0	2.0 m	11/2−	−1.1(5)	[165Ho]	LRIS	1989Al27
	67 Ho 154	0	11.76 m	2−	+0.19(10)	[165Ho]	LRIS	1989Al27
		320	3.10 m	8+	−1.0(5)	[165Ho]	LRIS	1989Al27

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Table 1 (*continued*)

Element	Nucleus	E (level) keV	$T_{1/2}$	I^{π}	Q (b)	Ref. Std.	Method	Reference
	67 Ho 155	0	48 m	5/2+	+1.56(12)	[165Ho]	LRIS	1989Al27
	67 Ho 156	0	56 m	4(+)	+2.40(18)	[165Ho]	LRIS	1989Al27
	67 Ho 157	0	12.6 m	7/2−	+3.05(13)	[165Ho]	LRIS	1989Al27
	67 Ho 158	0	11.3 m	5+	+4.2(4)	[165Ho]	LRIS	1989Al27
		67.2	28 m	2−	+1.66(17)	[165Ho]	LRIS	1989Al27
	67 Ho 159	0	35.05 m	7/2−	+3.27(13)	[165Ho]	LRIS	1989Al27
	67 Ho 160	0	25.6 m	5+	+4.0(2)	[165Ho]	LRIS	1989Al27
		60	5.02 h	2−	+1.83(17)	[165Ho]	LRIS	1989Al27
	67 Ho 161	0	2.48 h	7/2−	+3.30(11)	[165Ho]	LRIS	1989Al27
	67 Ho 162	106	67 m	6−	+4.0(7)	[165Ho]	LRIS	1989Al27
	67 Ho 163	0	4570 y	7/2−	+3.7(6)	[165Ho]	LRIS	1989Al27
Reference isotope	67 Ho 165	0	Stable	7/2−	+3.58(2)		Pi-X	1983Ol03
		95	22 ps	9/2−	+3.52(4)	[165Ho]	Mu-X	1976Po05
Erbium	*Muonic atom X-ray hyperfine structure*							
	A–Estimated efg in Er metal.							
	68 Er 153	0	37.1 s	(7/2−)	−0.42(2)	[167Er]	CLS	1987OtZW
	68 Er 155	0	5.3 m	7/2−	−0.27(2)	[167Er]	CLS	1987OtZW
	68 Er 157	0	25 m	3/2−	+0.92(1)	[167Er]	CLS	1987OtZW
	68 Er 159	0	36 m	3/2−	+1.17(1)	[167Er]	CLS	1987OtZW
	68 Er 161	0	3.21 h	3/2−	+1.363(8)	[167Er]	AB	1972Ek03
	68 Er 162	102	1.3 ns	2+	<0		CER	1981Hu02
		901	1.24 ps	2+	1.8(6)		CER	1983Hu01
	68 Er 163	0	75.1 m	5/2−	+2.56(2)	[167Er]	CLS	1987OtZW
	68 Er 164	92	1.48 ns	2+	<0		CER	1981Hu02
		860	1.9 ps	2+	2.4(3)		CER	1983Hu01
	68 Er 165	0	10.36 h	5/2−	+2.71(3)	[167Er]	CLS	1987OtZW
	68 Er 166	81	1.85 ns	2+	−1.9(4)	A	ME	1965Hu01
		265	118 ps	4+	−2.7(9)		CER	1970McZQ
		786	4.6 ps	2+	2.2(3)		CER	1983Hu01
Reference isotope	68 Er 167	0	Stable	7/2+	+3.57(3)		Mu-X	1984Ta04
	68 Er 168	264	121 ps	4+	−2.2(10)		CER	1970McZQ
		821	2.9 ps	2+	2.3(2)		CER	1983Hu01
	68 Er 170	79	1.90 ns	2+	−1.9(2)		CER	1973Lu02
		260	∼135 ps	4+	−2.2(10)		CER	1970McZQ
		934	1.81 ps	2+	2.0(3)		CER	1983Hu01
	68 Er 171	0	7.52 h	5/2−	2.86(9)	[167Er]	AB	1964Bu09
Thulium	*There is no adopted reference efg for Tm.*							
	A. For details of the efg used see 1973Ek01/1988Al04							
	B. Includes estimated Sternheimer correction							
	69 Tm 153	0	1.48 s	(11/2−)	+0.5(10)	[169Tm]	LRIS	2000Ba16
	69 Tm 154	0	8.1 s	(2−)	+0.4(9)	A	LRIS	2000Ba16
		0 + x	3.30 s	(9+)	−0.2(4)	A	LRIS	2000Ba16
	69 Tm 156	0	1.3 m	2−	−0.48(11)	A	LRIS	1987AlZb
	69 Tm 158	0	4.3 m	2−	+0.74(11)	A	LRIS	1988Al04
	69 Tm 159	0	9.0 m	5/2+	+1.93(7)	A	LRIS	1988Al04
	69 Tm 160	0	9.4 m	1−	+0.58(4)	A	LRIS	1988Al04
	69 Tm 161	0	38 m	7/2+	+2.90(7)	A	LRIS	1988Al04
	69 Tm 162	0	21 m	1−	+0.69(3)	A	LRIS	1988Al04
	69 Tm 164	0	2.0 m	1+	+0.71(5)	A	LRIS	1988Al04
	69 Tm 166	0	7.7 h	2+	+2.14(3)	A	LRIS	1988Al04
	69 Tm 168	0	85 d	3+	+3.23(7)	A	LRIS	1988Al04
	69 Tm 169	8	3.9 ns	3/2+	−1.2(1)	B	ME	1964Co08
	69 Tm 170	0	128.6 d	1+	+0.74(2)	A	LRIS	1988Al04
Ytterbium	*Muonic atom X-ray hyperfine structure*							
	A. Assumes relation Q(spectroscopic) = 2Q(intrinsic)/7 and Q(intrinsic) 2+(84 keV) 170Yb= 7.63(9) b.							
	70 Yb 155	0	1.59 s	(7/2−)	−0.5(3)	[173Yb]	LRIS	2000Ba16
	70 Yb 159	0	1.58 m	5/2(−)	−0.22(2)	[173Yb]	CLS	1983Ne13
	70 Yb 161	0	4.2 m	3/2−	+1.03(2)	[173Yb]	CLS	1983Ne13
	70 Yb 163	0	11.0 m	3/2−	+1.24(2)	[173Yb]	CLS	1983Ne13
	70 Yb 165	0	9.9 m	5/2−	+2.48(4)	[173Yb]	CLS	1983Ne13
	70 Yb 167	0	17.5 m	5/2−	+2.70(4)	[173Yb]	CLS	1983Ne13
	70 Yb 169	0	32.0 d	7/2+	+3.54(6)	[173Yb]	CLS	1983Ne13
	70 Yb 170	84	1.57 ns	2+	−2.18(3)	A		2001Ra27
	70 Yb 171	67	0.81 ns	3/2−	−2.34(7)	[170Yb 84 keV]	ME	1971Pl03
		76	1.64 ns	5/2−	−2.22(7)	[170Yb 84 keV]	ME	1971Pl03
	70 Yb 172	79	1.6 ns	2+	−2.22(4)	[170Yb 84 keV]	ME	1971Pl03
		260	0.122 ns	4+	−2.3(12)		CER	1970McZQ
		1172	7.8 ns	3+	−2.9(3)	[170Yb 84 keV]	TDPAC	1970Wa25
		1757	–	(1−)	−3.44(10)		Mu-X	1979Ho23
		1822	–	(3−)	+1.97(10)		Mu-X	1979Ho23
Reference isotope	70 Yb 173	0	Stable	5/2−	+2.80(4)		Mu-X	1975Ze04
	70 Yb 174	77	1.79 ns	2+	−2.18(5)	[170Yb 84 keV]	ME	1971Pl03

(*continued on next page*)

Table 1 (*continued*)

Element	Nucleus	E (level) keV	$T_{1/2}$	I^{π}	Q (b)	Ref. Std.	Method	Reference
		253	144 ps	4+	−1.8(12)		CER	1970McZQ
	70 Yb 175	0	4.19 d	7/2−	+3.52(5)	[173Yb]	CLS	2012Fl05
	70 Yb 176	82	1.8 ns	2+	−2.28(6)	[170Yb 84 keV]	ME	1967Ec01
		272	0.11 ns	4+	−0.9(12)		CER	1970McZQ
		1050	11.4 s	8−	+5.30(8)	[173Yb]	CLS	2007Bi14
	70 Yb 177	0	1.91 h	9/2+	+4.03(6)	[173Yb]	CLS	2012Fl05
Lutetium	*Muonic atom X-ray hyperfine structure*							
	71 Lu 162	0	1.37 m	1−	+0.519(8)	[175Lu]	CLS	1998Ge13
	71 Lu 164	0	3.14 m	1−	+0.608(7)	[175Lu]	CLS	1998Ge13
	71 Lu 166	0	2.65 m	6−	+4.33(4)	[175Lu]	CLS	1998Ge13
		34	1.41 m	3−	+2.72(2)	[175Lu]	CLS	1998Ge13
	71 Lu 167	0	51.5 m	7/2+	+3.28(2)	[175Lu]	CLS	1998Ge13
	71 Lu 168	0	5.5 m	6−	+4.77(6)	[175Lu]	CLS	1998Ge13
		220	6.7 m	3+	+2.43(2)	[175Lu]	CLS	1998Ge13
	71 Lu 169	0	34.1 h	7/2+	+3.48(3)	[175Lu]	CLS	1998Ge13
	71 Lu 171	0	8.24 d	7/2+	+3.53(3)	[175Lu]	CLS	1998Ge13
	71 Lu 172	0	6.70 d	4−	+3.80(4)	[175Lu]	CLS	1998Ge13
		42	3.7 m	1−	+0.76(3)	[175Lu]	CLS	1998Ge13
	71 Lu 173	0	1.37 y	7/2+	+3.53(2)	[175Lu]	CLS	1998Ge13
	71 Lu 174	0	3.3 y	1−	+0.773(7)	[175Lu]	CLS	1998Ge13
		171	142 d	6−	+4.80(5)	[175Lu]	CLS	1998Ge13
Reference isotope	71 Lu 175	0	Stable	7/2+	+3.49(2)		Mu-X	1979De29
	71 Lu 176	0	3.6×10^{10} y	7−	+4.92(3)	[175Lu]	A	1985Br09
		127	3.68 h	1−	−1.450(12)	[175Lu]	CLS	1998Ge13
	71 Lu 177	0	6.71 d	7/2+	+3.39(3)	[175Lu]	CLS	1998Ge13
		970	160 d	23/2	+5.71(5)	[175Lu]	CLS	1998Ge13
	71 Lu 178	0	28.4 m	1+	+0.708(10)	[175Lu]	CLS	1998Ge13
		120	23.1 m	9−	+5.39(10)	[175Lu]	CLS	1998Ge13
	71 Lu 179	0	4.59 h	7/2+	+3.32(3)	[175Lu]	CLS	1998Ge13
Hafnium	*Muonic atom X-ray hyperfine structure*							
	72 Hf 171	0	12.1 h	7/2+	+3.46(3)	[177Hf]	CLS	2000Ye02
	72 Hf 175	0	70 d	5/2−	+2.72(2)	[177Hf]	CLS	2002Ni12
	72 Hf 176	88	1.47 ns	2+	−2.10(2)	[177Hf]	Mu-X	1984Ta10
Reference isotope	72 Hf 177	0	Stable	7/2−	+3.37(3)		Mu-X	1984Ta04
			490 ps	9/2−	+1.30(2)	[177Hf]	Mu-X	1984Ta10
	72 Hf 178	93	1.47 ns	2+	−2.02(2)	[177Hf]	Mu-X	1984Ta10
		1147	4 s	23/2−	+4.99(4)	[177Hf]	CLS	2007Bi14
		2446	31 y	16+	+6.00(7)	[177Hf]	CLS	1994Bo15
Reference isotope	72 Hf 179	0	Stable	9/2+	+3.79(3)		Mu-X	1984Ta04
		123	37 ps	11/2+	+1.88(3)	[177Hf]	Mu-X	1984Ta10
	72 Hf 180	93	1.53 ns	2+	−2.00(2)	[177Hf]	Mu-X	1984Ta10
		1142	5.5 h	8−	+4.6(3)	[177Hf]	NO/S	1973Ka31
Tantalum	*Pionic atom X-ray hyperfine structure*							
	73 Ta 171	184	45 ns	9/2−	(+)3.1(2)	[181Ta]	TDPAD	1995Do32
	73 Ta 173	0	3.14 h	5/2−	−1.8(2)	[181Ta]	NO/S	1983Ed01
	73 Ta 175	0	10.5 h	7/2+	+3.5(3)	[181Ta]	NO/S	1983Ed01
	73 Ta 178	0 + x	9.3 m	1+	+0.63(6)	[181Ta]	NO/S	1983Ha49
	73 Ta 179	0	1.82 y	7/2+	+3.27(4)	[181Ta]	CLS	1996Wa02
	73 Ta 180	75	$>1.2 \times 10^{15}$ y	9−	+4.80(3)	[181Ta]	CLS	1994Wa34
Reference isotope	73 Ta 181	0	Stable	7/2+	+3.17(2)		Pi-X	1983Ol03
		6	6.05 ms	9/2−	+3.59(2)	[181Ta]	ME	1983Ei02
		482	10.8 ns	5/2+	+2.28(2)	[181Ta]	ME	1983Bu11
	73 Ta 182	0	115 d	3−	+2.6(3)	[181Ta]	NO/S	1991Fa12
Tungsten	*There is no adopted reference efg for W*							
	A. Efg calculation in Tl metal							
	74 W 176	3746	41 ns	14+	6.0(8)	A	TDPAD	2002Io01
	74 W 179	3348	750 ns	35/2−	+3.9(10)	A	LEMS	2001Ba04
	74 W 180	104	1.22 ns	2+	−2.1(4)	[182W 100 keV]	ME	1973Zi02
	74 W 182	100	1.37 ns	2+	−2.1(4)		CER	1977RuZV
	74 W 183	47	184 ps	3/2−	−1.8(4)	[182W 100 keV]	ME	1966Sh07
		99	0.71 ns	5/2−	−2.0(3)	[182W 100 keV]	ME	1967Ag02/1974Ge17
	74 W 184	111	1.25 ns	2+	−1.9(2)	[182W 100 keV]	CER	1974Ge17/1977RuZV
		904	1.73 ps	2+	+0.1(4)		CER	1977Ob02
	74 W 186	123	1.05 ns	2+	−1.6(3)	[182W 100 keV]	CER	1977RuZV
		396	36 ps	4+	−2.6(13)		CER	1970McZQ
		737	4.4 ps	2+	1.3(3)		CER	1977Ob02
Rhenium	*Pionic atom X-ray hyperfine structure*							
	75 Re 182	0	64.0 h	7+	+4.1(3)	[185,187Re]	NO/S	1983Ha49
		0 + x	12.7 h	2+	+1.8(2)	[185,187Re]	NO/S	1985Ha41/1981Er01
	75 Re 183	0	70.0 d	5/2+	+2.3(2)	[185,187Re]	NO/S	1983Ha49
		497	7 ns	9/2−	(+)3.7(4)	[185,187Re]	TDPAC	1978Ne14

(*continued on next page*)

Table 1 (*continued*)

Element	Nucleus	E (level) keV	$T_{1/2}$	I^{π}	Q (b)	Ref. Std.	Method	Reference
	75 Re 184	0	38.0 d	3−	+2.8(2)	[185,187Re]	NO/S	1983Ha49
Reference isotope	75 Re 185	0	Stable	5/2+	+2.18(2)		Pi-X	1981Ko11
	75 Re 186	0	90.6 h	1−	+0.618(6)	[185,187Re]	AB	1981Bu13
Reference isotope	75 Re 187	0	4×10^{10} y	5/2+	+2.07(2)		Pi-X	1981Ko11
		206	555 ns	9/2−	+3.04(5)	[187Re]	TDPAC	1973Ha61
	75 Re 188	0	16.9 h	1−	+0.572(6)	[185,187Re]	AB	1981Bu13
Osmium	*Muonic atom X-ray hyperfine structure*							
	76 Os 182	7049	150 ns	25+	4.2(2)	[188Os 155 keV]	TDPAD	1991Br25
	76 Os 183	0	13.0 h	9/2+	+3.1(3)	[188Os 155 keV]	NO/S	1985Ha41
	76 Os 184	120	1.18 ns	2+	−2.7(12)	[188Os 155 keV]	CER	1972La16
	76 Os 186	137	830 ps	2+	−1.63(4)		Mu-X	1981Ho22
Reference isotope	76 Os 188	155	710 ps	2+	−1.46(4)		Mu-X	1981Ho22
		633	6.3 ps	2+	+1.0(3)	[188Os 155 keV]	CER	1980Ba42
		2121	−	(3−)	+1.69(9)		Mu-X	1979Ho23
	76 Os 189	0	Stable	3/2−	+0.86(3)	[188Os 155 keV]	ME	1972Wa24
		70	1.63 ns	5/2−	−0.63(2)	[188Os 155 keV]	ME	1972Wa24
	76 Os 190	187	366 ps	2+	−1.18(3)		Mu-X	1981Ho22
		558	12.5 ps	2+	+0.8(5)	[188Os 155 keV]	CER	1980Ba42
	76 Os 191	0	15.4 d	9/2−	+2.53(16)	[188Os 155 keV]	NO/S	1979Er09
	76 Os 192	206	289 ps	2+	−0.96(3)		Mu-X	1981Ho22
		489	30.1 ps	2+	−0.7(3)	[188Os 155 keV]	CER	1980Ba42
	76 Os 193	0	30.5 h	3/2−	+0.48(6)	[188Os 155 keV]	NO/S,R	1985Be03/1979Er09
Iridium	*Muonic atom X-ray hyperfine structure*							
	A. Estimated efg at Ir in hcp Co metal crystal							
	B. Estimated efg at Ir in Os metal polycrystal							
	77 Ir 182	0	15 m	3+	−1.7(6)	[191Ir]	RIMS/LS	2006Ve10
	77 Ir 183	0	55 m	5/2−	−1.8(7)	[191Ir]	RIMS/LS	2006Ve10
	77 Ir 184	0	3.14 h	5−	+2.41(3)	A	QI-NMR/ON	1996Se15
	77 Ir 185	0	14.4 h	5/2−	−1.84(12)	A	NMR/ON R	1988Oh02
	77 Ir 186	0	16.64 h	5+	−2.55(3)	A	QI-NMR/ON	1996Se15
		x		2(−)	+1.456(17)	A	QI-NMR/ON	1996Se15
	77 Ir 187	0	10.5 h	3/2+	+0.941(11)	A	QI-NMR/ON	1996Se15
		434	152 ns	11/2−	2.33(14)	[193Ir]	TDPAC	1978HaXO
	77 Ir 188	0	40.5 h	1(−)	+0.484(6)	A	QI-NMR/ON	1996Se15
	77 Ir 189	0	13.1 d	3/2+	+0.82(8)	[191Ir]	RIMS/LS	2006Ve10
					['+0.878(10)]		Estimated	1996Se15
	77 Ir 190	0	11.8 d	(4)+	+2.87(16)	A	NO/S	1980Mu07
Reference isotope	77 Ir 191	0	Stable	3/2+	+0.816(9)		Mu-X	1984Ta04
	77 Ir 192	0	74.2 d	4−	+2.15(6)	A	QI-NMR/ON	1996Se15
	77 Ir 193	0	Stable	3/2+	+0.751(9)		Mu-X	1984Ta04
	77 Ir 194	0	19.4 h	1−	+0.339(12)	[191Ir]	NMR/ON	1985Ed02
Platinum	*There is no adopted reference efg for Pt.*							
	A. For details of the efg used see 1992Hi07							
	B. Estimated efg at Pt in osmium metal							
	78 Pt 183	35	43 s	7/2−	+3.4(3)	A	LS	1999Le52/1992Hi07
	78 Pt 185	0	70.9 m	9/2+	+3.73(17)	A	LS	1999Le52/1992Hi07
	78 Pt 187	0	2.35 h	3/2−	−1.02(4)	A	RIMS/LS	1992Hi07/1989Du01
	78 Pt 189	0	10.9 h	3/2−	−0.95(4)	A	RIMS/LS	1992Hi07/1989Du01
	78 Pt 191	0	2.9 d	3/2−	−0.87(4)	A	RIMS/LS	1992Hi07/1989Du01
	78 Pt 192	317	43.7 ps	2+	+0.6(2)		CER	1987Gy01
	78 Pt 194	328	41.8 ps	2+	+0.48(14)		CER	1986Gy04
	78 Pt 195	259	4.02 d	13/2+	+1.4(6)	B	NO/S	1985Ed05
	78 Pt 196	356	34 ps	2+	+0.62(8)		CER	1992Li14
		689	36.8 ps	2+	−0.39(16)		CER	1992Li14
		877	3.6 ps	4+	+1.03(12)		CER	1992Li14
		1526	0.98 ps	6+	−0.2(3)		CER	1992Li14
	78 Pt 198	407	22.3 ps	2+	+0.42(12)		CER	1986Gy04
Gold	*Muonic atom X-ray hyperfine structure*							
	79 Au 184	0	21 s	5	+4.7(3)	[197Au]	CLS	1997Le22
			49 s	2	+1.90(16)	[197Au]	CLS	1997Le22
	79 Au 185	0	4.2 m	5/2−	−1.10(10)	[186Au, 197Au]	CLS	1992Ki30/1994Pa37
	79 Au 186	0	10.7 m	3−	+3.10(6)	[186Au, 197Au]	CLS	1992Ki30/1994Pa37
	79 Au 191	0	3.18 h	3/2+	+0.72(2)	[197Au]	CLS	1994Pa37
	79 Au 192	0	5.0 h	1−	−0.228(8)	[197Au]	CLS	1994Pa37
	79 Au 193	0	17.65 h	3/2+	+0.66(2)	[197Au]	CLS	1994Pa37
		290	3.9 s	11/2−	+1.98(6)	[197Au]	MAPON	1996Se06
	79 Au 194	0	39.5 h	1−	−0.240(9)	[197Au]	CLS	1994Pa37
	79 Au 195	0	183 d	3/2+	+0.607(18)	[197Au]	QI-NMR/ON	1993Hi10
		319	30.6 s	11/2−	+1.87(6)	[197Au]	MAPON	1996Se06
	79 Au 196	0	6.18 d	2−	+0.81(7)	[197Au]	NMR/ON	1987Oh11

(*continued on next page*)

Table 1 (*continued*)

Element	Nucleus	*E* (level) keV	$T_{1/2}$	I^{π}	*Q* (*b*)	Ref. Std.	Method	Reference
Reference isotope	79 Au 197	0	Stable	3/2+	+0.547(16)		Mu-X	1974Po02
		409	7.8 s	11/2−	+1.68(5)	[197Au]	MAPON	1996Se06
	79 Au 198	0	2.696 d	2−	+0.640(19)	[197Au]	NMR/ON	1993Hi10
	79 Au 199	0	3.14 d	3/2+	+0.510(16)	[197Au]	NMR/ON	1993Hi10
Mercury	*Efg calculations in the $^3P_1$ state of neutral Hg*							
	80 Hg 185	99.3	27 s	13/2+	+0.2(3)	[201Hg]	β-RADOP	1979Da06
	80 Hg 187	0	2.4 m	13/2+	+0.5(3)	[201Hg]	β-RADOP	1979Da06
		134	1.9 m	3/2−	−0.75(18)	[201Hg]	β-RADOP	1986Ul02/1979Da06
	80 Hg 188	2724	135 ns	12+	0.91(11)	[199Hg 158 keV]	TDPAD	1984Dr09
	80 Hg 189	0	7.6 m	3/2−	−0.8(3)	[201Hg]	β-RADOP	1986Ul02/1979Da06
		0 + x	8.6 m	13/2+	+0.66(19)	[201Hg]	β-RADOP	1979Da06
	80 Hg 190	2621	21 ns	12+	1.17(14)	[199Hg 158 keV]	TDPAD	1984Dr09
	80 Hg 191	0	49 m	3/2−	−0.80(13)	[201Hg]	β-RADOP	1986Ul02/1979Da06
		140	50.8 m	13/2+	+0.6(2)	[201Hg]	β-RADOP	1979Da06
	80 Hg 193	0	3.80 h	3/2−	−0.7(3)	[201Hg]	O	1974Fu06/1966Da07
		141	11.8 h	13/2+	+0.92(2)	[201Hg]	O	1974Re05
	80 Hg 195	176	41.6 h	13/2+	+1.08(2)	[201Hg]	O	1965Sm01
	80 Hg 197	134	8.1 ns	5/2−	+0.081(6)	[199Hg 158 keV]	TDPAC	1980He05
		299	23.8 h	13/2+	+1.25(3)	[201Hg]	O	1961Br17
	80 Hg 198	412	23 ps	2+	+0.68(12) or +0.84(12)		CER	1979Bo16/1984Fe08
	80 Hg 199	158	2.45 ns	5/2−	+0.95(7)		Mu-X	1979Ha08
		208	69 ps	3/2−	+0.62(15)		Mu-X	1979Ha08
		532	42.6 m	13/2+	+1.2(3)	[201Hg]	β-RADOP	1979Da06
	80 Hg 200	368	46.6 ps	2+	+0.96(11) or +1.11(11)		CER	1979Bo16
Reference isotope	80 Hg 201	0	Stable	3/2−	+0.387(6)			2005Bi03/1961Ko05
	80 Hg 202	440	27.3 ps	2+	+0.87(13) or +1.01(13)		CER	1980Sp05
	80 Hg 203	0	46.8 d	5/2−	+0.344(7)	[201Hg]	O	1970Re14
	80 Hg 204	437	40.2 ps	2+	+0.4(2)		CER	1981Es03
	80 Hg 206	2102	2.15 ms	5−	0.74(15)	[199Hg 158 keV]	TDPAD	1984Ma43
Thallium	*There is no adopted reference efg for Tl*							
	A. For reference to the efg used in CLS studies see 1987Bo44 (PR C36 2560 (1987)							
	B. Estimated efg in In metal							
	81 Tl 187	335	15.6 s	(9/2−)	−2.43(5)	A	CLS	1993ScZW
	81 Tl 188	0 + x	71 s	7+	+0.129(4)	A	CLS	1992Me07
	81 Tl 189	281	1.4 m	9/2−	−2.29(4)	A	CLS	1987Bo44
	81 Tl 190	0 + x	2.6 m	2−	−0.329(9)	A	CLS	1992Me07
		0 + y	3.7 m	7+	+0.285(14)	A	CLS	1992Me07
	81 Tl 191	299	5.2 m	9/2−	−2.23(2)	A	CLS	1992Me07
	81 Tl 192	0 + x	9.6 m	2−	−0.328(11)	A	CLS	1992Me07
		0 + y	10.8 m	7+	+0.46(2)	A	CLS	1992Me07
		251 + x	296 ns	8−	0.44(7)	B	TDPAD	1982Sc27
	81 Tl 193	365	2.11m	9/2−	−2.20(2)	A	CLS	1987Bo44
	81 Tl 194	0	34 m	2−	−0.282(7)	A	CLS	1992Me07
		0 + y	32.8 m	7+	+0.607(16)	A	CLS	1992Me07
	81 Tl 196	0	1.84 h	2−	−0.178(14)	A	CLS	1992Me07
		394	1.41 h	7+	+0.76(2)	A	CLS	1992Me07
	81 Tl 205	204	1.5 ns	3/2+	+0.74(15)		Mu-X	1972Ch07
		2623	short	(5/2)−	−0.5(2)		Mu-X	1972Ch07
Lead	*Efg in $^3P_1$ state of neutral Pb*							
	A. Efg in $^1D_2$ state in neutral Pb							
	B. Normalised to estimated Q of 206Pb 4027 keV							
	C. Obtained from theory of relaxation in Hg metal							
	82 Pb 191	138	2.18 m	13/2+	+0.085(5)	A	CLS	1991Du07
	82 Pb 192	2581+d	1.07 ms	12+	0.32(4)	B	TDPAD	2007Io03
		2743	756 ns	11−	2.9(3)	B	TDPAD	2007Io03
	82 Pb 193	100	5.8 m	13/2+	+0.195(10)	A	CLS	1991Du07
		1586 + x	22 ns	(21/2−)	0.22(2)	B	TDPAD	2004Ba31
		2585 + x	9.4 ns	(27/2−)	2.6(3)	B	TDPAD	2011Ba02
				(29/2−)	2.8(3)	B	TDPAD	2004Ba31
		2613 + x	135 ns	(33/2+)	0.45(4)	B	TDPAD	2004Ba31
	82 Pb 194	2628	350 ns	12+	0.49(3)	B	TDPAD	1985St16
		2933	122 ns	11−	3.6(4)	B	TDPAD	2007Io03
	82 Pb 195	203	15.0 m	13/2+	+0.306(15)	A	CLS	1991Du07
	82 Pb 196	2694	269 ns	12+	0.65(5)	B	TDPAD	1981Zy02
		3191	85 ns	11−	(−)3.4(7)	B	LEMS	2002Vy01
	82 Pb 197	0	8 m	3/2−	−0.08(17)		CLS	1986An06
		319	43 m	13/2+	+0.378(19)	A	CLS	1991Du07
	82 Pb 198	2820	212 ns	12+	0.75(5)	B	TDPAD	1981Zy02
	82 Pb 199	0	1.5 h	3/2−	’+0.08(9)		CLS	1986An06
	82 Pb 200	2154	44 ns	7−	0.32(2)	B	TDPAD	1979MaYq
		2183	480 ns	9−	0.40(2)	B	TDPAD	1979MaYq
		3006	152 ns	12+	0.79(3)	B	TDPAD	1979Ma37

(*continued on next page*)

Table 1 (*continued*)

Element	Nucleus	E (level) keV	$T_{1/2}$	I^{π}	Q (b)	Ref. Std.	Method	Reference
	82 Pb 201	0	9.33 h	5/2−	0.01(4)		CLS	1986An06
		2719	63 ns	25/2−	0.46(2)	B	TDPAD	1979MaYq
	82 Pb 202	2170	3.62 h	9−	+0.58(9)		CLS	1986An06
		2208	65 ns	7−	0.28(2)	B	TDPAD	1979MaYq
	82 Pb 203	0	51.9 h	5/2−	+0.10(5)		CLS	1986An06
		1921	56 ns	21/2+	0.85(3)	B	TDPAD	1979MaYq
	82 Pb 204	899	2.94 ps	2+	+0.23(9)		CER	1978Jo04
		1274	280 ns	4+	0.44(2)	B	TDPAD	1979MaYq
	82 Pb 205	0	1.5×10^{7} y	5/2−	+0.23(4)		CLS	1986An06
		1014	5.55 ms	13/2+	0.30(5)	C	QIR	1974Ri03
		3196	217 ns	25/2−	0.63(3)	B	TDPAD	1979MaYq
	82 Pb 206	803	8.4 ps	2+	+0.05(9)		CER	1978Jo04
		2200	123 ms	7−	0.33(5)	C	QIR	1974Ri03
		4027	185 ns	12+	[0.51(2)]	From B(E2)	Not measured	1979Ma37
	82 Pb 208	2615	15 ps	3−	−0.34(15)		CER	1984Ve07
		4086	0.74 fs	2+	−0.7(3)		CER	1984Ve07
Reference isotope	82 Pb 209	0	3.25 h	9/2+	−0.27(17)		CLS	1986An06
	82 Pb 211	0	36.1 m	9/2+	+0.09(6)		CLS	1986An06
Bismuth	*Efg calculations in the $^{4}P_{3/2}$ state of neutral Bi*							2001Bi23
	83 Bi 202	0	1.72 h	(5+)	−1.00(9)	[209Bi]	LFRS	1996Ca02/2001Bi23
				(6+)	−1.21(9)	[209Bi]	LFRS	1996Ca02/2001Bi23
		615	3.04 ms	10−	0.14(2)	[209Bi]	TDPAD	1987Ma65
		2607	310 ns	17+	0.45(2)	[209Bi]	TDPAD	1987Ma65
	83 Bi 203	0	11.8 h	9/2−	−0.93(7)	[209Bi]	LFRS	1996Ca02/2001Bi23
	83 Bi 204	0	11.22 h	6+	−0.68(20)	[209Bi]	LFRS	1996Ca02/2001Bi23
		806	13.0 ms	10−	0.074(2)	[209Bi]	LEMS	1991Sc14
	83 Bi 205	0	15.3 d	9/2−	−0.81(3)	[209Bi]	LRFS	2000Pe30/2001Bi23
	83 Bi 206	0	6.243 d	6+	−0.54(4)	[209Bi]	LRFS	2000Pe30/2001Bi23
		1045	0.89 ms	(10−)	0.057(11)	[209Bi]	LEMS	1991Sc14
	83 Bi 207	0	32.2 y	9/2−	−0.76(2)	[209Bi]	LRFS	2000Pe30/2001Bi23
		2101	182 ms	21/2+	0.051(9)	[209Bi]	LEMS	1991Sc14
	83 Bi 208	0	3.7×10^{5} y	5+	−0.70(8)	[209Bi]	LRFS	2000Pe30/2001Bi23
Reference isotope	83 Bi 209	0	Stable	9/2−	−0.516(15)		AB	1970Hu05/2001Bi23
		2563	14 fs	(9/2)+	+0.15(7)	[209Bi]	Mu-X	1972Le07
		2741	12 ps	15/2+	0.0(5)	[209Bi]	Mu-X	1972Le07
	83 Bi 210	0	5.01 d	1−	+0.190(6)	[209Bi]	AB	1962Al02/2001Bi23
		271	3.0×10^{6} y	9−	−0.66(7)	[209Bi]	LRFS	2000Pe30/2001Bi23
	83 Bi 212	0	60.6 m	1(−)	+0.1(4)	[209Bi]	LRFS	2000Pe30/2001Bi23
	83 Bi 213	0	45.6 m	9/2−	−0.83(5)	[209Bi]	LRFS	2000Pe30/2001Bi23
Polonium	*There is no adopted reference efg for Po.*							
	A. The moments quoted are based on a calculated value for the 1557 keV, 8^{+} *state in 210Po [1991Be03, NPA522 483 (1991)].*							
	84 Po 200	1774	61 ns	8+	(−)1.38(7)	A	TDPAD	1987Ma65
	84 Po 202	1712	110 ns	8+	(−)1.21(16)	A	LEMS	1997Ne06
	84 Po 204	1639	158 ns	8+	(−)1.14(5)	A	TDPAD	1987Ma65
	84 Po 206	1586	212 ns	8+	(−)1.02(4)	A	TDPAD	1987Ma65
	84 Po 208	1528	380 ns	8+	(−)0.90(4)	A	TDPAD	1987Ma65
	84 Po 209	1473	98.1 ns	(17/2−)	(−)0.39(8)	A	TDPAD	1983Da01
	84 Po 210	1557	96 ns	8+	[−0.55(2)]	From B(E2)	Not measured	1991Be03
		2849	20.1 ns	11−	(−)0.86(11)	A	TDPAD	1991Be03
		4372	51 ns	13−	(−)0.90(7)	A	TDPAD	1991Be03
		5058	265 ns	16+	(−)1.30(2)	A	TDPAD	1991Be03
Astitine	*There is no adopted reference efg for At.*							
	A. The moments quoted are based on a calculated value for the 1417 keV, *21/2-, state in 211At [1995Ba66 NP A591 104 (1995)].*							
	85 At 208	1090	48 ns	10−	(−)1.67(18)	A	LEMS	1991Sc15
	85 At 209	1428	26 ns	21/2−	(−)0.78(6)	A	TDPAD	1983Ma08
		2429	890 ns	29/2+	(−)1.49(9)	A	TDPAD	1983Ma08
	85 At 210	1363	28.4 ns	11+	(−)0.64(5)	A	TDPAD	1983Ma08
		2550	480 ns	15−	(−)1.21(7)	A	TDPAD	1983Ma08
		4028	5.9 ms	19+	(−)2.16(18)	A	LEMS	1991Sc15
	85 At 211	1417	35.1 ns	21/2−	[(−)0.524(10)]	From B(E2)	Not measured	1995Ba66
		2641	50.8 ns	29/2+	(−)1.01(7)	A	TDPAD	1983Ma08
		4816	4.2 ms	39/2−	(−)1.88(19)	A	LEMS	1991Sc15
Radon	*Estimated efg in Rn atom*							
	A. Normalised to Q of 1694 keV, 8^{+} *state in 212Rn estimated from B(E2).*							
	86 Rn 203	361	28 s	(13/2+)	+1.28(13)	209Rn	CLS	1987OtZW
	86 Rn 205	0	2.83 m	5/2−	+0.062(6)	209Rn	CLS	1987OtZW
	86 Rn 207	0	9.3 m	5/2−	+0.22(2)	209Rn	CLS	1987OtZW
	86 Rn 208	1826	490 ns	8+	0.41(5)	A	TDPAD	1986Be40
	86 Rn 209	0	29 m	5/2−	+0.31(3)		efg in Rn atom	1987OtZW
	86 Rn 210	1665 + x	644 ns	(8+)	0.32(4)	A	TDPAD	1986Be40
		3812 + x	1.05 ms	(17)−	0.89(10)	A	TDPAD	1986Be40

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Table 1 (*continued*)

Element	Nucleus	E (level) keV	$T_{1/2}$	I^{π}	Q (b)	Ref. Std.	Method	Reference
	86 Rn 211	1578 + x	596 ns	17/2−	0.19(2)	A	TDPAD	1985Da14
		8855 + y	201 ns	63/2−	1.6(2)	A	TDPAD	1985Da14
	86 Rn 212	1694	0.91 ms	8+	[−0.18(2)]	From B(E2)	Not measured	1985Da13
	86 Rn 219	0	3.96 s	5/2+	+1.15(12)	209Rn	CLS	1987OtZW
	86 Rn 221	0	25 m	7/2+	−0.47(5)	209Rn	CLS	1987OtZW
	86 Rn 223	0	23.2 m	7/2	+0.80(8)	209Rn	CLS	1988NeZZ
	86 Rn 225	0	4.5 m	7/2−	+0.84(8)	209Rn	CLS	1988NeZZ
Francium	*Efg calculated in the $^2P_{3/2}$ state of the Fr atom (PR A27 3332 (1983) revised (PL B163 (1985)).*							
	A. Normalised to calculated Q of the 2538 keV *$29/2^+$ state in 211Fr.*							
	87 Fr 207	0	14.8 s	9/2−	−0.16(5)	223Fr	ABLS	1985Co24
	87 Fr 208	0	58.6 s	7+	0.00(4)	223Fr	ABLS	1985Co24
	87 Fr 209	0	50 s	9/2−	−0.24(2)	223Fr	ABLS	1985Co24
	87 Fr 210	0	3.2 m	6+	+0.19(2)	223Fr	ABLS	1985Co24
	87 Fr 211	0	3.1 m	9/2−	−0.19(3)	223Fr	ABLS	1985Co24
		2423	146 ns	29/2+	(−)1.07(18)	A	LEMS	1991Ha02
		4657	123 ns	45/2−	(−)2.0(6)	A	LEMS	1991Ha02
	87 Fr 212	0	19.3 m	5+	−0.10(1)	223Fr	ABLS	1985Co24
		2492	604 ns	(15−)	(−)0.84(13)	A	TDPAD	1990By03
		5854	312 ns	(27−)	(−)1.7(3)	A	TDPAD	1990By03
	87 Fr 213	0	34.7 s	9/2−	−0.14(2)	223Fr	ABLS	1985Co24
		2538	243 ns	29/2+	[−0.70(7)]	calculated	Not measured	1990By03
		8095	3.1 ms	65/2−	(−)2.2(5)	A	LEMS	1991Ha02
	87 Fr 214	640	103 ns	11+	0.8(2)	A	LEMS	1995Ne06
		6477+D'	108 ns	32/33+	2.2(5)	A	LEMS	1995Ne06
	87 Fr 220	0	27.4 s	1+	+0.47(3)	223Fr	ABLS	1985Co24/1987Co19
	87 Fr 221	0	4.8 m	5/2−	−0.98(6)	223Fr	ABLS	1985Co24/1987Co19
	87 Fr 222	0	14.2 m	2−	+0.51(4)	223Fr	ABLS	1985Co24
Reference isotope	87 Fr 223	0	21.8 m	3/2(−)	+1.17(1)		ABLS	1985Co24
	87 Fr 224	0	3.3 m	1(−)	+0.517(4)	223Fr	ABLS	1985Co24
	87 Fr 225	0	3.9 m	3/2−	”+1.32(5)	223Fr	ABLS	1985Co24/1987Co19
	87 Fr 226	0	48 s	1	−1.35(2)	223Fr	ABLS	1985Co24
	87 Fr 228	0	39 s	2−	+2.38(5)	223Fr	ABLS	1985Co24
Radium	*Efg calculated in 7s7p states of the Ra atom*							
	88 Ra 209	0	4.7 s	5/2−	+0.39(4)	223Ra	CLS	1989Ne03
	88 Ra 211	0	13s	5/2−	+0.46(4)	223Ra	CLS	1989Ne03
	88 Ra 221	0	30 s	5/2−	+1.92(6)	223Ra	CLS	1989Ne03
Reference isotope	88 Ra 223	0	11.44 d	3/2+	+1.21(3)		CLS	2008Py02/1989Ne03
	88 Ra 227	0	42.2 m	3/2+	+1.53(6)	223Ra	CLS	1989Ne03
	88 Ra 229	0	4.0 m	5/2(+)	+2.99(12)	223Ra	CLS	1989Ne03
Actinium	*There is no adopted reference efg for Ac.*							
	The quoted value and its error are both quite uncertain.							
	89 Ac 227	0	21.77 y	3/2−	+1.7(2)		O	1955Fr26
Thorium	*There is no adopted reference efg for Th.*							
	A. Based on estimated efg in the Th atom							
	90 Th 229	0	7340 y	5/2+	+4.3(9)	A	O	1974Ge06
Protactinium	*There is no adopted reference efg for Pa.*							
	A. Estimated from B(E2) value.							
	B. Based on estimated efg in the Pr atom							
	91 Pa 231	0	3.3×10^4 y	3/2−	[−1.72(5)]	From B(E2)	Not measured	1978Fr28
		84.2	41 ns	5/2+	+0.7(2)	231Pa	ME	1978Fr28
	91 Pa 233	0	27.0 d	3/2−	−3.0(4)	B	AB	1961Ma42
Uranium	*Muonic atom X-ray hyperfine structure*							
Reference isotope	92 U 233	0	1.6×10^5 y	5/2+	+3.663(8)		Mu-X	1984Zu02
		40	50 ps	7/2+	+0.64(3)		Mu-X	1984Zu02
Reference isotope	92 U 235	0	7.0×10^8 y	7/2−	+4.936(6)		Mu-X	1984Zu02
		46	<60 ps	9/2−	+1.87(3)		Mu-X	1984Zu02
Neptunium	*Muonic atom X-ray hyperfine structure*							
Reference isotope	93 Np 237	0	2.1×10^6 y	5/2+	+3.886(6)		Mu-X	1987De10
		60	68 ns	5/2−	+3.85(4)	237Np	ME	1968Pi01/1968St03
Plutonium	*Muonic atom X-ray hyperfine structure*							
	A. Calculated efg of the $^8F_{3/2}$ state of Pu II							
Reference isotope	94 Pu 239	8	36 ps	3/2+	−2.319(7)		Mu-X	1986Zu01
		57	101 ps	5/2+	−3.345(13)		Mu-X	1986Zu01
		76	83 ps	7/2+	−3.83(3)		Mu-X	1986Zu01
	94 Pu 241	0	14.4 y	5/2+	+6(2)	A	O	1964Ch12
Americium	*Muonic atom X-ray hyperfine structure*							
Reference isotope	95 Am 241	0	432.7 y	5/2−	+4.34(5)		Mu-X	1985Jo04

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Table 1 (*continued*)

Element	Nucleus	*E* (level) keV	$T_{1/2}$	I^{π}	*Q* (*b*)	Ref. Std.	Method	Reference
	95 Am 242	0	16.0 h	1−	−2.44((3)	241Am	AB	1966Ar04
		49	152 y	5−	+6.7(4)	241Am	ABLS	1988Be30
	95 Am 243	0	7370 y	5/2−	+4.32(6)		Mu-X	1985Jo04
		84	2.3 ns	5/2+	+4.2(2)	241Am	ME	1976Bo13
Einsteinium	*Efg calculated in the Es atom*							
Reference isotope	99 Es 253	0	20.4 d	7/2+	+6.7(8)		AB	1975Go05
Reference isotope	99 Es 254	78	39.3 h	2+	+3.7(5)		AB	1975Go05

Listing of NSR and corresponding journal references

NSR Keynumber	Journal reference
1953Li16	PR 90 609 (1953)
1955Aa06	PR 98 1224 (1955)
1955Fr26	PR 98 1514 (1955)/PR 111 1747 (1958)
1958Fl39	PR 110 536 (1958)
1959Ga12	PR 116 393 (1959)
1960Fe08	PhMg 5 1309 (1960)
1960Li11	PR 119 1053 (1960)
1960Wh06	BAPS 5 504 (1960)
1961Al20	UCRL 9850 (1960)
1961Br17	J Phys Radium 22 412 (1961)
1961Ko05	PR 121 1104 (1961)
1961Ma42	NP 23 90 (1961)
1962Al02	PR 125 256 (1962)
1962Ca10	PR 126 1004 (1962)
1962Pe21	PR 128 1740 (1962)
1963Bu14	PR 132 723 (1963)
1964Bu09	PR 135 B1281 (1964)
1964By01	PR 134 A47 (1964)
1964Ch12	JPPa 25 825 (1964)
1964Co08	PR 134 A94 (1964)
1964Pe06	PR 135B 1102 (1964)
1964Pe15	PL 13 198 (1964)
1964Wh05	PR 136 B584 (1964)
1965Hu01	ZP 182 499 (1965)
1965Sm01	PR A137 330 (1965)
1966Ar04	PR 144 994 (1966)
1966Bl05	PR 143 911 (1966)
1966Co13	PR 141 1106 (1966)
1966Co19	PR 148 1157 (1966)
1966Re04	PR 141 1123 (1966)
1966Sh07	JPSJ 21 829 (1966)
1967Ag02	PR 155 1342 (1967)
1967Ec01	PR 156 246 (1967)
1968Ra03	PR 165 1360 (1968)
1968CaZX	Th 68 Cass.
1968CaZX	Th 68 Cass.
1968Ch10	PR 170 136 (1968)
1968Ea04	PR 170 1083 (1968)
1968Eh02	PR 176 25 (1968)
1968Ma23	PRS A305 139 (1968)
1968Mu01	ZP A208 184 (1968)
1968Pi01	BAPS 13 28 (1968)
1968St03	PR 165 1319 (1968)
1969La05	PR 177 1606 (1969)
1969La06	PR 177 1615 (1969)
1969Sc34	PR 181 137 (1969)
1970Ge08	NP A151 252 (1970)
1970Hu05	PR A1 685 (1970)
1970McZQ	ORNL 4513 56 (1970)
1970Ne21	PR A2 1208 (1970)
1970Ni11	Phca 50 259 (1970)
1970Ol02	PR C2 228 (1970)
1970PiZR	BAPS 15 769 (1970)
1970Re14	PR A2 1135 (1970)
1970St13	PL A32 91 (1970)
1970Wa25	ZP A238 35 (1970)
1970Wo02	ZP 232 256 (1970)
1971ChZK	BAPS 16 625 (1971)
1971Go31	ZNat 26a 1931 (1971)
1971Jo10	NP A166 306 (1971)
1971Na05	PRL 24 903 (1970)
1971Na06	PL 34B 389 (1971)
1971Pa04	PR C3 841 (1971)
1971Pl03	NP A165 97 (1971)
1971Th14	PR C4 1699 (1971)
1972Be79	PL B42 349 (1972)
1972Ch07	NP A181 25 (1972)
1972Ch55	PR A6 2011 (1972)
1972Du06	PR A5 1036(1972)
1972Ek03	NP A194 237 (1972)
1972La16	PR C6 613 (1972)
1972Le07	NP A180 14 (1972)
1972Li12	PL B38 475 (1972)
1972Li12	PL B38 475 (1972)
1972Ni01	Phca 57 1 (1972)
1972Ra27	PRL 28 54 (1972)
1972Ro41	NIM 105 509 (1972)
1972St38	PR A6 1702 (1972)
1972Th16	PL 41B 585 (1972)
1972Th16	PL 41B 585 (1972)
1972Wa24	ZP A254 112 (1972)
1973Ar19	PL A44 279 (1973)
1973Ek01	PS 7 31 (1973)
1973Gr06	PRL 30 453 (1973)
1973Ha61	JCP 58 3339 (1973)
1973Ho05	PRL 30 388 (1973)
1973Ka31	PL B46 62 (1973)
1973KlZV	JPJS 34 265 (1973)
1973Lu02	PR C8 391 (1973)
1973Po15	NP A217 573 (1973)
1973St23	JPCR 5 1093 (1973)
1973Sy01	PR C7 2056 (1973)
1973To07	NP A204 574 (1973)
1973To07	NP A204 574 (1973)
1973Zi02	ZP 262 413 (1973)
1974Ar23	NP A233 385 (1974)
1974Ek01	NP A226 219 (1974)
1974Fe05	PL A49 287 (1974)
1974Ge06	JPPa 35 483 (1974)
1974Ge17	ZP 267 61 (1974)
1974Le13	NP A223 563 (1974)
1974Mi21	NP A236 415 (1974)
1974Po02	NP A230 413 (1974)
1974Re05	PR A9 1776 (1974)
1974Ri03	PS 11 228 (1975)
1975Ac01	NP A248 157 (1975)
1975Di02	PL B55 293 (1975)
1975Go05	PR A11 499 (1975)
1975Gr30	PR C12 1462 (1975)
1975Ri03	PS 11 228 (1975)
1975Ri03	Phys Scr 11 228 (1975)
1975To06	NP A250 381 (1975)
1975Vi03	NP A243 29 (1973)
1975Ze04	NP A254 315 (1975)
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