Nuclear Spins and Moments

Gladys H. Fuller*

Office of Standard Reference Data, National Bureau of Standards, Washington, D.C. 20234

A summary of nuclear–moment values and an index, arranged by Z and A, is presented. The summary value is based on the experimentally determined values of the nuclear moments which have been listed in tables according to the techniques used. Each table is preceded by a short introduction describing the experimental technique involved and the method of calculating the moment from the measured quantities. References are given for all data quoted. The date for the last systematic literature search is included with each table. This tabulation supplements and revises the earlier tables which appeared in Nuclear Data Tables, Volume A5, 433–612 (1969).

Key words: Evaluated data; nuclear electric hexadecapole moments; nuclear electric quadrupole moments; nuclear magnetic dipole moments; nuclear magnetic octupole moments; nuclear spins.

Contents

1. General Introduction

Measured values of nuclear moments, and of some of the auxiliary constants from which moment values are derived, are listed in this compilation. Since the auxiliary quantities determined by the various experimental techniques available today are quite different from each other, the experimental information is divided into eleven tables, each pertaining to a particular method or group of related methods. This division makes it possible to include information which is of interest to those concerned with a particular technique as well as values of the nuclear moments themselves.

Detailed descriptions of many of the methods have been presented by Ramsey [53Ra34]‡, Nierenberg [57Ni25], Kopfermann [58Ko90], Laukien [58La04], Townes [58To34], Cohen [59Co83], and by several authors in *Methods of Experimental Physics*, Volume 5, Nuclear Physics, Part B, edited by Yuan and Wu [63Yu02] and in *Hyperfine Interactions*, edited by Freeman and Frankel [67Fr15]. Brief introductions outlining the particular techniques are given with the individual tables.

In all tables, the values of the magnetic moments have been adjusted to a standard value of the magnetic moment of the proton by the compilers using the experimentally determined quantities and

*Guest worker.

‡Alpha-numeric codes in brackets indicate literature references, the first two digits representing the year of publication, the letters representing the author.

adopted standard values of μ_p and frequency ratios. An extensive discussion of the evaluation of the fundamental constants is given by Taylor, Parker, and Langenberg [69TaPa]. The most recent adjustment of the fundamental constants appears in Cohen and Taylor [73CoTa].

The Summary of Nuclear Moment Values and Index presents a list of the nuclear moments for all nuclei for which measurements have been made and serves as an index to the specific tables in which more detailed information will be found.

In preparation of the tables, all data available up to the cutoff date listed in each table were reviewed. Unless important for the determination of the sign of a moment, older values have been omitted when superseded by more accurate results.

The abbreviations used and policies adopted concerning signs, standards, uncertainties, standard values, and corrections are explained in tabular style on the following pages.

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The present compilation owes much to the earlier tabulations of J. Mack [50Ma50], H. E. Walchli [53Wa63], N. F. Ramsey [53Ra34], C. H. Townes [58To34], G. Laukien [58La04], I. Lindgren [65Li12], and V. S. Shirley [67Sh14].

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I would like to pay tribute to Dr. V. W. Cohen, my collaborator these many years, who died August 17, 1974. He was a man of very high principles, a good teacher and mentor. He was also a very warm, generous and direct person. He will be greatly missed – GHF.

2. Policies

Level Energies	Energies, given to identify the levels for which moment information is presented, are taken from the Nuclear Data Sheets (through Volume B5) or Table of Isotopes [67LeHo].
Half-lives	Half-lives which are given to identify the levels and which, in the case of Table J, are used to compute μ from values of $\omega\tau$, have been taken from Marelius [68Ma49], Nuclear Data Sheets (through Volume B5), Table of Isotopes [67LeHo], or the author (in that order).
Signs	The sign of the nuclear moment given is that actually measured by the experimenter. When the sign cannot be determined, "±" appears before the value.
Uncertainties	Uncertainties quoted for the measured quantities are those given by the experimenter. The uncertainty in the last figure of a number is printed in italics immediately after the number. For example, 0.745 *25* means 0.745 ±0.025.
[ ]	Brackets enclose values of the nuclear spins for which there are no spectroscopic or resonance measurements but which are assumed in order to calculate magnetic moments from g-values. They have also been used to indicate the model-dependent values of Q, Ω, and Q_4 which are obtained by electron scattering.

( )	Parentheses enclose values measured by someone other than the author quoted.
Zero–spin values	Measured zero–spin values for even–even nuclei have been included in the tables. Experiments which gave rise to the now–accepted concept of zero spin for all even–even nuclei can be divided into two groups. The first group proves that the spins of several such nuclei are definitely zero by the absence of alternating intensities in the observed spectra of homonuclear diatomic molecules. The second group, which can only give an upper limit on the interaction constants when no hyperfine splitting is observed, indicates either that the spin is zero or that μ (or Q) is very small. The spin values of zero determined by this second group of experiments are marked by "♦" after the value.
Standard μ_p	μ_p=2.792776 *31*nm. This result is obtained by averaging the values given by the experiments of [51Je10, 51So34, 55Co36, and 56Tr19] which yield μ directly in nuclear magnetons. This leads to a value of μ'_p, not corrected for atomic diamagnetism, of 2.79270 *3* which has been used throughout in the calculation of moments measured relative to that of the proton in samples of water. The uncertainties in the calculated magnetic moments do not include any uncertainty in the value of μ'_p.
Conversion factors	γ_p[in rad•s^{-1}•T^{-1}]×(1.043953 *10*)×10^{-8}=μ_p[in nm] μ_p[in Bohr magnetons]×(1836.109 *11*)=μ_p[in nm] See [69TaPa].
Standard frequency ratios	Standard frequency ratios, $\nu(A)/\nu_p$, which were used to calculate values of the magnetic moments from relative measurements, are given below. With the exception of the optical pumping (OP) measurement for ^{199}Hg, these ratios were determined by nuclear magnetic resonance (NMR).

^{2}H	0.15350609† *2*	^{45}Sc	0.24291623 *10*
^{7}Li	0.38863618† *8*	^{50}V	0.0997015‡ *10*
^{11}B	0.3208377‡ *2*	^{55}Mn	0.24789167 *6*
^{14}N	0.07226261 *1*	^{73}Ge	0.03488401 *14*
^{23}Na	0.26451775† *7*	^{85}Rb	0.096552095‡ *54*
^{27}Al	0.26056752 *7*	^{127}I	0.200080‡ *14*
^{35}Cl	0.09797858 *5*	^{199}Hg	0.178788 *15* (NMR)
^{39}K	0.0466636‡ *7*		0.1782706 *3* (OP)
^{41}K	0.02561295 *12*		

†From a least squares adjustment of the g–factors for ^{2}H, ^{7}Li, and ^{23}Na with g_p=5.58540 fixed.
‡Weighted average.

Diamagnetic corrections	All magnetic moments are given with the diamagnetic correction, σ, applied. To obtain the corrected g– or μ–value, the uncorrected value was multiplied by the factor, $(1-\sigma)^{-1}_{DK}$, listed in the table below for that element. These values, which are taken from Kopfermann [58Ko90] p450, are based on calculations of Dickinson [50Di10]. The uncertainty in the value of the added correction is assumed to be 5%. New calculations, using Hartree–Fock relativistic electron wave functions, show that the earlier values of σ are too small. Diamagnetic correction factors for some closed shell and closed sub–shell ions can be found in Feiock and Johnson [68Fe05]. Average correction factors for neutral atoms have been calculated by Lin, Johnson and Feiock [72Jo18]. These values include the contribution of the closed–shell core of the atoms and an average shielding factor for the valence electrons in the ground state configuration. This average is made over the ground state multiplet assigning statistical weights to the subshells. The diamagnetic correction factors do not include possible large contributions for individual valence electrons. In view of these better, unpublished values, which were received after most of the moments had been reevaluated, values of $(1-\sigma)^{-1}_{LJF}$ based on the average neutral–atom diamagnetic correction factors of Lin, Johnson and Feiock [72Jo18] are included in the table below.

Table of Diamagnetic Correction Factors

	$(1-\sigma)^{-1}_{DK}$	$(1-\sigma)^{-1}_{LJF}$		$(1-\sigma)^{-1}_{DK}$	$(1-\sigma)^{-1}_{LJF}$		$(1-\sigma)^{-1}_{DK}$	$(1-\sigma)^{-1}_{LJF}$		$(1-\sigma)^{-1}_{DK}$	$(1-\sigma)^{-1}_{LJF}$
$_{1}$H	1.0000278†	1.00001775†	$_{25}$Mn	1.00191	1.002077	$_{49}$In	1.00493	1.005994	$_{74}$W	1.00877	1.01340
$_{2}$He	1.000060	1.00005994	$_{26}$Fe	1.00202	1.002203	$_{50}$Sn	1.00506	1.006203	$_{75}$Re	1.00893	1.01382
$_{3}$Li	1.000101	1.0001048	$_{27}$Co	1.00214	1.002332	$_{51}$Sb	1.00520	1.006419	$_{76}$Os	1.00909	1.01426
$_{4}$Be	1.000149	1.0001531	$_{28}$Ni	1.00226	1.002468	$_{52}$Te	1.00534	1.006639	$_{77}$Ir	1.00925	1.01471
$_{5}$B	1.000199	1.0002068	$_{29}$Cu	1.00238	1.002611	$_{53}$I	1.00548	1.006861	$_{78}$Pt	1.00942	1.01519
$_{6}$C	1.000261	1.0002672	$_{30}$Zn	1.00250	1.002749	$_{54}$Xe	1.00562	1.007092	$_{79}$Au	1.00958	1.01567
$_{7}$N	1.000325	1.0003332	$_{31}$Ga	1.00262	1.002888	$_{55}$Cs	1.00576	1.007325	$_{80}$Hg	1.00974	1.01612
$_{8}$O	1.000395	1.0004059	$_{32}$Ge	1.00274	1.003031	$_{56}$Ba	1.00590	1.007563	$_{81}$Tl	1.00992	1.01663
$_{9}$F	1.000464	1.0004844	$_{33}$As	1.00286	1.003177	$_{57}$La	1.00606	1.007810	$_{82}$Pb	1.01008	1.01717
$_{10}$Ne	1.000547	1.0005693	$_{34}$Se	1.00297	1.003327	$_{58}$Ce	1.00620	1.008075	$_{83}$Bi	1.0102	1.01772
$_{11}$Na	1.000629	1.0006495	$_{35}$Br	1.00309	1.003479	$_{59}$Pr	1.00635	1.008341	$_{84}$Po	1.0104	1.01829
$_{12}$Mg	1.000710	1.0007322	$_{36}$Kr	1.00322	1.003635	$_{60}$Nd	1.00651	1.008615	$_{85}$At	1.0106	1.01889
$_{13}$Al	1.000795	1.0008172	$_{37}$Rb	1.00334	1.003790	$_{61}$Pm	1.00666	1.008897	$_{86}$Rn	1.0107	1.01952
$_{14}$Si	1.000881	1.0009056	$_{38}$Sr	1.00346	1.003950	$_{62}$Sm	1.00683	1.009188	$_{87}$Fr	1.0109	1.02016
$_{15}$P	1.000970	1.0009975	$_{39}$Y	1.00359	1.004114	$_{63}$Eu	1.00698	1.009487	$_{88}$Ra	1.0111	1.02082
$_{16}$S	1.00106	1.001093	$_{40}$Zr	1.00372	1.004282	$_{64}$Gd	1.00714	1.009789	$_{89}$Ac	1.0112	1.02151
$_{17}$Cl	1.00115	1.001191	$_{41}$Nb	1.00385	1.004456	$_{65}$Tb	1.00729	1.010094	$_{90}$Th	1.0114	1.02224
$_{18}$A	1.00124	1.001294	$_{42}$Mo	1.00398	1.004633	$_{66}$Dy	1.00746	1.01043	$_{91}$Pa	1.0116	1.0229‡
$_{19}$K	1.00133	1.001394	$_{43}$Tc	1.00413	1.004815	$_{67}$Ho	1.00762	1.01076	$_{92}$U	1.0117	1.0236‡
$_{20}$Ca	1.00142	1.001495	$_{44}$Ru	1.00427	1.005000	$_{68}$Er	1.00778	1.01110	$_{93}$Np	1.0119‡	1.0244‡
$_{21}$Sc	1.00151	1.001602	$_{45}$Rh	1.00440	1.005194	$_{69}$Tm	1.00794	1.01146	$_{94}$Pu	1.0121‡	1.0251‡
$_{22}$Ti	1.00161	1.001716	$_{46}$Pd	1.00454	1.005389	$_{70}$Yb	1.00810	1.01183	$_{95}$Am	1.0122‡	1.0258‡
$_{23}$V	1.00171	1.001834	$_{47}$Ag	1.00467	1.005586	$_{71}$Lu	1.00827	1.01220	$_{96}$Cm	1.0124‡	1.0265‡
$_{24}$Cr	1.00181	1.001956	$_{48}$Cd	1.00480	1.005789	$_{72}$Hf	1.00844	1.01259	$_{97}$Bk	1.0125‡	1.0274‡
						$_{73}$Ta	1.00860	1.01298			

† For a spherical sample of water the factor is 1.0000260 [66My01]

‡ Value obtained by graphic extrapolation

Hyperfine-structure anomaly Values of magnetic moments calculated from ratios of hyperfine-structure constants do not include a hyperfine-structure anomaly correction. This correction can range from zero to about 1% [70FuCo]. Some authors include a 1% uncertainty in the value of the magnetic moment to take account of this possible correction.

Q-values The value of the quadrupole moment given is that quoted by the experimenter. The uncertainty may be as much as 50% or more because of the difficulties in estimating the electric field inhomogeneity at the nucleus, arising from the molecular and electronic environment, and the effect of the polarization of the electron core. Values marked by an asterisk, *, indicate that the experimenter has made some Sternheimer or polarization corrections in computing the moment. For papers on Sternheimer corrections for specific atoms and ions, see [50St32, 51St93, 54Fo28, 54St11, 56St50, 57St39, 63St22, 66St23, 71St12, 71St44].

Compounds In general, standard chemical notation is used with the exception of using an italicized number for the waters of crystallization and an italicized chemical symbol for an element which is replaced in a doped material. Some specific abbreviations have been used for the following compounds:

CMN – cerium magnesium nitrate
NES – neodymium ethyl sulphate
*x*IG – *x* iron garnet.

3. Abbreviations

A– ashta–, 10^{+18}, an abbreviation of the Sanskrit for eighteen

ABMR atomic beam magnetic resonance

a– atto–, 10^{-18}

$a;A,B$	magnetic dipole interaction constant, given in MHz; cm^{-1} respectively. See introduction to Table F, equation (2) for definition of a.
B_o	resonance magnetic field for stroboscopic observation of perturbed angular correlation
b	electric quadrupole interaction constant, given in MHz. See introduction to Table F, equation (3) for definition of b.
CEx	Coulomb excitation
CMN	cerium magnesium nitrate, $Ce_2Mg_3(NO_3)_{12} \cdot 24H_2O$
c	magnetic octupole interaction constant, given in MHz. See introduction to Table F, equation (4) for definition of c.
DR	optical double resonance
d	day
ENDOR	electron–nuclear double resonance
eqQ	electric quadrupole coupling constant Note: This quantity has the dimensions of energy. However, in microwave and radiofrequency experiments it is customary to refer to it in units of MHz and in atomic spectra experiments, in units of cm^{-1}. To obtain proper energy units one should multiply the given values by h or hc, respectively.
eq_4Q_4	electric hexadecapole interaction constant Note: This quantity, which is an energy difference, is expressed for convenience in units of MHz in radiofrequency experiments. It is understood that one must multiply the values given by h to convert to energy units.
F	total atomic angular momentum, $F=I+J$
F	Fermi, 10^{-13}cm
f–	femto–, 10^{-15}
G–	giga–, 10^{+9}
G, G_2, G_4	angular correlation attenuation coefficients
g or g_I	nuclear g–factor, μ/I
g_J	electronic g–factor of the atom, μ_J/J
g_S	electronic spin g–factor
gs	ground state
H	magnetic field strength. In most of the tables H has been given in gauss. The SI (Système International) unit for the magnetic field, the tesla, corresponds to 10^4 gauss
H_o	external or applied magnetic field
H_{hf}	hyperfine magnetic field
H_{int}, H_{eff}	internal or effective magnetic field at the nucleus

H_{res}	magnetic field at resonance
h	hour
hfs	hyperfine structure
I	nuclear angular momentum or spin
J–	jitu–, 10^{+15}, from the Swahili for giant
J	total electronic angular momentum
K	Knight shift correction
k–	kilo–, 10^{+3}
k	Boltzmann constant, (1.38062 *6*)$\times 10^{-23}$J/°K [69TaPa]
LX	level crossing
M–	mega–, 10^{+6}
M_{22}	quadrupole matrix element for the 2+ state, $\langle 2+\|\|ME2\|\|2+\rangle$
m–	milli–, 10^{-3}
m	minute
m_I, m_J	magnetic quantum number, projection on H of I and J, respectively
NES	neodymium ethyl sulphate, $Nd(C_2H_5SO_4)_3 \cdot 9H_2O$
NMR	nuclear magnetic resonance
n–	nano–, 10^{-9}
nm	nuclear magneton
OP	optical pumping
P, P', P''	electric quadrupole interaction constants, given in cm^{-1} in paramagnetic resonance measurements
p–	pico–, 10^{-12}
Q	nuclear electric quadrupole moment

This quantity exists only for nuclei with $I \geqslant 1$ and is defined by

$$eQ = \int \rho r^2 (3 \cos^2\theta - 1) dV$$

where ρ is the nuclear charge density, and r and θ are the radial and polar coordinates of a volume element, dV, referred to the nuclear center and axis of symmetry.

Q_o	intrinsic quadrupole moment
Q_{rot}	rotational quadrupole moment

Q_4	nuclear electric hexadecapole moment This quantity exists only for nuclei with $I \geqslant 2$ and is defined by $$eQ_4 = \int \rho r^4 (35 \cos^4\theta - 30 \cos^2\theta + 3) dV$$ where ρ is the nuclear charge density, and r and θ are the radial and polar coordinates of a volume element, dV, referred to the nuclear center and axis of symmetry.
q	$-\partial E_Z / \partial z$, the first derivative, evaluated at the nucleus, of the electric field along the axis of the molecule or atom
q_4	$-\partial^3 E_Z / \partial z^3$, the third derivative, evaluated at the nucleus, of the electric field along the axis of the molecule or atom
SE	spin exchange
s	second
T−	tera−, 10^{+12}
T	temperature
T_o	repetition period for stroboscopic measurements
$T_{1/2}$	half−life
t_{ave}	mean time of observation
X	magnetic field attenuation coefficient, defined in terms of the G's [62Go17]
xIG	x iron garnet, $Fe_3 x_2^{3+} (SiO_4)_3$
y	year
β	paramagnetic correction factor, $H = \beta H_o$
γ_p	gyromagnetic ratio of the proton, $\gamma_p = \omega_{Larmor}/H = 4\pi\mu_p/h$
$\Delta, \Delta E$	energy splitting at low temperature, $\Delta = g\mu_N H/k$
$\Delta\theta$	total angular shift for static and transient fields, $\Delta\theta = \int_o^t \omega dt' = \omega\tau + \phi_t$
μ−	micro−, 10^{-6}
μ	nuclear magnetic dipole moment This quantity exists only for nuclei with $I \geqslant 1/2$ and is defined by $$\mu = -\int r \cos\theta \operatorname{div} M \, dV$$ where M is the total magnetic moment density due to the currents and spins in the nucleus, and r and θ are the radial and polar coordinates of a volume element, dV, referred to the nuclear center and axis of symmetry.
μ_B	Bohr magneton, $he/4\pi m_e c = (9.27410\ 6) 10^{-24} J{\cdot}T^{-1}$[69TaPa]
μ_B/μ_N	ratio of Bohr magneton to nuclear magneton, $\mu_B/\mu_N = M_p/m_e = 1836.109\ 11$[69TaPa]
μ_N	nuclear magneton, $he/4\pi M_p c = (5.05095\ 5) \times 10^{-27} J{\cdot}T^{-1}$[69TaPa]

μ_J electronic magnetic moment

ν resonant frequency, $\Delta E/h$; $\omega/2\pi$

$\Delta\nu$ hyperfine–structure splitting
This quantity in rf resonance literature is defined as $\Delta\nu=\Delta W/h$ in units of Hertz where ΔW is the energy separation between adjacent F–states in the absence of an external field. In optical spectroscopy it is defined by $\Delta\nu=\Delta W/hc$ in cm^{-1}(Kaysers).

σ diamagnetic correction factor, see Policies.

τ mean life, $T_{1/2} = \tau \ln 2 = 0.693\tau$

τ_c collision life–time, τ_c=mean free path/ recoil velocity

ϕ_t total transient–field angular shift

Ω nuclear magnetic octupole moment
This quantity exists only for nuclei with $I \geqslant 3/2$ and is defined by

$$\Omega=(1/2)\int r^3(5\cos^3\theta-3\cos\theta)\mathrm{div}M\ dV,$$

where M is the total magnetic moment density due to the currents and spins in the nucleus and r and θ are the radial and polar coordinates of a volume element, dV, referred to the nuclear center and axis of symmetry.

$\omega, \omega_{\mathrm{Larmor}}$ Larmor angular precession frequency, $2\pi\mu H/hI$ or $2\pi g H\mu_N/h$

ω_o quadrupole resonance angular frequency, $\omega_o=[3/4I(2I-1)]\omega_Q$ for integer I and $\omega_o=[3/2I(2I-1)]\omega_Q$ for half–integer I

ω_Q quadrupole interaction frequency, $\omega_Q=2\pi eqQ/h$

$\omega\tau$ angular shift of the angular correlation or distribution in the presence of a magnetic field

ω_p/ω_{cyc} ratio of the nuclear magnetic resonance frequency of the proton to the cyclotron frequency of the proton
This ratio is equal to the value of the magnetic moment of the proton in the nuclear magnetons.

ω_e/ω_p ratio of the cyclotron frequency of a free electron to the nuclear magnetic resonance frequency of the proton
The reciprocal of this ratio is equal to the value of the proton magnetic moment in Bohr magnetons.

4. Summary of Nuclear Moment Values and Index

Introduction

In this table, a value is given for every nuclear moment for which a measured value has been tabulated in the separate tables. The index letter, under the column headed 'Index', indicates the table in which the measured moment values and auxiliary quantities will be found. Since the individual tables list data for a particular measuring technique, the index also forms a code for the techniques by which moment information has been obtained.

In arriving at summary values of magnetic moments there has been no attempt to average all existing results since the spread of values is not always due to statistical fluctuations but often depends on the circumstances of the measurements. Certain techniques give more reliable results. These are listed below along with the major associated problems, enclosed in ( )'s.

ABMR by direct measurement, doublet separation, or triple resonance (configuration mixing)

ENDOR using materials for which the paramagnetic shielding is small (paramagnetic shielding)

OP (configuration mixing)

NMR using the most ionic materials or extrapolating to zero density or concentration (chemical shifts, Knight shifts for metals)

When the quoted experimental uncertainties and the differences between quoted values are of the same order to magnitude, a weighted average was made:

$$A = \sum_{i=1}^{n} e_i^{-2} (A_i) \,/\, \sum_i e_i^{-2},$$

where e_i is the quoted uncertainty in the quantity A_i. The uncertainty in the value A was then taken as the larger of the internal or external error:

$$e_{\mathrm{internal}} = (\sum_i e_i^{-2})^{-1/2},$$

$$e_{\mathrm{external}} = [(\sum_i e_i^{-2} (A_i - A)^2) \,/\, (\mathrm{n} - 1) (\sum_i e_i^{-2})]^{1/2}.$$

The arithmetic average, with an uncertainty given by one standard deviation, was used when the quoted uncertainties in the individual measurements are smaller than ($\approx$ or $<$ 1/10) the differences between the quoted values.

No attempt has been made to estimate uncertainties arising from chemical shifts or configuration mixing. Although these could be as large as 1%, most are of the order of 0.01% or less. No uncertainty is assumed for μ_p. In the summary table the uncertainty is in the last significant figure. The values quoted include the diamagnetic correction which is also tabulated.

For several nuclei the μ–values obtained by two different methods are very consistent but large discrepancies exist between the two sets of values, for example between NMR and OP measurements. Both values are now listed and footnoted. For most purposes, an arithmetic average of the two values could be used. For relative NMR measurements, the NMR–value would give a better measure of the effective moment. (It is interesting to note that the discrepancy between the NMR and OP magnetic moment values for the II–B elements, Zn, Cd, Hg, varies almost linearly with Z.)

It is not simple to estimate the accuracy of a particular quadrupole moment because the value of a quadrupole moment derived from an interaction constant depends upon the assumptions made concerning the electronic configurations, the Sternheimer effect or polarization of the electron distribution by a nonspherical nuclear charge distribution (nuclear quadrupole moment), and the molecular binding. Uncertainties, arising from incomplete knowledge of the molecular binding, may be as large as 50%. Corrections for polarization effects can be of the order of 10–20%, although some have been calculated to be as large as 50%, for example for the 3d configuration of Sc. To obtain the summary value, an average of the data for a particular isotope of an element has been made. This average value is indicated by a superscript "s". The values of the quadrupole moment of the other isotopes of that element, marked by a superscript "r", were calculated using this average and the more accurately determined quadrupole moment ratios.

Magnetic octupole and electric hexadecapole moments have also been included in the summary list.

A few values of Q, Ω, Q_4 have been tabulated which have been derived from electron–scattering experiments. These are model–dependent and are indicated by brackets, [ ], surrounding the value.

Explanation of the Summary Table

Nucleus Chemical symbol with Z–, A–, and N–numbers

Level The energy of the nuclear level, in keV, given to identify the level for which nuclear moment information is presented

Values have been taken from the Nuclear Data Sheets (through B5), Table of Isotopes [67LeHo] or the experimenter's quoted value.

$T_{1/2}$ The half–life of the radioactive nucleus or excited level

Values have been taken from Marelius [68Ma49], Nuclear Data Sheets (through B5), Table of Isotopes [67LeHo] or the experimenter's value.

See Abbreviations for definitions of prefix–symbols used with units.

I Nuclear spin or angular momentum in units of $h/2\pi$

Values enclosed in brackets, [ ], were not determined by spectroscopic or resonance measurements but were assumed in order to interpret data.

μ Nuclear magnetic moments in nuclear magnetons, with diamagnetic correction

When ratios are given, the level–energy of the reference isotope, in keV, is indicated by a subscript.

Diam. Corr. The diamagnetic correction which was added to the last significant figure of the uncorrected magnetic dipole moment to get the value quoted in the previous column

For example, for Li^6, $\mu = \mu_{\text{uncorrected}} +$ Diam. corr. = +0.82195 + 0.00008 = +0.82203

Q Nuclear electric quadrupole moment in barns

Values marked by "s" are averages of the Q–values listed in the individual tables.

Those marked by "r" have been calculated by use of Q^s and measured Q–ratios.

Values marked by "*" include polarization or Sternheimer corrections.

Values enclosed in brackets, [ ], are derived from electron–scattering experiments and are model–dependent.

When two values of Q are listed, the first refers to the value determined by Coulomb excitation reorientation assuming constructive interference and the second, destructive interference of the matrix elements.

When ratios are given, the level–energy of the reference isotope, in keV, is indicated by a subscript.

Ω Nuclear magnetic octupole moment in nm–barns

Values enclosed in brackets, [ ], are derived from electron–scattering experiments and are model–dependent.

Q_4 Nuclear electric hexadecapole moment in barns^2

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† For early data see [69FuCo]. See J. Stevens, J. Phys. Chem. Ref. Data 5, 1093 (1976), for recent data and evaluation.

Summary of Nuclear Moment Values and Index

Nucleus	Level (keV)	$T_{1/2}$	I ($h/2\pi$)	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{1}_{0}n_{1}$		12m	1/2	−1.91312					A
$^{1}_{1}\bar{H}_{0}$				−1.8					A
$^{1}_{1}H_{0}$			1/2	+2.79278^{j}	8				A B F G H
$^{2}_{1}H_{1}$			1	+0.85742	2	+0.0028			E F G H
$^{3}_{1}H_{2}$		12y	1/2	+2.9789	1				E F G H
$^{3}_{2}He_{1}$			1/2	−2.1276	1				E F G H
$^{3}_{2}He^{+}_{1}$			1/2						F H
$^{4}_{2}He_{2}$			0						G
$^{6}_{2}He_{4}$		0.8s	0♦						F
$^{6}_{3}Li_{3}$			1	+0.82203	8	−0.0008^{r}			E F H
$^{6}_{3}Li^{+}_{3}$			1						H
$^{7}_{3}Li_{4}$			3/2	+3.25636	33	−0.04^{S}	[+0.09]		E F G H K
$^{8}_{3}Li_{5}$		0.8s	2	+1.6532	2				E H J
$^{9}_{4}Be_{5}$			3/2	−1.17745	18	+0.05	[−0.04]		E F K
$^{8}_{5}B_{3}$		770ms	[2]	±1.0355^{p}	2				E J
$^{10}_{5}B_{5}$			3	+1.8006	4	+0.085*^{r}	[<±0.03]		C D E F J K
$^{10}_{5}B_{5}$	720	0.7ns	[1]	+0.6					J
$^{11}_{5}B_{6}$			3/2	+2.6885	5	+0.041*^{S}	[+0.08]		C D E F J K
$^{12}_{5}B_{7}$		20.4ms	1	+1.0028^{g}		+0.018			E J
$^{13}_{5}B_{8}$		19ms	[3/2]	±3.1771^{g}		±0.05			E J
$^{11}_{6}C_{5}$		21m	3/2	(−?)0.99		(+?)0.031*			F
$^{12}_{6}C_{6}$			0						G
$^{13}_{6}C_{7}$			1/2	+0.7024	2				E F G
$^{14}_{6}C_{8}$		5.6ky	0						G
$^{12}_{7}N_{5}$		12ms	1	±0.457					E J
$^{13}_{7}N_{6}$		10m	1/2	±0.3221	1				F
$^{14}_{7}N_{7}$			1	+0.40375	13	+0.01			C E F G H
$^{14}_{7}N_{7}$	5830	12.4ps	[3]	±1.5 to 2.6					J
$^{15}_{7}N_{8}$			1/2	−0.2831	1				E F G H
$^{15}_{8}O_{7}$		2.1m	1/2	±0.7189	3				F
$^{16}_{8}O_{8}$			0						G
$^{17}_{8}O_{9}$			5/2	−1.8937	7	−0.026*			B C E
$^{18}_{8}O_{10}$			0						C
$^{18}_{8}O_{10}$	1980	3.3ps	[2]	±0.4 to 0.7					J
$^{17}_{9}F_{8}$		66s	[5/2]	±4.722	2				E J
$^{18}_{9}F_{9}$	1125	153ns	[5]	+2.85					J
$^{19}_{9}F_{10}$			1/2	+2.6288	12				B C E F G H
$^{19}_{9}F_{10}$	197	89ns	[5/2]	+3.60		±0.11^{S}			J
$^{20}_{9}F_{11}$		11s	[2]	+2.094	1	±0.06^{r}			E J
$^{19}_{10}Ne_{9}$		18s	1/2	−1.887	1				F
$^{19}_{10}Ne_{9}$	238	17.7ns	[5/2]	−0.74					J
$^{20}_{10}Ne_{10}$			0♦						F G
$^{20}_{10}Ne_{10}$	1630	0.7ps	[2]			−0.25			K
$^{21}_{10}Ne_{11}$			3/2	−0.66176	36	+0.09			F G
$^{22}_{10}Ne_{12}$			0♦						G
$^{22}_{10}Ne_{12}$	1275	3ps	[2]			−0.21			K
$^{23}_{10}Ne_{13}$		38s	[5/2]	−1.08					F

Summary of Nuclear Moment Values and Index – Continued

Nucleus	Level (keV)	$T_{1/2}$	I $(h/2\pi)$	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{20}_{11}\mathrm{Na}_{9}$		408ms	2	±0.369					H J
$^{21}_{11}\mathrm{Na}_{10}$		23s	3/2	+2.3861	15				F H
$^{22}_{11}\mathrm{Na}_{11}$		2.6y	3	+1.746	1				F
$^{22}_{11}\mathrm{Na}_{11}$	583	243ns	[1]	+0.55					J
$^{23}_{11}\mathrm{Na}_{12}$			3/2	+2.21740[f] (+2.21755)	139	+0.10*			E F G H
$^{24}_{11}\mathrm{Na}_{13}$		15h	4	+1.690	1				F
$^{24}_{12}\mathrm{Mg}_{12}$			0♦						G
$^{24}_{12}\mathrm{Mg}_{12}$	1368	1ps	[2]			−0.27			K
$^{25}_{12}\mathrm{Mg}_{13}$			5/2	−0.8554	6	+0.22			B E F G
$^{26}_{12}\mathrm{Mg}_{14}$			0♦						G
$^{27}_{13}\mathrm{Al}_{14}$			5/2	+3.6413	29	+0.15*[b]	[±0.3]		E F G H K
$^{28}_{14}\mathrm{Si}_{14}$			0♦						C E
$^{28}_{14}\mathrm{Si}_{14}$	1779	0.5ps	[2]				+0.17		K
$^{29}_{14}\mathrm{Si}_{15}$			1/2	−0.55526	49				C E
$^{30}_{14}\mathrm{Si}_{16}$			0♦						C
$^{29}_{15}\mathrm{P}_{14}$		4.2s	[1/2]	±1.235	1				E J
$^{30}_{15}\mathrm{P}_{15}$		2.6m	1						F
$^{31}_{15}\mathrm{P}_{16}$			1/2	+1.1317	11				B C E F G
$^{32}_{15}\mathrm{P}_{17}$		14d	1	−0.2523	2				B
$^{32}_{16}\mathrm{S}_{16}$			0						G
$^{32}_{16}\mathrm{S}_{16}$	2237	0.25ps	[2]			−0.2			K
$^{33}_{16}\mathrm{S}_{17}$			3/2	+0.6435	7	−0.055[S]			C D E
$^{34}_{16}\mathrm{S}_{18}$			0♦						C
$^{35}_{16}\mathrm{S}_{19}$		87d	3/2	+1.00 or −1.07		+0.038[r]			C D
$^{36}_{16}\mathrm{S}_{20}$			0♦						C
$^{35}_{17}\mathrm{Cl}_{18}$			3/2	+0.82181	94	−0.10*[S]	−0.016*[S]		C D E F
$^{36}_{17}\mathrm{Cl}_{19}$		0.3My	2	+1.2853	14	−0.021*[r]			C E
$^{37}_{17}\mathrm{Cl}_{20}$			3/2	+0.68407	78	−0.079*[r]	−0.013*[r]		C D E F
$^{35}_{18}\mathrm{Ar}_{17}$		1.8s	[3/2]	+0.632[g]					F
$^{36}_{18}\mathrm{Ar}_{18}$			0♦						G
$^{36}_{18}\mathrm{Ar}_{18}$	1980	?	[2]			+0.11			K
$^{37}_{18}\mathrm{Ar}_{19}$		34d	3/2	+0.95					G
$^{37}_{18}\mathrm{Ar}_{19}$	1610	4.5ns	[7/2]	−1.33					J
$^{38}_{18}\mathrm{Ar}_{20}$			0♦						G
$^{39}_{18}\mathrm{Ar}_{21}$		265y	7/2	−1.3					G
$^{40}_{18}\mathrm{Ar}_{22}$			0♦						G
$^{40}_{18}\mathrm{Ar}_{22}$	1460	0.8ps	[2]			~0			K
$^{36}_{19}\mathrm{K}_{17}$		245ms	2	±0.548	1				H J
$^{37}_{19}\mathrm{K}_{18}$		1.2s	3/2	+0.2032	3				H
$^{37}_{19}\mathrm{K}_{18}$	1380	10.5ns	[7/2]	+5.2					J
$^{38}_{19}\mathrm{K}_{19}$		7.7m	3	+1.374	2				F
$^{39}_{19}\mathrm{K}_{20}$			3/2	+0.39143[f] (+0.39147)	52	+0.049*[S]			E F G H
$^{40}_{19}\mathrm{K}_{21}$		1.3Gy	4	−1.2981	17	−0.061*[r]			D F H
$^{41}_{19}\mathrm{K}_{22}$			3/2	(+0.21487)[f]	28	+0.060*[r]			E F H
$^{41}_{19}\mathrm{K}_{22}$	1290	7.3ns	[7/2]	+4.41					J

Summary of Nuclear Moment Values and Index — Continued

Nucleus	Level (keV)	$T_{1/2}$	I ($h/2\pi$)	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{42}_{19}K_{23}$		12h	2	−1.1424	15				F
$^{43}_{19}K_{24}$		22h	3/2	±0.163					F
$^{45}_{19}K_{26}$		20m	3/2	±0.1734	2				F
$^{40}_{20}Ca_{20}$			0^{+}						G
$^{40}_{20}Ca_{20}$	3740	41ps	[3]	$+0.4^{P}$					J
$^{40}_{20}Ca_{20}$	4490	272ps	[5]	$+1.6^{P}$					J
$^{41}_{20}Ca_{21}$		110ky	7/2	−1.5946	23				E
$^{42}_{20}Ca_{22}$	3190	5.5ns	[6]	−2.8					J
$^{43}_{20}Ca_{23}$			7/2	−1.3172	19	<±0.2			E F G H
$^{41}_{21}Sc_{20}$		0.59s	[7/2]	$±5.43^{P}$	1				E J
$^{43}_{21}Sc_{22}$		3.9h	7/2	+4.62	1	-0.26^{r}			F
$^{43}_{21}Sc_{22}$	3123	450ns	[19/2]	+3.14					J
$^{44}_{21}Sc_{23}$		3.9h	2	+2.56		$+0.11^{r}$			F
$^{44}_{21}Sc_{23}$	69	153ns	[1]	+0.34		±0.18*			J
$^{44}_{21}Sc_{23}$	270	2.4d	6	+3.88	1	-0.20^{r}			F
$^{45}_{21}Sc_{24}$			7/2	+4.7559	72	-0.22^{S}			E F G
$^{46}_{21}Sc_{25}$		84d	4	+3.03		$+0.12^{r}$			F
$^{47}_{21}Sc_{26}$		3.4d	7/2	+5.34	1	-0.22^{r}			F
$^{47}_{21}Sc_{26}$	767	274ns	[3/2]	±0.35					J
$^{48}_{21}Sc_{27}$		1.8d	6						F
$^{45}_{22}Ti_{23}$		3.1h	7/2	±0.095		$\sim±0.02^{r}$ μ/Q positive			F
$^{46}_{22}Ti_{24}$	889	7ps	[2]			−0.2			K
$^{47}_{22}Ti_{25}$			5/2	−0.78846	127	$+0.29^{S}$			B E F
$^{48}_{22}Ti_{26}$	983	3.6ps	[2]			−0.20			K
$^{49}_{22}Ti_{27}$			7/2	−1.10414	177	$+0.24^{r}$			B E F
$^{50}_{22}Ti_{28}$	1550	1ps	[2]			~0			K
$^{47}_{23}V_{24}$		31m	3/2						F
$^{48}_{23}V_{25}$		16d	4	±1.6					F J
$^{48}_{23}V_{25}$	306	7.09ns	[2]	+0.38					J
$^{49}_{23}V_{26}$		330d	7/2	$±4.5^{P}$					B
$^{50}_{23}V_{27}$		>40Jy	6	+3.3470	57	±0.06			B E
$^{51}_{23}V_{28}$			7/2	+5.1485	88	-0.05^{b}			B E F G
$^{51}_{23}V_{28}$	320	173ps	[5/2]	+4.0					J
$^{49}_{24}Cr_{25}$		42m	5/2	±0.476	1				F
$^{50}_{24}Cr_{26}$	783	8.4ps	[2]			−0.3			K
$^{51}_{24}Cr_{27}$		28d	7/2	±0.934	2				F
$^{51}_{24}Cr_{27}$	749	7.5ns	[3/2]	±1.1					J
$^{52}_{24}Cr_{28}$	1434	0.90ps	[2]			[−0.08]			K
$^{53}_{24}Cr_{29}$			3/2	-0.4735^{E} (−0.4744)	9	+0.03			B E F H K
$^{54}_{24}Cr_{30}$	834	8.9ps	[2]			−0.1			K
$^{51}_{25}Mn_{26}$		45m	5/2	$±3.56^{E}$					F
$^{52}_{25}Mn_{27}$		5.7d	6	$+3.059^{E}$	6	$+0.6^{r}$			B E F J
$^{52}_{25}Mn_{27}$	383	21m	2	±0.0076					F
$^{53}_{25}Mn_{28}$		2My	7/2	$±5.02^{E}$	1				B
$^{54}_{25}Mn_{29}$		312d	3	$+3.278^{E}$	6	$+0.4^{r}$			B E J
$^{55}_{25}Mn_{30}$			5/2	$+3.449^{E}$ (+3.4680)	7 66	$+0.4^{S}$			B C E F G H
$^{56}_{25}Mn_{31}$		2.6h	3	$+3.223^{E}$	6				F J

Summary of Nuclear Moment Values and Index – Continued

Nucleus	Level (keV)	$T_{1/2}$	I $(h/2\pi)$	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{54}_{26}Fe_{28}$	1408	1.0ps	[2]	+2.9					J
$^{54}_{26}Fe_{28}$	2950	1.22ns	[6]	±8.2					J
$^{56}_{26}Fe_{30}$	847	6.9ps	[2]	+1.2		−0.26			J K
$^{57}_{26}Fe_{31}$			1/2	+0.09042^{E}	18				B E F K
				(+0.09060)					
$^{57}_{26}Fe_{31}$	14.4	~10ns	[3/2]	−0.1550	3	+0.19*			I
$^{57}_{26}Fe_{31}$	136	8.8ns	[5/2]	+0.92					I J
$^{57}_{26}Fe_{31}$	367	7ps	[3/2]	<0.5					I J
$^{57}_{26}Fe_{31}$	707	3ps	[5/2]	<±1					J
$^{58}_{26}Fe_{32}$	811	6.4ps	[2]	+1.1					J
$^{59}_{26}Fe_{33}$		45d	3/2	±1.1					F J
$^{55}_{27}Co_{28}$		18h	[7/2]	±4.5					J
$^{56}_{27}Co_{29}$		77d	4	±3.83	1				B
$^{57}_{27}Co_{30}$		270d	7/2	+4.72	1	+0.5^{r}			B E J
$^{57}_{27}Co_{30}$	1378	19.4ps	[3/2]	+3					J
$^{58}_{27}Co_{31}$		71.3d	2	+4.04	1	+0.2^{r}			B E J
$^{58}_{27}Co_{31}$	54	10.2μs	[4]	+4.18					J
$^{59}_{27}Co_{32}$			7/2	+4.616	10	+0.38^{S}			B E F G
$^{59}_{27}Co_{32}$	1292	564ps	[3/2]	+1.8					J
$^{60}_{27}Co_{33}$		5.26y	5	+3.79	1	+0.4^{r}			B E J
$^{60}_{27}Co_{33}$	58	10.5m	2	+4.4		+0.3^{r}			F
$^{58}_{28}Ni_{30}$	1450	0.67ps	[2]			−0.14			K
$^{60}_{28}Ni_{32}$	1330	0.80ps	[2]			[−0.10]			K
$^{61}_{28}Ni_{33}$			3/2	−0.7498	17	+0.16*			B E F G
$^{61}_{28}Ni_{33}$	68	5.2ns	[5/2]	+0.42					I
$^{62}_{28}Ni_{34}$	1170	1.57ps	[2]			+0.2			K
$^{63}_{28}Ni_{35}$	87.2	1.72μs	[5/2]	+0.752^{g}					J
$^{64}_{28}Ni_{36}$	1350	0.78ps	[2]			+0.3			K
$^{60}_{29}Cu_{31}$		24m	2	+1.219	3				F
$^{61}_{29}Cu_{32}$		3.3h	3/2	+2.13					F
$^{62}_{29}Cu_{33}$		9.9m	1	−0.380	1				F
$^{62}_{29}Cu_{33}$	41	4.80ns	[2]	±1.3					J
$^{62}_{29}Cu_{33}$	390	11.5ns	[3]	±1.9					J
$^{63}_{29}Cu_{34}$			3/2	+2.2228^{f}	53	−0.211*^{r}			B D E F G H
				(+2.2262)					
$^{64}_{29}Cu_{35}$		13h	1	−0.216					F
$^{64}_{29}Cu_{35}$	1590	20.4ns	[6]	+1.04					J
$^{65}_{29}Cu_{36}$			3/2	+2.3812^{f}	57	−0.195*^{S}			B D E F G H
				(+2.3849)					
$^{66}_{29}Cu_{37}$		5.2m	1	−0.281	1				F
$^{66}_{29}Cu_{37}$	1154	596ns	[6]	+1.04					J
$^{63}_{30}Zn_{33}$		38m	3/2	−0.2816	7	+0.29^{r}			H
$^{64}_{30}Zn_{34}$			0♦						G
$^{64}_{30}Zn_{34}$	992	2.7ps	[2]			[−0.14]			K
$^{65}_{30}Zn_{35}$		245d	5/2	+0.7692	19	−0.024^{r}			H
$^{66}_{30}Zn_{36}$			0♦						G
$^{67}_{30}Zn_{37}$			5/2	+0.87524^{d}	218	+0.16^{S}			E F G H
				(+0.8756)	22				
$^{67}_{30}Zn_{37}$	185	1.01ns	[3/2]	+0.4					J
$^{67}_{30}Zn_{37}$	605	340ns	[9/2]	−1.09					J
$^{68}_{30}Zn_{38}$			0♦						G
$^{70}_{30}Zn_{40}$	884	3ps	[2]			[−0.2]			K

Summary of Nuclear Moment Values and Index – Continued

Nucleus	Level (keV)	$T_{1/2}$	I $(h/2\pi)$	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{66}_{31}Ga_{35}$		9.5h	0♦						F
$^{67}_{31}Ga_{36}$		78h	3/2	+1.849^{f}	5	+0.22^{r}			F
$^{68}_{31}Ga_{37}$		68m	1	±0.0117		±0.031^{r}			F
$^{69}_{31}Ga_{38}$			3/2	+2.0145^{f} (+2.0161)	53	+0.19^{S}	+0.14		C D E F G
$^{70}_{31}Ga_{39}$		21m	1						F
$^{71}_{31}Ga_{40}$			3/2	+2.5597^{f} (+2.5617)	67	+0.12^{r}	+0.18		C D E F G
$^{72}_{31}Ga_{41}$		14h	3	−0.1321^{f}	3	+0.59^{r}			F
$^{67}_{32}Ge_{35}$	734	70ns	[9/2]	−0.94		Q/Q^{69}_{398}=1.22			J
$^{69}_{32}Ge_{37}$		38h	5/2	±0.73		±0.03^{r} μ/Q positive			F
$^{69}_{32}Ge_{37}$	398	3μs	[9/2]	−1.001	3				J
$^{70}_{32}Ge_{38}$			0♦						C
$^{70}_{32}Ge_{38}$	1040	1.3ps	[2]	+1.8		~0			J K
$^{71}_{32}Ge_{39}$		11d	1/2	+0.546	1				F
$^{71}_{32}Ge_{39}$	175	79ns	[5/2]	+1.02		Q/Q^{69}_{398}=0.22			J
$^{71}_{32}Ge_{39}$	198	20.2ms	[9/2]	−1.040	3	±0.3			J
$^{72}_{32}Ge_{40}$			0♦						C
$^{72}_{32}Ge_{40}$	835	3.14ps	[2]	+1.2					J
$^{73}_{32}Ge_{41}$			9/2	−0.87918	240	−0.18			C E F
$^{74}_{32}Ge_{42}$			0♦						C
$^{74}_{32}Ge_{42}$	596	12ps	[2]	+0.9		~0			J K
$^{75}_{32}Ge_{43}$		82m	1/2	+0.51					F
$^{76}_{32}Ge_{44}$			0♦						C
$^{76}_{32}Ge_{44}$	563	17.6ps	[2]	+0.7		−0.2;~0			J K
$^{70}_{33}As_{37}$		55m	4						F
$^{72}_{33}As_{39}$		26h	2	±2.2					F
$^{72}_{33}As_{39}$	215	80ns	[3]	+1.58					J
$^{73}_{33}As_{40}$	66.9	5.0ns	[5/2]	+1.6					J
$^{73}_{33}As_{40}$	427	5.8μs	[9/2]	+5.21	1				E J
$^{74}_{33}As_{41}$	274	26.8ns	[3]	+2.43	1				J
$^{75}_{33}As_{42}$			3/2	+1.439	4	+0.29			B C D E F G
$^{75}_{33}As_{42}$	265	11.9ps	[3/2]	+1.0					J
$^{75}_{33}As_{42}$	280	0.28ns	[5/2]	+0.9					J
$^{76}_{33}As_{43}$		26h	2	−0.905	2	±7 8			B F
$^{76}_{33}As_{43}$	45	2.60μs	[1]	+0.559	1				J
$^{77}_{33}As_{44}$	473	116μs	[9/2]	±5.52	1				J
$^{74}_{34}Se_{40}$			0♦						C
$^{75}_{34}Se_{41}$		120d	5/2			+1.0^{r}			C
$^{76}_{34}Se_{42}$			0♦						C G
$^{76}_{34}Se_{42}$	559	11.1ps	[2]	+0.8					J
$^{77}_{34}Se_{43}$			1/2	+0.534	1				C E G
$^{77}_{34}Se_{43}$	249	9.4ns	[5/2]	+1.2					J
$^{77}_{34}Se_{43}$	440	24ps	[5/2]	+1.0					J
$^{78}_{34}Se_{44}$			0						C G
$^{78}_{34}Se_{44}$	614	8.6ps	[2]	+0.8					J
$^{79}_{34}Se_{45}$		60ky	7/2	−1.02		+0.8^{S}			C
$^{80}_{34}Se_{46}$			0						C G
$^{80}_{34}Se_{46}$	666	8.05ps	[2]	+0.8					J
$^{82}_{34}Se_{48}$			0♦						C G
$^{82}_{34}Se_{48}$	655	11.3ps	[2]	+0.9					J

Summary of Nuclear Moment Values and Index — Continued

Nucleus	Level (keV)	$T_{1/2}$	I $(h/2\pi)$	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{76}_{35}Br_{41}$		17h	1	±0.548	2	±0.30*^{r}			F
						μ/Q negative			
$^{77}_{35}Br_{42}$		58h	3/2						F
$^{78}_{35}Br_{43}$	181	100μs	[4]	+4.11	1				E J
$^{79}_{35}Br_{44}$			3/2	+2.1055	65	+0.37*^{S}	+0.09*		C D E F G
$^{80}_{35}Br_{45}$		18m	1	±0.514	2	±0.22*^{r}			F
						μ/Q positive			
$^{80}_{35}Br_{45}$	85	4.5h	5	+1.317	4	+0.84*^{r}			F
$^{81}_{35}Br_{46}$			3/2	+2.2696	70	+0.31*^{r}	+0.10*^{r}		C D E F G
$^{81}_{35}Br_{46}$	540	35μs	[9/2]	±5.77	2				E J
$^{82}_{35}Br_{47}$		36h	5	+1.626	5	±0.84*^{r}			F J
$^{79}_{36}Kr_{43}$	148	77.7ns	[5/2]	+1.12					J
$^{82}_{36}Kr_{46}$			0♦						G
$^{83}_{36}Kr_{47}$			9/2	−0.9703	31	+0.26^{S}	−0.18		E F G
$^{83}_{36}Kr_{47}$	9.3	143ns	[7/2]	−1.8		+0.44^{r}			I J
$^{84}_{36}Kr_{48}$			0♦						G
$^{85}_{36}Kr_{49}$		11y	9/2	±1.005	3	+0.43^{r}			F G
$^{86}_{36}Kr_{50}$			0♦						G
$^{81}_{37}Rb_{44}$		4.7h	3/2	+2.05					F
$^{81}_{37}Rb_{44}$	85	32m	9/2						F
$^{82}_{37}Rb_{45}$	30	6.3h	5	+1.643	6				F
$^{83}_{37}Rb_{46}$		83d	5/2	+1.42					F
$^{84}_{37}Rb_{47}$		33d	2	−1.32					F
$^{85}_{37}Rb_{48}$			5/2	+1.3524^{df}	45	+0.26*^{S}			E F G H
				(+1.3527)					
$^{86}_{37}Rb_{49}$		19d	2	−1.691	6				F
$^{87}_{37}Rb_{50}$		47Gy	3/2	+2.7500^{df}	92	+0.13*^{r}			E F G H
				(+2.7506)					
$^{88}_{37}Rb_{51}$		18m	2	±0.51					F
$^{86}_{38}Sr_{48}$			0♦						G
$^{86}_{38}Sr_{48}$	?	460ns	[8]	−1.9					J
$^{87}_{38}Sr_{49}$			9/2	−1.093	4	+0.3			B E F G H
$^{88}_{38}Sr_{50}$			0♦						G
$^{86}_{39}Y_{47}$	243	28.5ns	[2]	−1.06					J
$^{89}_{39}Y_{50}$			1/2	−0.13733	49				E F G H
$^{90}_{39}Y_{51}$		64h	2	−1.63	1	−0.15			F
$^{91}_{39}Y_{52}$		58d	1/2	±0.164	1				F
$^{90}_{40}Zr_{50}$	3590	130ns	[8]	±10.8					J
$^{91}_{40}Zr_{51}$			5/2	−1.3028	48				E G
$^{91}_{40}Zr_{51}$	>2265	29.0ns	[15/2]	±5.3					J
$^{91}_{41}Nb_{50}$	2378	10.0ns	[17/2]	±10.6					J
$^{93}_{41}Nb_{52}$			9/2	+6.167	24	−0.22			B E G
$^{95}_{41}Nb_{54}$		35d	[9/2]	±6.3					J
$^{92}_{42}Mo_{50}$			0♦						G
$^{92}_{42}Mo_{50}$	2761	190ns	[8]	±11.2					J
$^{94}_{42}Mo_{52}$			0♦						G
$^{94}_{42}Mo_{52}$	2953	97.7ns	[8]	+10.5					J
$^{95}_{42}Mo_{53}$			5/2	−0.9135	36	±0.12			B E G
$^{95}_{42}Mo_{53}$	204	760ps	[3/2]	−0.4					J
$^{96}_{42}Mo_{54}$			0♦						G

Summary of Nuclear Moment Values and Index — Continued

Nucleus	Level (keV)	$T_{1/2}$	I ($h/2\pi$)	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{97}_{42}Mo_{55}$			5/2	−0.9327	37	±1.1			B E G
$^{98}_{42}Mo_{56}$			0♦						G
$^{98}_{42}Mo_{56}$	787	3.5ps	[2]	+0.7					J
$^{100}_{42}Mo_{58}$			0♦						G
$^{100}_{42}Mo_{58}$	536	10ps	[2]	+0.7					J
$^{96}_{43}Tc_{53}$		4.3d	6	±4.6					E J
$^{99}_{43}Tc_{56}$		210ky	9/2	+5.681	23	+0.3			B E G
$^{99}_{43}Tc_{56}$	141	192ps	[7/2]	+5					J
$^{99}_{43}Tc_{56}$	181	3.59ns	[5/2]	+3.3					J
$^{98}_{44}Ru_{54}$	654	5.9ps	[2]	+0.8					J
$^{99}_{44}Ru_{55}$			5/2	−0.62		$\lvert Q/Q_{90}\rvert \leq 0.3$			B G I J
$^{99}_{44}Ru_{55}$	90	20.7ns	3/2	−0.28		$\geq \pm 0.1$			I J
$^{100}_{44}Ru_{56}$	540	11.9ps	[2]	+1.0					J
$^{101}_{44}Ru_{57}$			5/2	−0.68					B G
$^{101}_{44}Ru_{57}$	127	550ps	[3/2]	−0.31					J
$^{102}_{44}Ru_{58}$	475	17.6ps	[2]	+0.74					J
$^{104}_{44}Ru_{60}$	358	58ps	[2]	+0.8					J
$^{100}_{45}Rh_{55}$	74.8	215ns	[2]	+4.32	2				J
$^{103}_{45}Rh_{58}$			1/2	−0.0883	4				E G
$^{103}_{45}Rh_{58}$	93	1.13ns	[9/2]	±6.2					J
$^{103}_{45}Rh_{58}$	298	6.3ps	[3/2]	$+1^{b}$					J
$^{103}_{45}Rh_{58}$	360	59ps	[5/2]	$+1.2^{b}$					J
$^{104}_{46}Pd_{58}$	556	9.7ps	[2]	+0.7		−0.3;∼0			J K
$^{105}_{46}Pd_{59}$			5/2	−0.642	3	+0.8			E F G
$^{106}_{46}Pd_{60}$	512	12.7ps	[2]	+0.73		−0.5;−0.3			J K
$^{106}_{46}Pd_{60}$	1128	2.5ps	[2]	+0.7					J
$^{108}_{46}Pd_{62}$	434	23.8ps	[2]	+0.77		−0.6;−0.4			J K
$^{110}_{46}Pd_{64}$	374	45.8ps	[2]	+0.70		−0.3			J K
$^{101}_{47}Ag_{54}$		9m	9/2						F
$^{102}_{47}Ag_{55}$		13m	5						F
$^{102}_{47}Ag_{55}$	?	7m	2	+4.2					F
$^{103}_{47}Ag_{56}$		66m	7/2	$+4.45^{c}$					F
$^{104}_{47}Ag_{57}$		1.2h	5	+4.0					F
$^{104}_{47}Ag_{57}$	∼20	27m	2	+3.7					F
$^{105}_{47}Ag_{58}$		40d	1/2	±0.101					F
$^{106}_{47}Ag_{59}$		24m	1	+2.9					F
$^{106}_{47}Ag_{59}$	∼300	8.3d	6						F
$^{107}_{47}Ag_{60}$			1/2	−0.1135	5				E F G
$^{107}_{47}Ag_{60}$	325	5.9ps	[3/2]	+0.7					J
$^{107}_{47}Ag_{60}$	423	34ps	[5/2]	+0.9					J
$^{108}_{47}Ag_{61}$		2.4m	1	+2.80	1				F
$^{109}_{47}Ag_{62}$			1/2	−0.1305	6				E F G
$^{109}_{47}Ag_{62}$	88	40s	7/2	±4.3					F
$^{109}_{47}Ag_{62}$	309	5.2ps	[3/2]	+0.9					J
$^{109}_{47}Ag_{62}$	414	33ps	[5/2]	+0.9					J
$^{110}_{47}Ag_{63}$		24.4s	1	+2.72	1				E F J
$^{110}_{47}Ag_{63}$	116	253d	6	+3.604	17				B F J
$^{111}_{47}Ag_{64}$		7.5d	1/2	−0.145	1				F
$^{112}_{47}Ag_{65}$		3.2h	2	±0.054					F
$^{113}_{47}Ag_{66}$		5.3h	1/2	±0.159	1				F

Summary of Nuclear Moment Values and Index – Continued

Nucleus	Level (keV)	$T_{1/2}$	I ($h/2\pi$)	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{105}_{48}Cd_{57}$		55m	5/2	−0.738	4	+0.43[r]			H
$^{106}_{48}Cd_{58}$	633	6ps	[2]			−0.8			K
$^{107}_{48}Cd_{59}$		6.7h	5/2	−0.61443[d]	294	+0.68[r]			H
$^{108}_{48}Cd_{60}$	633	5ps	[2]			−0.8			K
$^{109}_{48}Cd_{61}$		470d	5/2	−0.82701[d]	395	+0.69[S]			H
$^{109}_{48}Cd_{61}$	469	8.9μs	[11/2]	−1.10	1				J
$^{110}_{48}Cd_{62}$			0♦						G
$^{110}_{48}Cd_{62}$	656	5.0ps	[2]	+0.7		−0.5;−0.3[b]			J K
$^{111}_{48}Cd_{63}$			1/2	−0.59428[d] (−0.59500)	284				E F G H
$^{111}_{48}Cd_{63}$	247	84ns	[5/2]	−0.793	4	+1			J
$^{111}_{48}Cd_{63}$	397	49m	11/2	−1.1040	53	−0.85[r]			H
$^{112}_{48}Cd_{64}$			0♦						G
$^{112}_{48}Cd_{64}$	617	6.2ps	[2]	+0.7		−0.2			J K
$^{113}_{48}Cd_{65}$		>3Jy	1/2	−0.62167[d] (−0.62245)	297				E F G H
$^{113}_{48}Cd_{65}$	265	14y	11/2	−1.0871[d]	52	−0.71[r]			H
$^{114}_{48}Cd_{66}$			0♦						G
$^{114}_{48}Cd_{66}$	558	9.0ps	[2]	+0.8		−0.32			J K
$^{115}_{48}Cd_{67}$		2.3d	1/2	−0.6478[d]	31				H
$^{115}_{48}Cd_{67}$	180	43d	11/2	−1.0400[d]	50	−0.55[r]			H
$^{116}_{48}Cd_{68}$			0♦						G
$^{116}_{48}Cd_{68}$	513	13.7ps	[2]	+0.8		−0.9[b]			J K
$^{109}_{49}In_{60}$		4.3h	9/2	+5.53	3	+0.85[r]			F
$^{110}_{49}In_{61}$		66m	2	+4.36	2	+0.36[r]			F
$^{110}_{49}In_{61}$	?	4.9h	7	+10.4 or −10.7		−0.21[r] or +0.22[r]			F
$^{111}_{49}In_{62}$		2.8d	9/2	+5.53	3	+0.84[r]			F
$^{112}_{49}In_{63}$		14m	1	+2.81	1	+0.089[r]			F
$^{112}_{49}In_{63}$	155	21m	4						F
$^{113}_{49}In_{64}$			9/2	+5.5229	271	+0.82[r]	+0.57		E F G H
$^{113}_{49}In_{64}$	393	1.7h	1/2	−0.210	1				F
$^{114}_{49}In_{65}$		72s	[1]	≤±1.7					J
$^{114}_{49}In_{65}$	190	50d	5	+4.7					F
$^{115}_{49}In_{66}$		600Ty	9/2	+5.5348	272	+0.83[S]	+0.56		C E F G H
$^{115}_{49}In_{66}$	335	4.5h	1/2	−0.244	1				F
$^{116}_{49}In_{67}$		14s	[1]	±2.786	14	±0.1			E J
$^{116}_{49}In_{67}$	70	54m	5	+4.3					F
$^{117}_{49}In_{68}$		45m	9/2						F
$^{117}_{49}In_{68}$	310	1.9h	1/2	−0.2515	12				F
$^{117}_{49}In_{68}$	660	60ns	[3/2]	+1.0		±0.64			J
$^{112}_{50}Sn_{62}$	1257	0.3ps	[2]			~0			K
$^{113}_{50}Sn_{63}$		118d	1/2	±0.88					F
$^{114}_{50}Sn_{64}$	~3100	700ns	[9,7?]	g=−0.081					J
$^{115}_{50}Sn_{65}$			1/2	−0.9178	46				E F G
$^{115}_{50}Sn_{65}$	619	3.3μs	[7/2]	<±1.0					J
$^{115}_{50}Sn_{65}$	726	159μs	[11/2]	−1.368	7	±0.8			E J
$^{116}_{50}Sn_{66}$			0♦						G
$^{116}_{50}Sn_{66}$	1290	0.4ps	[2]			[−0.1]			K
$^{116}_{50}Sn_{66}$	2369	350ns	[5]	−0.32					J
$^{117}_{50}Sn_{67}$			1/2	−0.9999	50				E F G
$^{118}_{50}Sn_{68}$			0♦						G
$^{118}_{50}Sn_{68}$	1230	0.5ps	[2]			−0.2			K
$^{118}_{50}Sn_{68}$	2320	21.7ns	[5]	−0.32					J

Summary of Nuclear Moment Values and Index – Continued

Nucleus	Level (keV)	$T_{1/2}$	I ($h/2\pi$)	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{119}_{50}Sn_{69}$			1/2	−1.0461	53				B E F G
$^{119}_{50}Sn_{69}$	24	18.5ns	[3/2]	+0.68		−0.07			I
$^{120}_{50}Sn_{70}$			0♦						G
$^{120}_{50}Sn_{70}$	1170	0.5ps	[2]			~0			K
$^{120}_{50}Sn_{70}$	2300	5.5ns	[5]	−0.30		±0.02			J
$^{121}_{50}Sn_{71}$		27h	3/2	±0.699	4	±0.08 μ/Q negative			F
$^{122}_{50}Sn_{72}$	1140	0.6ps	[2]			~0.3			K
$^{123}_{50}Sn_{73}$	~24	40m	3/2						F
$^{124}_{50}Sn_{74}$	1130	0.8ps	[2]			−0.1			K
$^{115}_{51}Sb_{64}$		31m	5/2	+3.46	2	-0.28^{r}			F
$^{116}_{51}Sb_{65}$		15m	3						F
$^{117}_{51}Sb_{66}$		2.8h	5/2	+2.67	1	-0.42^{r}			F
$^{117}_{51}Sb_{66}$	3130	340μs	[21/2?]	+1.22					J
$^{118}_{51}Sb_{67}$	~200	3.5m	1	±2.46	1				F
$^{119}_{51}Sb_{68}$		38h	5/2	+3.45	2	-0.29^{r}			F
$^{120}_{51}Sb_{69}$		16m	1	±2.3					F
$^{121}_{51}Sb_{70}$			5/2	+3.3592	174	-0.28^{abS}			B C D E F G I
$^{121}_{51}Sb_{70}$	37	3.5ns	[7/2]	+2.51	1	-0.4^{r}			I
$^{122}_{51}Sb_{71}$		2.73d	2	−1.90	1	$+0.66^{r}$			B F J
$^{122}_{51}Sb_{71}$	61	1.8μs	[3]	+2.98	2				J
$^{123}_{51}Sb_{72}$			7/2	+2.5466	132	-0.36^{r}			B C D E F G
$^{124}_{51}Sb_{73}$		60d	3	±1.3					F J
$^{125}_{51}Sb_{74}$		2.77y	7/2	±2.61	1				E J
$^{126}_{51}Sb_{75}$		12.5d	[8]	±1.3					J
$^{127}_{51}Sb_{76}$		3.9d	[7/2]	±2.6					J
$^{128}_{51}Sb_{77}$		8.6h	[8]	±1.3					J
$^{116}_{52}Te_{64}$		2.5h	0♦						F
$^{117}_{52}Te_{65}$		61m	1/2						F
$^{119}_{52}Te_{67}$		16h	1/2	±0.25					F
$^{119}_{52}Te_{67}$	~300	4.5d	11/2						F
$^{120}_{52}Te_{68}$	560	9.3ps	[2]	+0.6					J
$^{122}_{52}Te_{70}$	564	7.6ps	[2]	+0.66					J
$^{123}_{52}Te_{71}$		>50Ty	1/2	−0.7359	39				E G
$^{123}_{52}Te_{71}$	159	190ps	[3/2]	±0.7					J
$^{123}_{52}Te_{71}$	248	117d	[11/2]	−1.00					J
$^{123}_{52}Te_{71}$	440	?	?	g=+0.2					J
$^{123}_{52}Te_{71}$	506	?	?	g=+0.03					J
$^{124}_{52}Te_{72}$	603	6.6ps	[2]	$+0.5^{b}$		−0.5;−0.3			J K
$^{125}_{52}Te_{73}$			1/2	−0.8872	47				E G
$^{125}_{52}Te_{73}$	35.5	1.6ns	3/2	+0.60		−0.2			I
$^{125}_{52}Te_{73}$	145	58d	[11/2]	±0.9					J
$^{125}_{52}Te_{73}$	321	695ps	[9/2]	−0.91					J
$^{125}_{52}Te_{73}$	443	21ps	[3/2]	+0.5					J
$^{125}_{52}Te_{73}$	463	13ps	[5/2]	+0.6					J
$^{125}_{52}Te_{73}$	525	?	[7/2?]	negative					J
$^{126}_{52}Te_{74}$			0♦						G
$^{126}_{52}Te_{74}$	667	4.4ps	[2]	+0.6		$-0.3;-0.1^{b}$			J K
$^{127}_{52}Te_{75}$		9.4h	[3/2]	±0.61					J
$^{127}_{52}Te_{75}$	89	109d	[11/2]	−0.91					J
$^{128}_{52}Te_{76}$			0♦						G
$^{128}_{52}Te_{76}$	743	3.2ps	[2]	+0.5		$-0.1;+0.1^{b}$			J K
$^{129}_{52}Te_{77}$		69m	[3/2]	±0.67					J
$^{129}_{52}Te_{77}$	106	34d	[11/2]	−1.15					J

Summary of Nuclear Moment Values and Index — Continued

Nucleus	Level (keV)	$T_{1/2}$	I ($h/2\pi$)	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{130}_{52}$Te$_{78}$			0♦						G
$^{130}_{52}$Te$_{78}$	840	2.0ps	[2]	+0.6		−0.2;−0.1			J K
$^{123}_{53}$I$_{70}$		13h	5/2						F
$^{124}_{53}$I$_{71}$		4.0d	2						F
$^{125}_{53}$I$_{72}$		60d	5/2	+3		-0.89^{r}			C
$^{125}_{53}$I$_{72}$	188	35ns	[3/2]	±3					J
$^{126}_{53}$I$_{73}$		13d	2						F
$^{127}_{53}$I$_{74}$			5/2	+2.8091	153	-0.79^{cS}	+0.18		C D E F G
$^{127}_{53}$I$_{74}$	58	1.92ns	[7/2]	$\pm 2.2^{b}$		-0.71^{r}			I J
$^{127}_{53}$I$_{74}$	203	330ps	[3/2]	≥±1.1					J
$^{128}_{53}$I$_{75}$		25m	1						F
$^{129}_{53}$I$_{76}$		16My	7/2	+2.6174	143	-0.55^{r}			C D E
$^{129}_{53}$I$_{76}$	27	15ns	[5/2]	+2.8		-0.68^{r}			I
$^{130}_{53}$I$_{77}$		12h	5						F
$^{131}_{53}$I$_{78}$		8.1d	7/2	+2.738	15	-0.40^{r}			C F
$^{131}_{53}$I$_{78}$	150	0.95ns	[5/2]	+2.8					J
$^{131}_{53}$I$_{78}$	1797	5.9ns	[9/2 or 11/2]	−0.7 −0.9					J
$^{132}_{53}$I$_{79}$		2.3h	4	±3.08	2	$\pm 0.08^{r}$ μ/Q negative			F
$^{132}_{53}$I$_{79}$	49.7	0.95ns	[3]	+2.2					J
$^{133}_{53}$I$_{80}$		21h	7/2	+2.84	2	-0.26^{r}			F
$^{135}_{53}$I$_{82}$		6.7h	7/2						F
$^{129}_{54}$Xe$_{75}$			1/2	−0.7768	43				E F G H
$^{129}_{54}$Xe$_{75}$	40	700ps	[3/2]			$\pm 0.41^{r}$			I
$^{131}_{54}$Xe$_{77}$			3/2	+0.6908	39	-0.12^{S}	+0.048		E F G
$^{132}_{54}$Xe$_{78}$			0♦						G
$^{132}_{54}$Xe$_{78}$	668	7ps	[2]	+0.9					J
$^{134}_{54}$Xe$_{80}$			0♦						G
$^{136}_{54}$Xe$_{82}$			0♦						G
$^{125}_{55}$Cs$_{70}$		45m	1/2	+1.41	1				F
$^{127}_{55}$Cs$_{72}$		6.2h	1/2	+1.45	1				F
$^{129}_{55}$Cs$_{74}$		31h	1/2	+?1.479	8				F
$^{130}_{55}$Cs$_{75}$		30m	1	+1.37 or −1.45	1				F
$^{131}_{55}$Cs$_{76}$		10d	5/2	+3.54	2	$-0.57*^{r}$			F H
$^{131}_{55}$Cs$_{76}$	133	9.3ns	[5/2]	+2.1					J
$^{132}_{55}$Cs$_{77}$		6.2d	2	+2.22	1	$+0.47*^{r}$			F H
$^{133}_{55}$Cs$_{78}$			7/2	$+2.5779^{d}$ (+2.5788)	148	$-0.0030*^{r}$		<100	D E F G H
$^{133}_{55}$Cs$_{78}$	81	6.31ns	[5/2]	+3.44	2				I J
$^{133}_{55}$Cs$_{78}$	160	190ps	[5/2]	+1.5					J
$^{134}_{55}$Cs$_{79}$		2.2y	4	+2.989	17	$+0.36*^{S}$			F H
$^{134}_{55}$Cs$_{79}$	11.2	47.0ns	[5]	+3.34	2				J
$^{134}_{55}$Cs$_{79}$	137	3.1h	8	+1.096	6				F
$^{135}_{55}$Cs$_{80}$		2My	7/2	$+2.7280^{d}$ (+2.7289)	156	$+0.044*^{r}$			F H
$^{136}_{55}$Cs$_{81}$		13d	5	+3.70	2				F
$^{137}_{55}$Cs$_{82}$		30y	7/2	$+2.8372^{d}$ (+2.8382)	162	$+0.045*^{r}$			F H
$^{138}_{55}$Cs$_{83}$		32m	3	±0.5					F

Summary of Nuclear Moment Values and Index — Continued

Nucleus	Level (keV)	$T_{1/2}$	I ($h/2\pi$)	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{130}_{56}Ba_{74}$	356	63ps	[2]			+0.3[b]			K
$^{134}_{56}Ba_{78}$			0♦						G
$^{134}_{56}Ba_{78}$	605	7ps	[2]	~±0.006?		+0.1[b]			J K
$^{135}_{56}Ba_{79}$			3/2	+0.8365[d] (+0.8372)	49	+0.18[S]			D E F G H
$^{135}_{56}Ba^{+}_{79}$			3/2						H
$^{136}_{56}Ba_{80}$			0♦						G
$^{136}_{56}Ba_{80}$	818	1.5ps	[2]			+0.3[b]			K
$^{137}_{56}Ba_{81}$			3/2	+0.9357[d] (+0.9365)	55	+0.28[r]			E F G H
$^{137}_{56}Ba^{+}_{81}$			3/2						H
$^{137}_{56}Ba_{81}$	662	2.55m	[11/2]			≈−0.05			J
$^{138}_{56}Ba_{82}$			0♦						G
$^{131}_{57}La_{74}$		59m	3/2						F
$^{132}_{57}La_{75}$		4.5h	2						F
$^{132}_{57}La_{75}$	?	25m	6						F
$^{133}_{57}La_{76}$		4.0h	5/2						F
$^{133}_{57}La_{76}$	535	49ns	[11/2]	±8					J
$^{135}_{57}La_{78}$		19.4h	5/2						F
$^{136}_{57}La_{79}$		9.9m	1						F
$^{137}_{57}La_{80}$		60ky	7/2	+2.69	2	+0.26*[r]			G
$^{138}_{57}La_{81}$		112Gy	5	+3.704	22	+0.51*[r]			E G
$^{139}_{57}La_{82}$			7/2	+2.778	17	+0.22*[S]			E F G H
$^{140}_{57}La_{83}$		40h	3	+0.73		+0.1*[r]			F J
$^{130}_{58}Ce_{72}$		25m	0♦						F
$^{132}_{58}Ce_{74}$		4.2h	0♦						F
$^{133}_{58}Ce_{75}$		5.4h	9/2						F
$^{133}_{58}Ce_{75}$	?	97m	1/2						F
$^{134}_{58}Ce_{76}$		72h	0♦						F
$^{135}_{58}Ce_{77}$		17h	1/2						F
$^{137}_{58}Ce_{79}$		9.0h	3/2	±0.7					F J
$^{137}_{58}Ce_{79}$	255	34.4h	11/2	±0.69					F J
$^{139}_{58}Ce_{81}$		140d	3/2	±0.9					F J
$^{140}_{58}Ce_{82}$	2083	3.41ns	[4]	+4.3		±0.40*			J
$^{141}_{58}Ce_{83}$		33d	7/2						B J
$^{142}_{58}Ce_{84}$	650	6.2ps	[2]			−0.1			K
$^{143}_{58}Ce_{85}$		34h	3/2	~±1					F J
$^{133}_{59}Pr_{74}$		7.5m	5/2						F
$^{134}_{59}Pr_{75}$		18.5m	2						F
$^{135}_{59}Pr_{76}$		24m	3/2						F
$^{136}_{59}Pr_{77}$		13.5m	2						F
$^{137}_{59}Pr_{78}$		1.28h	5/2						F
$^{138}_{59}Pr_{79}$	?	2.0h	7						F
$^{139}_{59}Pr_{80}$		4.5h	5/2						F
$^{140}_{59}Pr_{81}$		3.4m	1						F
$^{141}_{59}Pr_{82}$			5/2	+4.16	3	−0.058[S]			B F G
$^{142}_{59}Pr_{83}$		19h	2	−0.24		−0.034[r]			F J
$^{142}_{59}Pr_{83}$	?	?	5						F
$^{143}_{59}Pr_{84}$		14d	7/2						F
$^{143}_{59}Pr_{84}$	57	4.17ns	[5/2]	+2.8					J
$^{134}_{60}Nd_{74}$		8m	0♦						F
$^{135}_{60}Nd_{75}$		15m	9/2						F
$^{136}_{60}Nd_{76}$		55m	0♦						F

Summary of Nuclear Moment Values and Index – Continued

Nucleus	Level (keV)	$T_{1/2}$	I $(h/2\pi)$	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{137}_{60}Nd_{77}$		37m	1/2						F
$^{138}_{60}Nd_{78}$		5.2h	0♦						F
$^{139}_{60}Nd_{79}$		29.7m	3/2						F
$^{139}_{60}Nd_{79}$	232	5.5h	11/2						F
$^{140}_{60}Nd_{80}$		3.4d	0♦						F
$^{141}_{60}Nd_{81}$		2.4h	3/2						F
$^{143}_{60}Nd_{83}$			7/2	−1.063	7	-0.48^{hS}			B F G
$^{144}_{60}Nd_{84}$	695	4.2ps	[2]	+0.26		−0.2;−0.6			J K
$^{144}_{60}Nd_{84}$	1314	90ps	[4]	+0.2					J
$^{145}_{60}Nd_{85}$			7/2	−0.654	4	-0.25^{hr}			B F G
$^{146}_{60}Nd_{86}$	454	21ps	[2]	+0.48		−0.7			J K
$^{147}_{60}Nd_{87}$		11d	5/2	±0.55		$\pm0.7^{r}$ μ/Q negative			B F
$^{148}_{60}Nd_{88}$	300	116ps	[2]	+0.45		−1.3			J K
$^{149}_{60}Nd_{89}$		1.9h	5/2	±0.35		$\pm1.0^{r}$			F
$^{150}_{60}Nd_{90}$	132	1.52ns	[2]	+0.64		−1.7			J K
$^{150}_{60}Nd_{90}$	397	55.9ps	[4]	+1.3					J
$^{141}_{61}Pm_{80}$		20.9m	5/2						F
$^{143}_{61}Pm_{82}$		265d	[5/2, or 7/2]	±3.8, ±3.9					J
$^{144}_{61}Pm_{83}$		360d	[5, or 6]	±1.7, ±1.8					J
$^{147}_{61}Pm_{86}$		2.6y	7/2	+2.62	2	+0.7			B F G
$^{147}_{61}Pm_{86}$	91	2.55ns	[5/2]	+3.4					J
$^{148}_{61}Pm_{87}$		5.4d	1	+2.0		+0.2			F J
$^{148}_{61}Pm_{87}$	137	43d	[6]	±1.8					J
$^{149}_{61}Pm_{88}$		53h	7/2	±3.3					F J
$^{149}_{61}Pm_{88}$	114	2.58ns	[5/2]	+2.1					J
$^{149}_{61}Pm_{88}$	188	3.24ns	[3/2]	+1.6					J
$^{149}_{61}Pm_{88}$	211	80ps	[5/2]	+2.2					J
$^{149}_{61}Pm_{88}$	270	2.59ns	[7/2]	+3					J
$^{151}_{61}Pm_{90}$		28h	5/2	±1.6		±1.9 μ/Q positive			F
$^{140}_{62}Sm_{78}$		15m	0♦						F
$^{141}_{62}Sm_{79}$		11.3m	1/2						F
$^{141}_{62}Sm_{79}$	?	22.9m	11/2						F
$^{142}_{62}Sm_{80}$		1.2h	0♦						F
$^{143}_{62}Sm_{81}$		8.8m	3/2						F
$^{145}_{62}Sm_{83}$		340d	[7/2]	±0.92					J
$^{147}_{62}Sm_{85}$		0.1Ty	7/2	−0.813	6	-0.18^{S}			B F G H
$^{147}_{62}Sm_{85}$	121	780ps	[5/2]	−0.3					J
$^{147}_{62}Sm_{85}$	198	1.31ns	[3/2]	−0.28					J
$^{148}_{62}Sm_{86}$	551	7.35ps	[2]	+0.3		−0.8			J K
$^{149}_{62}Sm_{87}$			7/2	−0.670	5	$+0.052^{r}$			B F G
$^{149}_{62}Sm_{87}$	22	7.6ns	5/2	−0.61		+0.4			I
$^{150}_{62}Sm_{88}$	334	48ps	[2]	+0.60		−1.3			J K
$^{151}_{62}Sm_{89}$	105	480ps	[5/2]	+0.5					J
$^{151}_{62}Sm_{89}$	168	760ps	[3/2]	+0.6					J
$^{152}_{62}Sm_{90}$	122	1.42ns	[2]	+0.69		−1.8			I J K
$^{152}_{62}Sm_{90}$	366	57ps	[4]	+1.2					J
$^{153}_{62}Sm_{91}$		47h	3/2	−0.0217	1	+0.9			F
$^{154}_{62}Sm_{92}$	82	3.02n	[2]	+0.61					J
$^{154}_{62}Sm_{92}$	267	165ps	[4]	+1.3					J
$^{154}_{62}Sm_{92}$	549	23.5ps	[6]	+1.9					J
$^{155}_{62}Sm_{93}$		24m	3/2			$\pm0.8^{r}$			F

Summary of Nuclear Moment Values and Index – Continued

Nucleus	Level (keV)	$T_{1/2}$	I ($h/2\pi$)	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{145}_{63}Eu_{82}$		5.9d	5/2						F
$^{146}_{63}Eu_{83}$		4.65d	4						F
$^{147}_{63}Eu_{84}$		22d	5/2						F
$^{147}_{63}Eu_{84}$	625	765ns	[11/2]	+6.0					J
$^{148}_{63}Eu_{85}$		54d	5						F
$^{149}_{63}Eu_{86}$		93d	5/2						F
$^{149}_{63}Eu_{86}$	497	2.43μs	[11/2]	+6.1					J
$^{150}_{63}Eu_{87}$		12.5h	0♦						F
$^{151}_{63}Eu_{88}$			5/2	$+3.4631^{h}$ [+3.466]	240	$+1.1^{S}$			B F G I
$^{151}_{63}Eu_{88}$	21.7	9.4ns	7/2	+2.57	2	$+1.8^{r}$			I
$^{152}_{63}Eu_{89}$		13y	3	−1.937	13	$+3.0^{r}$			B F G
$^{152}_{63}Eu_{89}$	49	9.3h	0♦						F
$^{153}_{63}Eu_{90}$			5/2	+1.530	11	$+2.8^{r}$			B E F G
$^{153}_{63}Eu_{90}$	97	200ps	[5/2]	+3.2 or −0.5					I
$^{153}_{63}Eu_{90}$	103	3.8ns	[3/2]	$+1.5^{b}$					I J
$^{154}_{63}Eu_{91}$		16y	3	±2.001	14	$+1.9^{r}$			B G J
$^{155}_{63}Eu_{92}$	105	400ps	[5/2]	+2.5					J
$^{145}_{64}Gd_{81}$		22.9m	1/2						F
$^{147}_{64}Gd_{83}$		38.5h	7/2						F
$^{149}_{64}Gd_{85}$		9.4d	7/2						F
$^{151}_{64}Gd_{87}$		120d	7/2						F
$^{152}_{64}Gd_{88}$	344	29ps	[2]	+1.0					J
$^{153}_{64}Gd_{89}$		242d	3/2						F
$^{154}_{64}Gd_{90}$	123	1.18ns	[2]	+0.84	1				J
$^{154}_{64}Gd_{90}$	371	39ps	[4]						J
$^{155}_{64}Gd_{91}$			3/2	−0.2584	18	$+1.6^{S}$	−1.6		B E F G I
$^{155}_{64}Gd_{91}$	87	6.66ns	5/2	-0.93^{i}	1	$\sim\pm0.2^{r}$			I J
$^{155}_{64}Gd_{91}$	105	1.1ns	3/2	$+0.4^{i}$		$\sim\pm1^{r}$			I J
$^{156}_{64}Gd_{92}$	89	2.22ns	[2]	$+0.72^{i}$		$\pm1.2^{r}$			I J
$^{156}_{64}Gd_{92}$	288	115ps	[4]	+1.4					J
$^{156}_{64}Gd_{92}$	1513	190ps	[4]	+3.1					J
$^{157}_{64}Gd_{93}$			3/2	−0.3388	24	$+1.7^{r}$			B F G
$^{157}_{64}Gd_{93}$	64	460ns	[5/2]			$\pm3.0^{r}$			I
$^{158}_{64}Gd_{94}$	79.5	2.49ns	[2]	$+0.73^{i}$	1	$\pm1.3^{r}$			I J
$^{159}_{64}Gd_{95}$		18h	3/2	±0.44					F J
$^{160}_{64}Gd_{96}$	75	2.7ns	[2]	+0.63		$\pm1.3^{r}$			I J
$^{151}_{65}Tb_{86}$		18h	1/2						F
$^{152}_{65}Tb_{87}$		18h	2						F
$^{153}_{65}Tb_{88}$		2.3d	5/2						F
$^{154}_{65}Tb_{89}$		21h	0♦						F
$^{154}_{65}Tb_{89}$	?	8.5h	3						F
$^{155}_{65}Tb_{90}$		5.6d	3/2						F
$^{156}_{65}Tb_{91}$		5.4d	3	±1.4		+1.4			F J
$^{157}_{65}Tb_{92}$		>30y	[3/2]	±2.0					B
$^{158}_{65}Tb_{93}$		150y	3	±1.75	1	+2.7*			B
$^{159}_{65}Tb_{94}$			3/2	±2.008	14	+1.3*			B F G J
$^{159}_{65}Tb_{94}$	58	130ps	[5/2]	±2					I
$^{160}_{65}Tb_{95}$		72d	3	±1.70	1	+2.3			B F J
$^{161}_{65}Tb_{96}$		6.9d	3/2						F
$^{151}_{66}Dy_{85}$		18m	7/2						F
$^{152}_{66}Dy_{86}$		2.4h	0♦						F

Summary of Nuclear Moment Values and Index — Continued

Nucleus	Level (keV)	$T_{1/2}$	I ($h/2\pi$)	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{153}_{66}Dy_{87}$		6.4h	7/2	±0.7		±0.14*			F
						μ/Q positive			
$^{155}_{66}Dy_{89}$		10h	3/2	±0.28		±0.9*			F J
						μ/Q negative			
$^{157}_{66}Dy_{91}$		8.1h	3/2	±0.31		±1.2*			F
						μ/Q negative			
$^{158}_{66}Dy_{92}$	630	?	[6]	±2.2					J
$^{159}_{66}Dy_{93}$		144d	3/2						F
$^{160}_{66}Dy_{94}$	87	2.0ns	[2]	+0.73		−2			I J
$^{160}_{66}Dy_{94}$	966	2.2ps	[2]	+0.4					J
$^{161}_{66}Dy_{95}$			5/2	−0.482	3	+2.4*^{S}		~+0.6	B F I
$^{161}_{66}Dy_{95}$	26	28.4ns	5/2	+0.67^{i}		+2.4*^{r}			I J
$^{161}_{66}Dy_{95}$	75	3.4ns	3/2	−0.38		+1.3*^{r}			I J
$^{162}_{66}Dy_{96}$	80.7	2.25ns	[2]	+0.72					I J
$^{163}_{66}Dy_{97}$			5/2	+0.676	5	+2.5*^{r}		~+0.7	B E F
$^{164}_{66}Dy_{98}$	73.3	2.39ns	[2]	+0.70		−2.0*^{r}			I J
$^{165}_{66}Dy_{99}$		2.3h	7/2	±0.52		+3.3*^{r}			F
$^{166}_{66}Dy_{100}$		82h	0♦						F
$^{154}_{67}Ho_{87}$		12m	1						F
$^{155}_{67}Ho_{88}$		50m	5/2						F
$^{156}_{67}Ho_{89}$		55m	1						F
$^{157}_{67}Ho_{90}$		14m	7/2						F
$^{158}_{67}Ho_{91}$		11m	5						F
$^{158}_{67}Ho_{91}$	67	29m	2						F
$^{159}_{67}Ho_{92}$		33m	7/2						F
$^{160}_{67}Ho_{93}$		26m	5						F
$^{160}_{67}Ho_{93}$	60	5.0h	2						F
$^{161}_{67}Ho_{94}$		2.5h	7/2						F
$^{162}_{67}Ho_{95}$		15m	1						F
$^{162}_{67}Ho_{95}$	~100	68m	6						F
$^{164}_{67}Ho_{97}$		29m	1						F
$^{164}_{67}Ho_{97}$	~46	38m	6						F
$^{165}_{67}Ho_{98}$			7/2	+4.12	3	+2.7		~+0.8	B F G J
$^{166}_{67}Ho_{99}$		27h	0♦						F
$^{166}_{67}Ho_{99}$	9	1.2ky	[7]	±4.1					J
$^{156}_{68}Er_{88}$	344	47.9ps	[2]	g_{ave}~±0.4					J
	453	7.83ps	[4]						
$^{157}_{68}Er_{89}$		20m	3/2						F
$^{158}_{68}Er_{90}$		2.3h	0♦						F
$^{158}_{68}Er_{90}$	193	433ps	[2]	g_{ave}~±0.4					J
	356	20.8ps	[4]						
	434	4.04ps	[6]						
$^{159}_{68}Er_{91}$		36m	3/2						F
$^{160}_{68}Er_{92}$		29h	0♦						F
$^{160}_{68}Er_{92}$	264	49.8ps	[4]	g_{ave}~±0.3					J
	376	7.77ps	[6]						
	465	4.04ps	[8]						
$^{161}_{68}Er_{93}$		3.2h	3/2	−0.369	3	+1.2*			F
$^{163}_{68}Er_{95}$		75m	5/2	+0.56		+2.2*			F
$^{164}_{68}Er_{96}$	92	1.6ns	[2]	±0.71					I
$^{165}_{68}Er_{97}$		10h	5/2	±0.65		±2.2^{r}			F
						μ/Q positive			
$^{166}_{68}Er_{98}$	80.6	1.82ns	[2]	+0.63		−2.0*			I J K
$^{166}_{68}Er_{98}$	265	120ps	[4]	+1.2		−2.7			J K
$^{166}_{68}Er_{98}$	787	?	[2]			+2.0			K

Summary of Nuclear Moment Values and Index — Continued

Nucleus	Level (keV)	$T_{1/2}$	I ($h/2\pi$)	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
${}^{167}_{68}\mathrm{Er}_{99}$			7/2	−0.564	4	+2.83[S]			B F
${}^{168}_{68}\mathrm{Er}_{100}$	80	1.91ns	[2]	+0.65					I J
${}^{168}_{68}\mathrm{Er}_{100}$	264	120ps	[4]	+1.2		−2			J K
${}^{168}_{68}\mathrm{Er}_{100}$	~7800	?	[4]	~0					J
${}^{168}_{68}\mathrm{Er}_{100}$	~7800	?	[3]	±6					J
${}^{169}_{68}\mathrm{Er}_{101}$		9.4d	1/2	+0.513	4				F
${}^{170}_{68}\mathrm{Er}_{102}$	79	1.90ns	[2]	+0.64		−2.1*			I J K
${}^{170}_{68}\mathrm{Er}_{102}$	261	135ps	[4]	±1.2		−2			J K
${}^{171}_{68}\mathrm{Er}_{103}$		7.5h	5/2	±0.70	1	±2.3[r]			F
						μ/Q negative			
${}^{159}_{69}\mathrm{Tm}_{90}$		9m	5/2						F
${}^{160}_{69}\mathrm{Tm}_{91}$		9m	1						F
${}^{161}_{69}\mathrm{Tm}_{92}$		37m	7/2						F
${}^{162}_{69}\mathrm{Tm}_{93}$		21m	1						F
${}^{163}_{69}\mathrm{Tm}_{94}$		1.8h	1/2	±0.08					F
${}^{164}_{69}\mathrm{Tm}_{95}$		2m	1						F
${}^{164}_{69}\mathrm{Tm}_{95}$	?	5m	6						F
${}^{165}_{69}\mathrm{Tm}_{96}$		29h	1/2	±0.138	1				F
${}^{166}_{69}\mathrm{Tm}_{97}$		7.7h	2	±0.092	1	±1.9*			F
						μ/Q positive			
${}^{167}_{69}\mathrm{Tm}_{98}$		9.6d	1/2	−0.20					F
${}^{168}_{69}\mathrm{Tm}_{99}$		85d	3						F
${}^{169}_{69}\mathrm{Tm}_{100}$			1/2	−0.231	2				B F G H
${}^{169}_{69}\mathrm{Tm}_{100}$	8.4	4ns	[3/2]	+0.52		−1.3*			I
${}^{169}_{69}\mathrm{Tm}_{100}$	118	62ps	[5/2]	+0.74	1				J
${}^{169}_{69}\mathrm{Tm}_{100}$	139	320ps	[7/2]	+1.30	1	Q/Q_{118}=1.0			J
${}^{169}_{69}\mathrm{Tm}_{100}$	316	660ns	[7/2]	±0.15					J
${}^{169}_{69}\mathrm{Tm}_{100}$	379	36ns	[7/2]	±0.96	1				J
${}^{170}_{69}\mathrm{Tm}_{101}$		127d	1	±0.246	2	±0.59			F
						μ/Q positive			
${}^{171}_{69}\mathrm{Tm}_{102}$		1.9y	1/2	±0.229	2				F
${}^{171}_{69}\mathrm{Tm}_{102}$	117	55ps	[5/2]	+0.8					J
${}^{171}_{69}\mathrm{Tm}_{102}$	129	362ps	[7/2]	+1.2					J
${}^{169}_{70}\mathrm{Yb}_{99}$		32d	[7/2]	±0.6					J
${}^{170}_{70}\mathrm{Yb}_{100}$	84	1.58ns	[2]	+0.68	1	negative			I J
${}^{171}_{70}\mathrm{Yb}_{101}$			1/2	+0.4919[d]	40				B E G H
				(+0.4930)					
${}^{171}_{70}\mathrm{Yb}_{101}$	67	900ps	[3/2]	±0.35					I
${}^{171}_{70}\mathrm{Yb}_{101}$	76	2ns	[5/2]	+1.01					I
${}^{172}_{70}\mathrm{Yb}_{102}$	78.7	1.6ns	[2]	+0.64[b]		+3			I J
${}^{172}_{70}\mathrm{Yb}_{102}$	260	132ps	[4]			−2			K
${}^{172}_{70}\mathrm{Yb}_{102}$	1174	7.95ps	[3]	+0.66	1	±4			J
${}^{173}_{70}\mathrm{Yb}_{103}$			5/2	−0.6776[d]	54	+3.0			B E G H
				(−0.6791)					
${}^{173}_{70}\mathrm{Yb}_{103}$	79	38ps	[7/2]	−0.20					J
${}^{173}_{70}\mathrm{Yb}_{103}$	179	36ps	[9/2]	~+0.3					J
${}^{173}_{70}\mathrm{Yb}_{103}$	351	0.45ns	[11/2]	~−0.7					J
${}^{174}_{70}\mathrm{Yb}_{104}$	76.5	1.79ns	[2]	+0.68[b]	1				I J
${}^{174}_{70}\mathrm{Yb}_{104}$	252	?	[4]			−2			K
${}^{175}_{70}\mathrm{Yb}_{105}$		4.2d	[7/2]	±0.3[b]		~±6			J
${}^{176}_{70}\mathrm{Yb}_{106}$	82	1.76ns	[2]	+0.76	1				I J
${}^{176}_{70}\mathrm{Yb}_{106}$	270	?	[4]			~0			K

Summary of Nuclear Moment Values and Index — Continued

Nucleus	Level (keV)	$T_{1/2}$	I ($h/2\pi$)	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{167}_{71}Lu_{96}$		54m	7/2						F
$^{169}_{71}Lu_{98}$		1.5d	7/2						F
$^{170}_{71}Lu_{99}$		2.0d	0♦						F
$^{171}_{71}Lu_{100}$		8.3d	7/2						F
$^{175}_{71}Lu_{104}$			7/2	+2.230	18	$+5.6^{S}$			E F G H
$^{175}_{71}Lu_{104}$	114	100ps	[9/2]	+1.9					J
$^{175}_{71}Lu_{104}$	251	42ps	[11/2]	+1.9					J
$^{176}_{71}Lu_{105}$		20Gy	7	+3.18	3	$+8.0^{r}$			F G
$^{176}_{71}Lu_{105}$	~300	3.7h	1	+0.318	3	-2.3^{r}			F
$^{177}_{71}Lu_{106}$		6.8d	7/2	+2.24	2	$+5.4^{r}$			F
$^{177}_{71}Lu_{106}$	971	155d	[23/2]			+13			J
$^{176}_{72}Hf_{104}$	88.4	1.40ns	[2]	+0.53					J
$^{177}_{72}Hf_{105}$			7/2	+0.7902	66	+4.5*			F G
$^{177}_{72}Hf_{105}$	113	500ps	[9/2]	+1.12	1				J
$^{177}_{72}Hf_{105}$	250	55ps	[11/2]	+2.6					J
$^{177}_{72}Hf_{105}$	321	660ps	[9/2]	−0.51					J
$^{178}_{72}Hf_{106}$			0♦						G
$^{178}_{72}Hf_{106}$	93	1.50ns	[2]	$+0.58^{b}$					I J
$^{179}_{72}Hf_{107}$			9/2	−0.638	5	+5.1*			F G
$^{180}_{72}Hf_{108}$			0♦						G
$^{180}_{72}Hf_{108}$	93	1.50ns	[2]	$+0.64^{b}$					J
$^{180}_{72}Hf_{108}$	309	71ps	[4]	+2.3					J
$^{181}_{73}Ta_{108}$			7/2	+2.35	2	$+3*^{S}$			E F G
$^{181}_{73}Ta_{108}$	6.2	6.8μs	[9/2]	+5.1		$+3*^{r}$			I
$^{181}_{73}Ta_{108}$	482	10.8ns	[5/2]	+3.29	3	positive			H J
$^{182}_{73}Ta_{109}$		115d	[3]	±2.6					J
$^{183}_{73}Ta_{110}$		5.0d	7/2						F
$^{182}_{74}W_{108}$			0♦						G
$^{182}_{74}W_{108}$	100	1.37ns	[2]	+0.51					I J
$^{182}_{74}W_{108}$	329	64ps	[4]	+0.7					J
$^{182}_{74}W_{108}$	1289	1.04ns	[2]	+1.4					J
$^{182}_{74}W_{108}$	1374	2.25ns	[3]	±0.10					J
$^{183}_{74}W_{109}$			1/2	+0.1169	10				E G
$^{183}_{74}W_{109}$	46	180ps	[3/2]	−0.1					I
$^{183}_{74}W_{109}$	99	700ps	[5/2]	+0.7					I J
$^{184}_{74}W_{110}$			0♦						G
$^{184}_{74}W_{110}$	111	1.26ns	[2]	+0.56					I J
$^{184}_{74}W_{110}$	364	43.5ps	[4]	+1.2					J
$^{185}_{74}W_{111}$		74d	3/2						F
$^{186}_{74}W_{112}$			0♦						G
$^{186}_{74}W_{112}$	123	1.01ns	[2]	+0.65	1				I J
$^{186}_{74}W_{112}$	399	25ps	[4]	+0.8		−3			J K
$^{186}_{74}W_{112}$	730	4.2ps	[2]			+0.7			K
$^{187}_{74}W_{113}$		24h	3/2						F
$^{183}_{75}Re_{108}$		70d	[5/2]	±3.1					J
$^{183}_{75}Re_{108}$	496	7.89ns	[9/2]	±5.3					J
$^{184}_{75}Re_{109}$		38d	[3]	±2.5					J
$^{184}_{75}Re_{109}$	188	165d	[8]	±2.9					J
$^{185}_{75}Re_{110}$			5/2	+3.172	28	$+2.3^{r}$			C D E G
$^{186}_{75}Re_{111}$		90h	1	+1.73	1	$\sim\pm0.4^{r}$			F G
$^{187}_{75}Re_{112}$		60Gy	5/2	+3.204	28	$+2.2^{S}$			C E G
$^{187}_{75}Re_{112}$	206	560ns	[9/2]	+4.8					J
$^{188}_{75}Re_{113}$		17h	1	+1.78	1	$\sim\pm0.4^{r}$			F G

Summary of Nuclear Moment Values and Index — Continued

Nucleus	Level (keV)	$T_{1/2}$	I ($h/2\pi$)	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{184}_{76}Os_{108}$	?	?	[2]			−2			K
$^{186}_{76}Os_{110}$	137	840ps	[2]	+0.61	1	+1.5			J K
$^{187}_{76}Os_{111}$			1/2	+0.0643	6				E G
$^{188}_{76}Os_{112}$	155	710ps	[2]	+0.55		−0.4;−1.3			J K
$^{188}_{76}Os_{112}$	633	5.6ps	[2]	+0.9					J
$^{189}_{76}Os_{113}$			3/2	+0.6565	59	+0.8*			E G
$^{190}_{76}Os_{114}$	187	350ps	[2]	+0.68	1	+0.3;−1.0			J K
$^{190}_{76}Os_{114}$	548	28ps	[4]	+0.9					J
$^{192}_{76}Os_{116}$	206	280ps	[2]	+0.78	1	+1.2;−0.4			J K
$^{192}_{76}Os_{116}$	489	28ps	[2]	±0.7					J
$^{191}_{77}Ir_{114}$			3/2	+0.1454	14	$+1.1^{r}$			B E F G
$^{191}_{77}Ir_{114}$	82	3.8ns	[1/2]	+0.546	5				I
$^{191}_{77}Ir_{114}$	129	131ps	[5/2]	+0.5					J
$^{191}_{77}Ir_{114}$	171	4.9s	[11/2]	±6.1	1				E J
$^{192}_{77}Ir_{115}$		74d	4	+1.90	2				E F J
$^{193}_{77}Ir_{116}$			3/2	+0.1583	15	$+1.0^{S}$			B E F G
$^{193}_{77}Ir_{116}$	73	6.2ns	1/2	+0.468	4				I
$^{193}_{77}Ir_{116}$	139	90ps	[5/2]	+0.6					J
$^{194}_{77}Ir_{117}$		17h	1	±0.37					F J
$^{192}_{78}Pt_{114}$	316	35ps	[2]	$+0.93^{l}$	1				J
$^{192}_{78}Pt_{114}$	612	20ps	[2]	$+1.0^{k}$					J
$^{192}_{78}Pt_{114}$	785	12ps	[4]	$\pm0.9^{k}$					J
$^{194}_{78}Pt_{116}$			0♦						G
$^{194}_{78}Pt_{116}$	328	35ps	[2]	+0.6		+0.6;+0.9			J K
$^{194}_{78}Pt_{116}$	622	44ps	[2]	+0.4					J
$^{195}_{78}Pt_{117}$			1/2	+0.6022	56				E F G
$^{195}_{78}Pt_{117}$	99	160ps	[3/2]	−0.60	1				I
$^{195}_{78}Pt_{117}$	210	67ps	[3/2]	+0.3					J
$^{195}_{78}Pt_{117}$	240	230ps	[5/2]	+0.22					J
$^{195}_{78}Pt_{117}$	259	4.1d	[13/2]	±0.60	1				E J
$^{196}_{78}Pt_{118}$			0♦						G
$^{196}_{78}Pt_{118}$	356	35ps	[2]	+0.55		+0.5;+0.6			J K
$^{197}_{78}Pt_{119}$		20h	1/2	$\pm0.5^{p}$					F
$^{198}_{78}Pt_{120}$	408	19ps	[2]	+0.5		+1.2			J K
$^{190}_{79}Au_{111}$		40m	1	±0.066	1				F
$^{191}_{79}Au_{112}$		3.0h	3/2	±0.137	1				F
$^{192}_{79}Au_{113}$		4.1h	1	±0.0079	1				F
$^{193}_{79}Au_{114}$		18h	3/2	±0.139	1				F
$^{194}_{79}Au_{115}$		39h	1	±0.074	1				F
$^{195}_{79}Au_{116}$		192d	3/2	±0.147	1				F J
$^{196}_{79}Au_{117}$		6.2d	2	+0.588	6				F
$^{196}_{79}Au_{117}$	596	9.7h	12	±5.4					F J
$^{197}_{79}Au_{118}$			3/2	+0.14486	137	+0.59	∼+0.01		B E F G H
$^{197}_{79}Au_{118}$	77	1.9ns	[1/2]	+0.42					I
$^{198}_{79}Au_{119}$		2.7d	2	+0.590	6				F
$^{198}_{79}Au_{119}$	367	123ns	[3]	±3.6					J
$^{198}_{79}Au_{119}$	?	49h	[12?]	±5.6	1				J
$^{199}_{79}Au_{120}$		3.2d	3/2	+0.270	3				F
$^{200}_{79}Au_{121}$	?	18.7h	[12]	±6.1	1				E J
$^{183}_{80}Hg_{103}$		8.8s	1/2	+0.52					E H J
$^{185}_{80}Hg_{105}$		50s	1/2	+0.50					E H J
$^{187}_{80}Hg_{107}$		2.4m	3/2	−0.59	1	−0.3			H J

Summary of Nuclear Moment Values and Index – Continued

Nucleus	Level (keV)	$T_{1/2}$	I ($h/2\pi$)	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{193}_{80}Hg_{113}$		6h	3/2	−0.6236	60	-1^r			G H
$^{193}_{80}Hg_{113}$	140	11h	13/2	−1.052	10	$+1.2^r$			G H
$^{195}_{80}Hg_{115}$		9.5h	1/2	+0.538	5				G H
$^{195}_{80}Hg_{115}$	176	40h	13/2	−1.038	10	$+1.2^r$			G H
$^{197}_{80}Hg_{117}$		65h	1/2	+0.5241	51				G H
$^{197}_{80}Hg_{117}$	134	7.3ns	[5/2]	+0.96	1				J
$^{197}_{80}Hg_{117}$	299	24h	13/2	−1.0214	99	$+1.4^r$			G H
$^{198}_{80}Hg_{118}$			0♦						G
$^{198}_{80}Hg_{118}$	412	22.0ps	[2]	+1.1					J
$^{199}_{80}Hg_{119}$			1/2	$+0.50271^d$ (+0.50415)	485				G
$^{199}_{80}Hg_{119}$	158	2.32ns	[5/2]	+1.0		±0.7			J
$^{199}_{80}Hg_{119}$	533	44m	13/2	±1.0083	97	+2			H J
$^{200}_{80}Hg_{120}$			0♦						G
$^{200}_{80}Hg_{120}$	368	42ps	[2]	+0.9					J
$^{201}_{80}Hg_{121}$			3/2	-0.55671^d (−0.55830)	537	$+0.44^S$	−0.13		D E F G H
$^{202}_{80}Hg_{122}$			0♦						G
$^{202}_{80}Hg_{122}$	439	26ps	[2]	+1.2					J
$^{203}_{80}Hg_{123}$		47d	5/2	+0.86	1	+0.5			G H
$^{204}_{80}Hg_{124}$			0♦						G
$^{204}_{80}Hg_{124}$	437	46ps	[2]	+0.8					J
$^{205}_{80}Hg_{115}$		5.5m	1/2	+0.597	6				H J
$^{193}_{81}Tl_{112}$		23m	1/2						F
$^{194}_{81}Tl_{113}$		33m	2	±0.135	1				F
$^{195}_{81}Tl_{114}$		1.2h	1/2	+1.57	2				F G
$^{196}_{81}Tl_{115}$		1.8h	2	±0.0699	7				F
$^{197}_{81}Tl_{116}$		2.7h	1/2	+1.56	2				F G
$^{198}_{81}Tl_{117}$		5.3h	2	±0.00121	1				F
$^{198}_{81}Tl_{117}$	544	1.8h	7	±0.64	1				F
$^{199}_{81}Tl_{118}$		7.4h	1/2	+1.62	2				F G
$^{200}_{81}Tl_{119}$		26h	2	±0.03568	35				F G
$^{201}_{81}Tl_{120}$		72h	1/2	+1.65	2				F G
$^{202}_{81}Tl_{121}$		12d	2	±0.0565	6				F G
$^{202}_{81}Tl_{121}$	950	560μs	[7]	±0.90	1				J
$^{203}_{81}Tl_{122}$			1/2	+1.6115	158				E F G H
$^{203}_{81}Tl_{122}$	279	280ps	[3/2]	+0.16					J
$^{204}_{81}Tl_{123}$		3.9y	2	±0.089	1				F
$^{205}_{81}Tl_{124}$			1/2	+1.6274	160				E F G H
$^{206}_{81}Tl_{125}$		4.2m	0♦						F
$^{204}_{82}Pb_{122}$	1274	260ns	[4]	+0.22		±0.3			J
$^{205}_{82}Pb_{123}$	1014	5.55ns	[13/2]	−0.98	1				J
$^{206}_{82}Pb_{124}$			0♦						G
$^{206}_{82}Pb_{124}$	803	6ps	[2]	~0					J
$^{206}_{82}Pb_{124}$	2200	123μs	[7]	−0.152	1				J
$^{206}_{82}Pb_{124}$	2385	29ps	[6]	+0.8					J
$^{206}_{82}Pb_{124}$	4027	200ns	[12]	−1.86	2				J
$^{207}_{82}Pb_{125}$			1/2	$+0.5783^d$ (+0.5881)	58				E F G H
$^{207}_{82}Pb_{125}$	570	129ps	[5/2]	+0.8					J
$^{208}_{82}Pb_{126}$			0♦						G
$^{208}_{82}Pb_{126}$	2615	15ps	[3]	+1.8		−1.1			J K
$^{208}_{82}Pb_{126}$	3198	298ps	[5]	+0.10					J

Summary of Nuclear Moment Values and Index — Continued

Nucleus	Level (keV)	$T_{1/2}$	I $(h/2\pi)$	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{199}_{83}Bi_{116}$		25m	9/2						F
$^{200}_{83}Bi_{117}$		35m	7						F
$^{201}_{83}Bi_{118}$		1.8h	9/2						F
$^{202}_{83}Bi_{119}$		1.6h	5						F
$^{203}_{83}Bi_{120}$		12h	9/2	+4.59	5	-0.71^{r}			F
$^{204}_{83}Bi_{121}$		12h	6	+4.25	4	-0.46^{r}			F
$^{205}_{83}Bi_{122}$		15d	9/2	~+5.5					F
$^{206}_{83}Bi_{123}$		6.3d	6	+4.56	5	-0.21^{r}			F G
$^{207}_{83}Bi_{124}$	2102	182μs	[21/2]	+3.4					J
$^{209}_{83}Bi_{126}$		>2Ay	9/2	+4.080	41	-0.38^{S}	+0.5		D E F G
$^{210}_{83}Bi_{127}$		5d	1	−0.0442	4	$+0.14^{r}$			F
$^{211}_{83}Bi_{128}$	405	318ps	[7/2]	+4.4					J
$^{201}_{84}Po_{117}$		18m	3/2						F
$^{202}_{84}Po_{118}$		51m	0♦						F
$^{203}_{84}Po_{119}$		42m	5/2						F
$^{204}_{84}Po_{120}$		3.5h	0♦						F
$^{204}_{84}Po_{120}$	~1700	140ns	[8]	±7.8	1				J
$^{205}_{84}Po_{121}$		1.8h	5/2	≈+0.26		+0.17			F
$^{206}_{84}Po_{122}$		8.8d	0♦						F
$^{206}_{84}Po_{122}$	?	212ns	[8]	±7.4	1				J
$^{207}_{84}Po_{123}$		6.0h	5/2	≈+0.27		+0.28	+0.11		F
$^{207}_{84}Po_{123}$	1115	47μs	[13/2]	−0.93	1				J
$^{208}_{84}Po_{124}$	1530	380ns	[8]	±7.3	1				J
$^{209}_{84}Po_{125}$		103y	1/2	+0.77	1				G
$^{209}_{84}Po_{125}$	>1327	~100ns	[17/2?]	+7.5	1				J
$^{210}_{84}Po_{126}$		138d	0♦						F
$^{210}_{84}Po_{126}$	1472	38ns	[6]	±5.6	1				J
$^{210}_{84}Po_{126}$	1552	110ns	[8]	+7.3	1				J
$^{210}_{84}Po_{126}$	~2800	24ns	[11]	+12.0	1				J
$^{210}_{84}Po_{126}$	4372	93ns	[13]	±7.1	1				J
$^{211}_{84}Po_{127}$	1064	16ns	[15/2]	±0.4					J
$^{211}_{85}At_{126}$		7.2h	9/2						F
$^{211}_{85}At_{126}$	1416	50ns	[21/2]	±9.4	1				J
$^{211}_{85}At_{126}$	4816	4.2μs	[39/2	±14					J
			or 41/2]	±15					
$^{212}_{86}Rn_{126}$	~1700	1.0μs	[8]	±7.2	1				J
$^{222}_{86}Rn_{136}$	186	320ps	[2]	+0.9					J
$^{223}_{88}Ra_{135}$	50	630ps	[3/2]	+0.42					J
$^{227}_{89}Ac_{138}$		22y	3/2	+1.1		+1.7			G
$^{229}_{90}Th_{139}$		7.3ky	5/2	+0.38		~+4.6			G
$^{231}_{91}Pa_{140}$		34ky	3/2	±1.98	2				B G
$^{233}_{91}Pa_{142}$		27d	3/2	+3.4		−3.0			F
$^{233}_{92}U_{141}$		162ky	5/2	+0.64	1	$+4.2^{S}$			B G J
$^{235}_{92}U_{143}$		710My	7/2	−0.43		$+4.9^{r}$			B G J

Summary of Nuclear Moment Values and Index — Continued

Nucleus	Level (keV)	$T_{1/2}$	I ($h/2\pi$)	μ (nm)	Diam. Corr.	Q (b)	Ω (nmb)	Q_4 (b^2)	Index
$^{237}_{93}Np_{144}$		2.1My	5/2	+2.4[l]		positive			B G J
$^{237}_{93}Np_{144}$	60	63ns	[5/2]	+1.3[k]		$Q/Q_{gs}=+1.0$			I J
$^{238}_{93}Np_{145}$		2.1d	2						F
$^{239}_{93}Np_{146}$		2.3d	5/2						B F
$^{239}_{93}Np_{146}$	75	1.40ns	[5/2]	+1.3[k]					J
$^{239}_{94}Pu_{145}$		24ky	1/2	+0.200[l]	2				B F G
$^{241}_{94}Pu_{147}$		13y	5/2	−0.68[k]	1	+5.6			B G
$^{241}_{95}Am_{146}$		460y	5/2	+1.59	2	+4.9			B F G
$^{242}_{95}Am_{147}$		16h	1	+0.383	5	−2.8			F
$^{243}_{95}Am_{148}$		8ky	5/2	+1.59	2	+4.9			G
$^{242}_{96}Cm_{146}$		160d	0♦						F
$^{243}_{96}Cm_{147}$		28y	5/2	±0.4					B
$^{245}_{96}Cm_{149}$		8.26ky	7/2	±0.5					B
$^{247}_{96}Cm_{151}$		15.4My	9/2	±0.4					B
$^{249}_{97}Bk_{152}$		314d	7/2	±5		±5			G
$^{253}_{99}Es_{154}$		20.5d	7/2	+4.0		+6			B F G J

♦ No hyperfine structure observed
* Polarization or Sternheimer corrections included
[a] Weighted average
[b] Wide spread in tabulated values
[c] Atomic beam value of [59St46] adopted
[d] OP and NMR values discrepant. Values in ( )'s based on NMR values
[E] ENDOR and NMR values discrepant. Values in ( )'s based on NMR values
[f] ABMR and NMR values discrepant. Values in ( )'s based on NMR values
[g] No diamagnetic correction added. Not certain of corrections used by authors or if corrected.
[h] ABMR and ENDOR values discrepant. Values in [ ]'s based on ENDOR values
[i] Mössbauer and PAC values discrepant
[j] In the latest adjustment of fundamental constants [73CoTa], this value has been increased to 2.7928456 *11*.
[k] Relative value calculated from μ-ratio and μ^{l}
[l] Summary value upon which relative μ-values depend
[p] Preliminary value from meeting abstract, report, thesis or private communication
[r] Relative value calculated from Q-ratio and Q^{S}
[S] Summary value, average of tabulated values unless otherwise marked

5. Tables of Nuclear Moment Data

Table A: Neutron, Proton, and Anti–Proton Moments

Introduction

Since the methods used for the measurement of the moments of the proton, anti–proton, and neutron differ appreciably from those used for other particles, the available information is incorporated into a separate table. All methods involve an application of the principle of magnetic resonance.

Consider a particle with a spin quantum number $s=1/2$ with an associated magnetic dipole moment μ in a magnetic field H. The particle will become oriented in one of two possible states characterized by the magnetic quantum number $m=+1/2$ and $m=-1/2$. The behavior of the particle may be described semi–classically by saying that the spin vector precesses about H with a rotational frequency ν (Larmor frequency)

$$\nu=\gamma H/2\pi,$$

where the gyromagnetic ratio of the particle is $\gamma=2\pi\mu/sh$.

If, now, we introduce a weak magnetic field H_1 perpendicular to H and rotating about it with frequency ν, s will be forced to precess about H_1 as well as H and the particle will slowly change from the $m=+1/2$ to the $-1/2$ state and vice versa. It is this resonance between the applied rotation frequency of H_1 and the Larmor frequency of the particle that constitutes magnetic resonance.

Since the frequency can be measured with very high accuracy, the limitation in the determination of μ lies in the difficulty of measuring the field H. Absolute measurement of magnetic field is extremely difficult. Two alternate procedures have been adopted for the proton:

(1) The ratio of the proton precession frequency to the cyclotron frequency of either the free electron or the free proton is measured. The first yields the magnetic moment in terms of $eh/4\pi mc$, the Bohr magneton; the second, the moment in terms of the nuclear magneton, $eh/4\pi M_p c$.

(2) The proton precession frequency is measured in terms of the standard ampere which may be expressed in units of length, mass and time.

In computing the magnetic moment of the proton in nuclear magnetons from the measured quantities, the following conversion factors based on the fundamental constants in [69TaPa] have been used:

$$\gamma_p(\text{in rad}\cdot\text{s}^{-1}\cdot\text{T}^{-1})\times(1.043953\ \mathit{10})\times10^{-8}=\mu_p(\text{in nm}),$$

$$\mu_p(\text{in Bohr magnetons})\times(1836.109\ \mathit{11})=\mu_p(\text{in nm}).$$

Total diamagnetic corrections of +0.000073 nm for water samples or +0.000079 nm for oil samples, as given in [50Th06], have been added to the uncorrected proton moments. The uncertainties quoted in the table include the uncertainties in the conversion factors used.

Detailed descriptions of the techniques and measurements can be found in the original papers and in Laukien [58La04]. There is a good discussion of the various experiments for the measurement of the proton moment and their sources of error in Taylor, Parker and Langenberg's article on *The Fundamental Constants and Quantum Electrodynamics* [69TaPa] as well as in the earlier papers by Cohen and Dumond [66Co36, 65Co20].

The neutron magnetic moment is measured by passing a beam of polarized neutrons through a strong magnetic field and inducing a magnetic transition with a resonant rotating magnetic field. This transition causes a reversal of the polarization with a consequent decrease in the neutron intensity at the polarization analyzer–detector. The change in intensity serves to indicate the resonance condition. The uniform magnetic field is measured by a point–to–point determination of the proton precession frequency. This procedure yields a value of μ_n/μ_p subject to the correction for the chemical form of the hydrogen in the resonance probe.

The last systematic literature search for information included in the table was in early 1971.

Explanation of Table A

I	Nuclear spin, in units of $h/2\pi$
μ	Nuclear magnetic dipole moment, in nuclear magnetons, given with diamagnetic correction
Refer.	Reference key
Quantity Measured	Directly measured frequency ratio, magnetic moment, or gyromagnetic ratio in appropriate units These values are given without diamagnetic correction unless otherwise indicated.
Method (Compound)	Method by which frequency ratio, moment, or gyromagnetic ratio was measured Compound used for measurement

Table A: Neutron, Proton, and Anti-Proton Moments

I	μ	Refer.	Quantity Measured	Method (Compound)
			Neutron	
1/2		37S09		Slow neutron scattering from ortho- and para- H_2
	−2 *1*	38P08		Non-adiabatic transitions in a rotating magnetic field
	±1.913002 *80*	48B29	ω_n/ω_p=0.685001 *30*	Neutron beam resonance; NMR (H_2O)
1/2		50H67		Reflection from magnetized iron
	negative	50S88	μ_p/μ_n negative	Neutron beam resonance; NMR (H_2O)
1/2		54S90		Neutron beam resonance
	−1.913159 *47*	56C57	ω_n/ω_p=0.685057 *17*	Neutron beam resonance and proton resonance over same field (H_2O)
			Proton	
1/2		27D01		Specific heat
1/2		29M01		Band spectra
1/2		30H02		Band spectra
	+2.785 *2*	39K12		Molecular beam magnetic resonance (H_2,HD)
	±2.79283 *11*	49T01	$g/g_J(Cs,{}^2S_{1/2})=15.1911\times10^{-4}$ $g/g_J(In,{}^2P_{1/2})=45.6877\times10^{-4}$ $\mu_p=(15.2106^{a}\ 6)10^{-4}\mu_B$	Atomic and molecular beam magnetic resonance (NaOH)
	±2.79249 *20*	50B73 51J10	ω_p/ω_{cyc}=2.79242 *20*	NMR (H_2O); decelerating cyclotron
	positive	50S88		NMR (H_2O)
	±2.79288 *6* ±2.79292 *6* ±2.79292 *7* ±2.79291 *4*	50T07 (65Co20) (65Hu13) (69TaPa)	$\gamma_p=(2.67523\ 6)10^8 r\cdot s^{-1}T^{-1}$ $\gamma_p=(2.67534^{aC}\ 6)10^8 r\cdot s^{-1}T^{-1}$ $\gamma_p=(2.67527^{C}\ 6)10^8 r\cdot s^{-1}T^{-1}$ $\gamma_p=(2.675231^{fgh}\ 26)10^8 r\cdot s^{-1}T^{-1}$	NMR in magnetic field determined by force on straight wire carrying known current (H_2O); strong field measurement
	±2.79274 *4* ±2.79275 *4*	51G31 (69TaPa)	ω_e/ω_p=657.475 *8* $\mu_p=(15.20970\ 18)10^{-4}\mu_B$ $\mu_p=(15.21016^{a}\ 19)10^{-4}\mu_B$	NMR (oil); measured cyclotron frequency of free electrons
	 ±2.792787 *17*	52K32 (69TaPa)	$g_J(H,{}^2S_{1/2})/g_p$=658.2171 *6* $\mu_p=(15.210355^{a}\ 13)10^{-4}\mu_B$	ABMR and NMR (oil) in same field
	±2.792764 *60* ±2.792763 *60*	51S34 (69TaPa)	ω_p/ω_{cyc}=2.792685 *60* $\omega_p/\omega_{cyc}=2.792690^{f}$ *60*	NMR (oil); omegatron
	 ±2.792784 *17*	54Bell (69TaPa)	$g_J(H)/g$=658.21734 *19* $\mu_p=(15.2103347^{ai}\ 65)10^{-4}\mu_B$	Mic; NMR (cylinder of oil)

Table A: Neutron, Proton, and Anti–Proton Moments — Continued

I	μ	Refer.	Quantity Measured	Method (Compound)
	±2.79281 4	55C36	$\omega_p/\omega_{cyc}=2.79273\ 4$	NMR (H_2O); decelerating cyclotron
	±2.79275 10	56T19	$\omega_p/\omega_{cyc}=2.792675\ 100$	NMR ($H_2O+FeCl_3$); decelerating cyclotron
	±2.79315 8	56W41	$\gamma_p=(2.67549\ 8)10^{8}\mathrm{r{\cdot}s^{-1}T^{-1}}$	NMR in a field determined by the dimensions of and current in an iron–free coil (H_2O)
	 ±2.792788 17	57G89 (69TaPa)	$g_J(D)/g=658.2162\ 8$ $\mu_p=(15.210360^{ai}\ 23)10^{-4}\mu_B$	Mic; NMR (cylinder of oil)
	±2.79277 3 ±2.79277 2 ±2.79278 2	58Dr05 (65Co20) (65Hu13)	$\gamma_p=(2.67513\ 2)10^{8}\mathrm{r{\cdot}s^{-1}T^{-1}}$ $\gamma_p=(2.675192^{aC}\ 8)10^{8}\mathrm{r{\cdot}s^{-1}T^{-1}}$ $\gamma_p=(2.675137^{C}\ 11)10^{8}\mathrm{r{\cdot}s^{-1}T^{-1}}$	Free precession in the field of a standard solenoid (H_2O) See 68Dr06 below
	 ±2.79277 3	59H32 (69TaPa)	$\omega_e/\omega_p=657.4501$ $\mu_p=(15.210280^{ai}\ 12)10^{-4}\mu_B$	NMR (H_2)
	 ±2.792781 17	59L15 (69TaPa)	$g_J(H)/g=658.215909^{f}\ 44$ $\mu_p=(15.2099284^{fj}\ 10)10^{-4}\mu_B$	Mic ($H+H_2$+buffer gas)
	±2.79280 2 ±2.79281 2	59L54 (69TaPa)	$\omega_e/\omega_p=657.462\ 3$ $\mu_p=(15.21000\ 7)10^{-4}\mu_B$ $\omega_e/\omega_p=657.4620\ 45$ $\mu_p=(15.21046^{a}\ 10)10^{-4}\mu_B$	NMR (oil); measured cyclotron frequency of free electrons
	±2.79290 6	61Bo11	$\omega_{cyc}(H_2^+)/\omega_d=1.65957\ 28$ $\omega_p/\omega_d=6.514411\ 3$	cyclotron frequency of H_2^+ and NMR ($D_2O+CuCl_2{\cdot}2H_2O$) in same field; NMR ($D_2O+CuCl_2{\cdot}2H_2O$; $H_2O+CuCl_2$) Used $M_p/M(H_2^+)=0.49986388\ 50$
	±2.79288 10 ±2.79283 10 ±2.79288 10	61Ca20 (65Co20) (65Hu13)	$\gamma_p=(2.67530^{a}\ 10)10^{8}\mathrm{r{\cdot}s^{-1}T^{-1}}$ $\gamma_p=(2.67525^{aC}\ 10)10^{8}\mathrm{r{\cdot}s^{-1}T^{-1}}$ $\gamma_p=(2.67523^{C}\ 10)10^{8}\mathrm{r{\cdot}s^{-1}T^{-1}}$	NMR in known magnetic field
	±2.79277[b] 5 ±2.79277 7	63Sa04 (69TaPa)	$\omega_p/\omega_{cyc}=2.792676\ 50$ $\omega_p/\omega_{cyc}=2.79270^{f\ddagger}\ 7$	NMR ($H_2O+MnSO_4$); decelerating cyclotron ‡Includes additional corrections
	±2.79280 2 ±2.79281 15	63Sa05 (69TaPa)	$\omega_e/\omega_p=657.4621\ 25$ $\mu_p=(15.21043^{a}\ 6)10^{-4}\mu_B$ $\mu_p=(15.21046^{a}\ 84)10^{-4}\mu_B$	NMR (liquid paraffin); measured cyclotron frequency of free electrons
	±2.79277 2 ±2.79276 2 ±2.79278 2 ±2.79276 3	63Vi04 (65Co20) (65Hu13) (69TaPa)	$\gamma_p=(2.67513\ 1)10^{8}\mathrm{r{\cdot}s^{-1}T^{-1}}$ $\gamma_p=(2.675188^{aC}\ 8)10^{8}\mathrm{r{\cdot}s^{-1}T^{-1}}$ $\gamma_p=(2.675132^{C}\ 8)10^{8}\mathrm{r{\cdot}s^{-1}T^{-1}}$ $\gamma_p=(2.675144^{fg}\ 16)10^{8}\mathrm{r{\cdot}s^{-1}T^{-1}}$	NMR in weak magnetic field (H_2O)
	±2.79286 2	65Ma25 (69TaPa)	$\mu_p=2.79279\ 2$ $\mu_p=2.792794^{f}\ 17$	cyclotron frequency of $^{4}He^{+}$, $^{20}Ne^{2+}$. $^{20}Ne^{+}$; NMR ($H_2O+CuCl_2$)
	+3.0 3	66Be50	$\gamma_p=-(2.9\ 3)10^{8}\mathrm{r{\cdot}s^{-1}T^{-1}}$	NMR in weak rotating rf field (H_2O)
	±2.792782 17	66My01 (69TaPa)	$g_J(H,{}^{2}S_{1/2})/g=658.21049\ 20$ $\mu_p=(15.210326\ 4)10^{-4}\mu_B$ $g_J(H)/g=658.21053^{d}\ 20$	MASER See 70Wi22 below

Table A: Neutron, Proton, and Anti-Proton Moments — Continued

I	μ	Refer.	Quantity Measured	Method (Compound)
	±2.79273	66Ya07	γ_p=(2.675071)10^8r·s^{-1}T^{-1}	NMR in strong field (H_2O)
	±2.79274[C]		γ_p=(2.67510[C])10^8r·s^{-1}T^{-1}	
	±2.79277 *4*	(69TaPa)	γ_p=(2.675105[fg] *20*)10^8r·s^{-1}T^{-1}	
	±2.79267 *12*	67Ma17		Determined from existing time-of-flight and magnetic analysis data on ^{27}Al(p,γ)^{28}Si resonanace and ^{7}Li(p,n)^{7}Be threshold
	±2.79267[d] *13*	(69TaPa)	μ_p=2.79260[df] *13*	
	±2.79281 *5*	67Pe09	ω_p/ω_{cyc}=2.79274 *5*	NMR (H_2O); omegatron (H_2^+; HD^+; D_2^+)
	±2.792773	68Dr06	γ_p=(2.6751526)10^8r·s^{-1}T^{-1}	Free precession in the field of a standard solenoid (H_2O)
		(69TaPa)	γ_p=(2.6751465[fg])10^8r·s^{-1}T^{-1}	[Fredericksburg, Va. 1958]
		(69TaPa)	γ_p=(2.6751555[fg])10^8r·s^{-1}T^{-1}	[Washington, D.C., 1960–1967]
		(69TaPa)	γ_p=(2.6751526[fg])10^8r·s^{-1}T^{-1}	[Gaithersburg, Md. 1968]
	±2.792773 *30*	(69TaPa)	$\gamma_{p,ave}$=(2.6751525[fg] *99*)10^8r·s^{-1}T^{-1}	
	±2.79276 *3*	68Ha49	γ_p=(2.675138 *11*)10^8r·s^{-1}T^{-1}	Free precession in an air-core field-coil system (H_2O)
		(69TaPa)	γ_p=(2.6751392[fg] *86*)10^8r·s^{-1}T^{-1}	
	±2.792782 *18*	68Kl02	ω_p/ω_e=(15.2099441 *11*)10^{-4}	NMR (H_2O+0.2M $CuSO_2$ in cylinder); cyclotron resonance of electron
			ω_p/ω_e=(15.210329 *9*)10^{-4}	
	±2.79278 *3*	68St27	γ_p=(2.675162 *14*)10^8r·s^{-1}T^{-1}	Free precession in field of Helmholtz coils (H_2O)
	±2.79275	(69TaPa)	γ_p=(2.6751349[fg])10^8r·s^{-1}T^{-1}	
		69Te08	γ_p=(2.67512)10^8r·s^{-1}T^{-1}	Value adopted by BIPM for spherical sample of H_2O
	±2.792766 *15*	70Wi22	g_J(H)/g_p(H)=658.210705[j] *6*	MASER (atomic H)
			Anti-Proton	
	-1.8 *12*	62Bu19		Double scattering

[a] Includes diamagnetic correction
[b] Includes diamagnetic and paramagnetic corrections
[C] Corrected for standard BIPM ampere
[d] Includes corrections sent by experimenters to compilers 65Co20 or 69TaPa
[e] Value corrected for solution concentration, shape of holder, and shielding of electrons and neighboring molecules
[f] For spherical container of H_2O
[g] In terms of NBS as-maintained Ampere
[h] Includes corrections for better values of "g", the acceleration of gravity, and the diamagnetic correction
[i] Calculated using μ_e=1.001159639μ_B, g_J=g_S(1 −17.75 ppm), σ(H_2)=26.6 *3* ppm, σ(H_2O)=26.0 *3* ppm, and σ(oil)=29.7 *6* ppm
[j] Calculated using g_J(H)/g_p(H)=(g_S/g_p)(1−0.204 ppm). See [69TaPa], page 324.

Table B: Nuclear Moments by Paramagnetic Resonance

Introduction

Paramagnetic resonance provides a means of studying the Zeeman levels of a paramagnetic system which may be ionic, atomic, or molecular. The sample can be in the form of a gas, crystal, or solution. To be paramagnetic the system must have one or more electrons which are magnetically unpaired.

When the sample is placed in an external magnetic field, the interaction of the electron with the field causes a splitting of the electronic states. The interaction of the electron with the nuclear magnetic moment causes each of these states to be split again into $2I+1$ levels (see figure 1). In practice, the sample is placed in a resonant microwave cavity in the region where the microwave magnetic field is perpendicular to the external magnetic field. The microwave frequency ν_0 is maintained constant and equal to the natural frequency of the cavity while the external field is varied slowly. When the energy difference between two levels, for which a transition is allowed, satisfies the condition $|E_2-E_1|=h\nu_0$, an absorption of microwave energy is observed.

The nuclear spin I is indicated by the multiplicity $(2I+1)$ of the spectrum. The magnetic moment can be calculated from the spacing of the resonance lines if wavefunctions for the electrons for the appropriate atom or ion are available. The ratio of the magnetic moments of two isotopes can be determined simply from the relative splitting factors of the respective resonance patterns. If the nuclear magnetic moment of one isotope is known from a technique such as nuclear magnetic resonance, which gives a rather precise value of the magnetic moment, the moment of the second isotope can be determined from the ratio with greater accuracy than by direct calculation.

A variation of the paramagnetic resonance method for the determination of g_I is the Electron–Nuclear Double Resonance (ENDOR) experiment described by Feher [56Fe43] and by Pipkin and Culvahouse [58Pi43]. In a strong field the ground–state energy level is split into states specified by m_J and m_I. Figure 2 represents a typical splitting for a case in which $J=1/2$ and $I=1$. The transition labeled A, $(m_J=+1/2, m_I=-1) \leftrightarrow (m_J=-1/2, m_I=-1)$, can be induced to saturation with a strong microwave signal. The transition labeled B, $(+1/2,0) \leftrightarrow (+1/2,-1)$, can be induced by an appropriate radio frequency signal, which then decreases the population of the $(+1/2,-1)$ state and increases the microwave absorption. Similarly, the transition labeled C, $(-1/2,-1) \leftrightarrow (-1/2,0)$, can be induced and detected. Since the difference between pairs of m_I transition frequencies such as these depends only upon the interaction of the nuclear moment with the external field, the nuclear g_I–value can be calculated directly.

The interaction of the nuclear quadrupole moment with an inhomogeneous electric field at the nucleus causes second–order shifts in the levels, from which the quadrupole coupling constant can be determined. The evaluation of the quadrupole moment from the coupling constant depends upon a calculation of the field inhomogeneity at the nucleus, which may be uncertain by a few percent. In addition, the nuclear electric quadrupole moment causes a polarization of the atomic core electrons (Sternheimer effect) which can affect the evaluation of the field gradient by tens of percent.

A very thorough discussion of the method and theory can be found in a recent book by Abragam and Bleaney [70Ab20]. Earlier helpful reviews include those by Low [60Lo05] and Bowers and Owen [55Bo56]. Data on observed g_J or splitting factors have been omitted intentionally since these are characteristic of the lattice as well as the nucleus in question. Paramagnetic resonance data on crystals are given by Bowers and Owen [55Bo56], Orton [59Or36] and Konig [66Ko25].

The last systematic literature search for information included in the table was in early 1971.

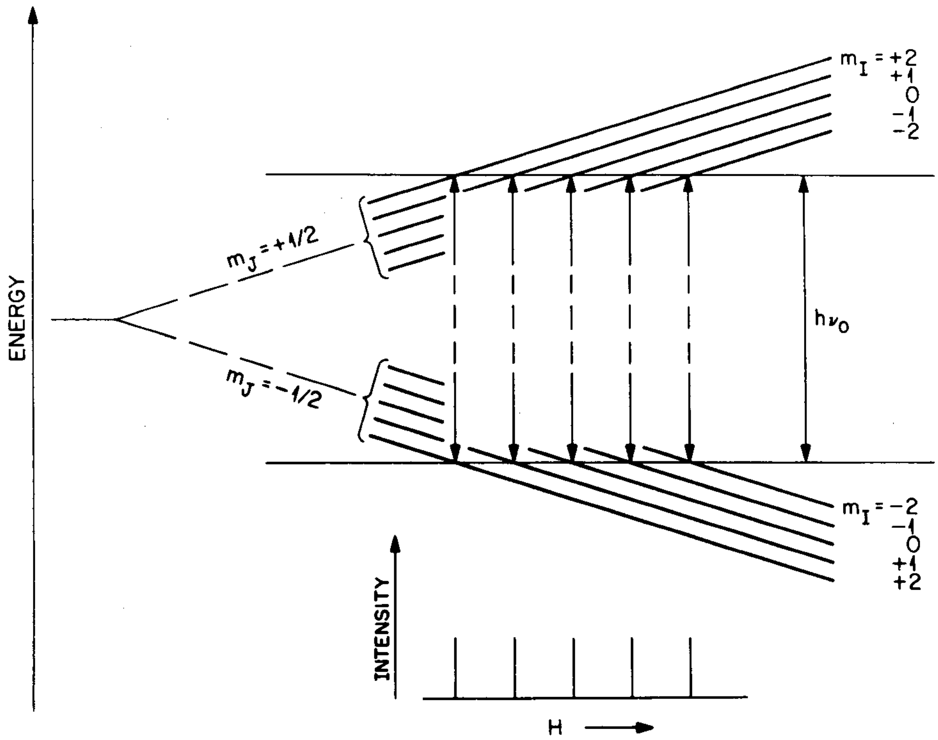

FIGURE 1. Schematic Zeeman energy level diagram for a state with $J=1/2$, $I=2$. The applied magnetic field H increases to the right. The spectrum for the hyperfine components of an $m_J=+1/2 \leftrightarrow -1/2$ transition is shown below.

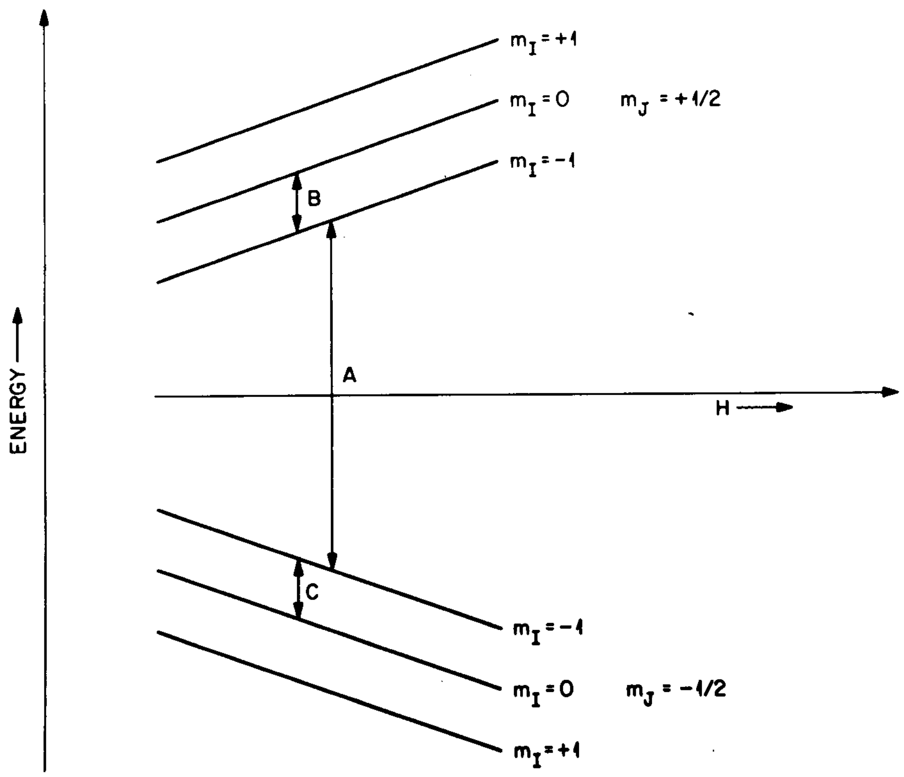

FIGURE 2. Schematic diagram of the energy levels and transitions involved in a typical ENDOR experiment. Transition A ($\Delta m_J = \pm 1$) is saturated by an intense microwave signal. The application of an rf field makes possible the observation of transitions B and C ($\Delta m_I = \pm 1$), from which g_I may be determined.

Explanation of Table B

Nucleus	Chemical symbol with $Z-$ and $A-$numbers
$T_{1/2}$	Half-life of radioactive nucleus
I	Nuclear spin, in units of $h/2\pi$
μ	Nuclear magnetic dipole moment, in nuclear magnetons, given with diamagnetic correction. See Policies, Diamagnetic corrections, for factors used
Q	Nuclear electric quadrupole moment, in barns, as given by the experimenter Values marked by an asterisk, *, indicate that the experimenter has made some polarization or Sternheimer correction in computing the moment.
Refer.	Reference key
μ^1/μ^2	Ratio of the magnetic moments of the indicated pair of nuclei as determined by the relative spread of the resonance pattern or by the ratio of the magnetic interaction constants Values marked with an 'e' are determined from the $g-$values.
Valence and Lattice	The valence of the paramagnetic ion and the chemical formula of the crystal used For diluted crystals, the chemical symbol of the element which is replaced by the element under study is italicized. The number of waters of crystallization is represented by the italicized number following the dot. Example: $\mathit{Zn}K_2(SO_4)_2 \cdot \mathit{6}$ for ^{56}Co indicates that a small fraction of the Zn atoms are replaced by ^{56}Co atoms.

Table B: Nuclear Moments by Paramagnetic Resonance

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	μ^1/μ^2	Valence and Lattice
$^{1}_{1}$H					56W46	$\Delta\nu(^2S_{1/2})$=1420.40580 *6* MHz	
$^{14}_{7}$N				±0.014^c	65Ev09		N impurity in diamond
$^{14}_{7}$N				+0.057 to 0.011‡	65Lo12		N impurity in diamond
						‡Depends upon choice of q, the field gradient at the nucleus	
$^{17}_{8}$O				−0.026* *3*	57K27		Atomic O
$^{17}_{8}$O				−0.0205^c	62Ko22		
$^{17}_{8}$O				−0.0256*^{c}*5*	68Sc18 (65Ha35)	a=−219.61 *5*MHz b=−10.438 *30*MHz a=4.738 *36*MHz b=5.199 *90*MHz	$^3P_2$state $^3P_1$state atomic ^{17}O gas
$^{17}_{8}$O				−0.025*^{c}*3*	69Go12 (65Ha35)		atomic ^{17}O gas
$^{17}_{8}$O				−0.0263*^{c}	69Ke07 (65Ha35)		atomic ^{17}O gas
$^{17}_{8}$O				−0.02578*^{c}	69Sc34 (65Ha35)		
$^{19}_{9}$F					61Ra14	$\Delta\nu(^2P_{3/2})$=4020.01 *2*MHz	
$^{25}_{12}$Mg		5/2			57W13		MgO, irradiated
$^{31}_{15}$P		1/2			54F41		P doped Si
$^{31}_{15}$P			±1.133^E *1*		69Se11		$(PO_4)^{2-}$or $(PO_3)^{2-}$ natural $CaCO_3$ crystal
$^{32}_{15}$P	14d	1	−0.2523^E *3*		57F32		^{32}P in Si plates
$^{33}_{16}$S		3/2^E			65Lu06		1+ S doped Si
$^{47}_{22}$Ti		5/2			61Ga16		3+ $^{47}Ti_2(SO_4)_3$
$^{47}_{22}$Ti		5/2			62Mc05		3+ Al acetylacetonate
$^{47}_{22}$Ti		5/2			62Wa03		3+ $TiCl_3$
$^{47}_{22}$Ti					68Lo05	$^{47}/_{49}$=1.400 *1*	3+ CaF_2
$^{49}_{22}$Ti		7/2			61Ga16		3+ $^{49}Ti_2(SO_4)_3$
$^{49}_{22}$Ti		7/2			62Mc05		3+ Al acetylacetonate
$^{49}_{22}$Ti		7/2			62Wa03		3+ $TiCl_3$
$^{49}_{23}$V	330d	7/2^P	±4.5^P		57W17		4+ V−cupferron chelate
$^{50}_{23}$V	>40Jy	6	±3.34 *1*		52B63	$^{50}/_{51}$=0.651 *2*	2+ $K_4Fe(CN)_6\cdot 3$
$^{50}_{23}$V	>40Jy	6	±3.346 *8*		53K41	$^{50}/_{51}$=0.6501 *14*	2+ $Zn(NH_4)_2(SO_4)_2\cdot 6$
$^{51}_{23}$V		7/2			51B43		2+ $Zn(NH_4)_2(SO_4)_2\cdot 6$
$^{51}_{23}$V		7/2			52B63		2+ $K_4Fe(CN)_6\cdot 3$
$^{53}_{24}$Cr		3/2	±0.58		52B66		3+ $K_3Co(CN)_6$
$^{53}_{24}$Cr			±0.475		57L50		3+ MgO
$^{53}_{24}$Cr				−0.03^E‡	61Te01		3+ Al_2O_3
						‡Magnitude and even sign may be wrong, from comparison of hyperfine fields and electric field gradients for impurities in corundum [63La16]	
$^{53}_{24}$Cr				<+0.05^{Ec} ~0.024^c	64Ar23		3+ Al_2O_3
$^{53}_{24}$Cr			−0.4735^E‡ *4*		67Wo04		3+ MgO at 4.2°K
						‡Includes estimated paramagnetic correction	

Table B: Nuclear Moments by Paramagnetic Resonance – Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	μ^1/μ^2	Valence and Lattice	
$^{52}_{25}$Mn	5.7d	6	±2.97 *15*		61Je04	$^{52}/_{55}$=0.86 *4*	2+	$La_2Mg_3(NO_3)_{12}$· *24*
$^{53}_{25}$Mn	2My	7/2	±5.018 *7*		56D45	$^{53}/_{55}$=1.455 *2*	2+	powdered $SrCl_2$
$^{54}_{25}$Mn	290d	3	±3.28 *6*		61Je04	$^{54}/_{55}$=0.952 *18*	2+	$La_2Mg_3(NO_3)_{12}$· *24*
$^{55}_{25}$Mn		5/2			51B30		2+	$ZnSiF_6$· *6*
$^{55}_{25}$Mn			±3.469^E *6*		60Lu02		1–	Mn in Si
$^{55}_{25}$Mn				±0.20 *4*	60Sc17		3+	K_2CrO_4 crystal
$^{55}_{25}$Mn			±3.4		65Ik01		2+	Mn doped $BaTiO_3$
$^{55}_{25}$Mn			+3.4486 *15*		67Dy02		2+	MgO at 4.2°K
$^{55}_{25}$Mn			+3.444^E *6*		67Es04		2+	MgO
$^{55}_{25}$Mn			±3.4502^E*23*		67Mi04	$\gamma/2\pi$=10.500 *7* kHz/gauss	2+	$CaWO_4$, CaO, ZnS
$^{57}_{26}$Fe		1/2			57G16		3+	$FeCl_3$ and Borax
$^{57}_{26}$Fe		1/2			58L64			Fe doped Si
$^{57}_{26}$Fe			+0.0905^E *7*		60Lu02		0	Fe doped Si
$^{57}_{26}$Fe			+0.09042^E *7*		65Lo11		3+	Fe_2O_3 diffused in MgO
$^{57}_{26}$Fe			±0.09054^E *15*		70Ca15		3+	natural Fe impurity in CaO
$^{56}_{27}$Co	77d	4	±3.822 *15*		56B69	$^{56}/_{59}$=0.828 *3*	2+	$ZnK_2(SO_4)_2$· *6*
$^{56}_{27}$Co	77d	4	±3.831 *12*		56J06	$^{59}/_{56}$=1.205 *2*	2+	$ZnK_2(SO_4)_2$· *6*
$^{57}_{27}$Co	270d	7/2	±4.62 *4*		56B69	$^{57}/_{59}$=1.00 *1*	2+	$ZnK_2(SO_4)_2$· *6*
$^{58}_{27}$Co	71d	1,2?	±4.032 *14*		57D38	$^{58}/_{59}$=0.8734 *24* $^{58}/_{60}$=1.0645 *20*	2+	$ZnK_2(SO_4)_2$· *6*
$^{59}_{27}$Co		7/2			51B38		2+	$Zn(NH_4)_2(SO_4)_2$· *6*
$^{60}_{27}$Co	5.3y	5	±3.781 *11*		56D08	$^{60}/_{59}$=0.8191 *16*	2+	$Zn(NH_4)_2(SO_4)_2$· *6*
$^{60}_{27}$Co	5.3y		±3.787 *18*		57D38	$^{58}/_{60}$=1.0645 *20*	2+	$ZnK_2(SO_4)_2$· *6*
$^{61}_{28}$Ni		3/2			58W52			Ni, As doped Ge
$^{61}_{28}$Ni			±0.9^c		62Be15		2+	Ni doped Ge
								Ni doped MgO
$^{61}_{28}$Ni			±0.748^E *7*		63Lo05		2+	Al_2O_3
$^{63}_{29}$Cu				±0.11	51A28		2+	Tutton salts
$^{63}_{29}$Cu				–0.16 *3*	55B21		2+	$La_2Mg_3(NO_3)_{12}$· *24*
$^{63}_{29}$Cu					63Bl27	A^{63}/A^{65}=0.933559^E *7*	3+	Al_2O_3
$^{63}_{29}$Cu					68Ma22	$^{63}/_{65}$=0.9328 *8*	2+	$Mg(C_2H_3O_2)_2$
$^{63}_{29}$Cu				–0.15 *2*	69Ri07		2+	$ZnWO_4$
$^{65}_{29}$Cu				±0.11	51A28		2+	Tutton salts
$^{65}_{29}$Cu				–0.15 *3*	55B21		2+	$La_2Mg_3(NO_3)_{12}$· *24*
$^{65}_{25}$Cu					67Ga03	$^{65}/_{63}$=1.063 *2*	2+	doped $ZnWO_4$ crystal
$^{65}_{29}$Cu				0.14 *2*	69Ri07		2+	$ZnWO_4$
$^{75}_{33}$As		3/2			54F41			As doped Si
$^{76}_{33}$As	26.5h	2(1?)	–0.903 *5*		58P43	$^{76}/_{75}$=–0.6293 *4*		As doped Si
$^{87}_{38}$Sr		9/2		+0.154	65Cu05			n irradiated SrO crystal
$^{93}_{41}$Nb			±6.17 *16*		69Ki19		4+	$CaWO_4$
$^{95}_{42}$Mo		5/2			56O04		5+	$K_3(InCl_6)$· *2*
$^{97}_{42}$Mo		5/2			56O04		5+	$K_3(InCl_6)$· *2*
$^{99}_{43}$Tc	210ky	9/2			58L62		4+	K_2PtCl_6 crystal
$^{99}_{44}$Ru		5/2			52G19	$^{101}/_{99}$=1.09 *3*	3+	$Co(NH_3)_6Cl_3$
$^{99}_{44}$Ru					68Ya06	$^{101}/_{99}$=1.12	3+	TiO_2(4.2°K)
$^{101}_{44}$Ru		5/2			52G19		3+	$Co(NH_3)_6Cl_3$

Table B: Nuclear Moments by Paramagnetic Resonance — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	μ^1/μ^2	Valence and Lattice
$^{110m}_{47}Ag$	253d	6	±3.55‡ *4*		66Ea01		2+ $[(iso-C_3H_7)_2NCS_2]Ag$
						‡Includes Δ(hfs anomaly) correction=(3.7 *10*)%	
$^{119}_{50}Sn$					67Su06	$^{119}/_{117}$=1.046 *2*	3+ Sn doped ZnS
$^{121}_{51}Sb$			±3.3600^E *17*		58E03	$^{121}/_{123}$=1.31437 *6*	Sb doped Si
$^{122}_{51}Sb$	2.8d	2	−1.904^E *20*		58P45	$^{122}/_{121}$=−0.5678 *4*	Sb doped Si
$^{123}_{51}Sb$			±2.5484^E *10*		58E03		Sb doped Si
$^{141}_{58}Ce$	33d	7/2	±0.89 *9*		57K13		3+ $La_2Mg_3(NO_3)_{12}\cdot 24$
$^{141}_{58}Ce$	33d		±1.18^c *12*		62Li06		
$^{141}_{58}Ce$	33d		±0.968^c *30*		63Bl25		
$^{141}_{59}Pr$		5/2			51D28		3+ $PrCl_3\cdot 7$
$^{141}_{59}Pr$		5/2	±3.94 *20*		58B35		3+ $Y(C_2H_5SO_4)_3\cdot 9$
$^{141}_{59}Pr$		5/2	±4.6		58Hu17		3+ $LaCl_3$
$^{141}_{59}Pr$			±4.0^c		62Fr14		
$^{141}_{59}Pr$			±5.1^c *3*		62Li06 (58B35)		
$^{141}_{59}Pr$			±4.24^c *10*		63Bl25		
$^{143}_{60}Nd$		7/2	±1.04	±<1	55Bl51	$^{143}/_{145}$=±1.6083 *12*	3+ $La(C_2H_5SO_4)_3\cdot 9$
$^{143}_{60}Nd$		7/2			57K13	$^{143}/_{145}$=±1.614 *2*	3+ $La_2Mg_3(NO_3)_{12}\cdot 24$
$^{143}_{60}Nd$		7/2	±1.1		58Hu17		3+ $LaCl_3$
$^{143}_{60}Nd$			±0.99^c		62Fr14		
$^{143}_{60}Nd$			−1.086^E *60*	+0.0206 *30*	62Ha29		3+ $LaCl$
$^{143}_{60}Nd$			±1.24^c *20*		62Li06 (55Bl51)		
$^{143}_{60}Nd$			±1.10 *10*		66Er08	$^{143}/_{145}$=1.60892 *10*	3+ $LaCl_3$ at 14,4·K;H_o=0
						=1.60886 *29*	3+ $La(C_2H_5SO_4)_3\cdot 9$ at 4°K;
						Q^{143}/Q^{145}=−‡1.45 *65*	H_o=0
						‡Some confusion of signs in paper	
$^{145}_{60}Nd$		7/2	±0.64	±<1	55Bl51		3+ $La(C_2H_5SO_4)_3\cdot 9$
$^{145}_{60}Nd$		7/2	±0.7		58Hu17		3+ $LaCl_3$
$^{145}_{60}Nd$			+0.675^E *40*	+0.0105 *20*	62Ha29	$^{143}/_{145}$=+1.60883 *4*	3+ $LaCl$
						Q^{143}/Q^{145}=+1.96 *2*	
$^{145}_{60}Nd$			±0.77^c *20*		62Li06 (55Bl51)		
$^{145}_{60}Nd$			±0.68 *7*		66Er08		3+ $LaCl_3;H_o$=0
							3+ $La(C_2H_5SO_4)_3\cdot 9$; H_o=0
$^{147}_{60}Nd$	11d	5/2	±0.56 *6*		57K13	$^{143}/_{147}$=±1.844 *2*	3+ $La_2Mg_3(NO_3)_{12}\cdot 24$
$^{147}_{60}Nd$	11d		±0.589 *30*		62Ha29	($^{143}/_{147}$=1.844 *2*)	
$^{147}_{60}Nd$	11d		±0.67^c *7*		62Li06		
$^{147}_{61}Pm$	2.6y	7/2	±3.0 *3*		61St18		3+ $La(C_2H_5SO_4)_3\cdot 9$
$^{147}_{61}Pm$	2.6y		±2.55^c *6*		63Bl25		
$^{147}_{62}Sm$		7/2			52B21	$^{147}/_{149}$=±1.222 *8*	3+ $La(C_2H_5SO_4)_3\cdot 9$
$^{147}_{62}Sm$			±0.83 *15*	±<0.7	55Bl51		3+ $La(C_2H_5SO_4)_3\cdot 9$
$^{147}_{62}Sm$		7/2	±0.86		58Hu17		3+ $LaCl_3$
$^{147}_{62}Sm$			±0.85^c		62Fr14		
$^{147}_{62}Sm$			±1.04^c *18*		62Li06 (55Bl51)		
$^{147}_{62}Sm$			±0.812^c *22*		63Bl25		
$^{149}_{62}Sm$		7/2			52B21		3+ $La(C_2H_5SO_4)_3\cdot 9$
$^{149}_{62}Sm$			±0.68 *10*	±<0.7	55Bl51		3+ $La(C_2H_5SO_4)_3\cdot 9$
$^{149}_{62}Sm$		7/2	±0.75		58Hu17		3+ $LaCl_3$

Table B: Nuclear Moments by Paramagnetic Resonance — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	μ^1/μ^2	Valence and Lattice
${}^{149}_{62}\mathrm{Sm}$			$\pm0.85^{c}$ *15*		62Li06 (55Bl51)		
${}^{149}_{62}\mathrm{Sm}$			$\pm0.656^{c}$ *18*		63Bl25		
${}^{151}_{63}\mathrm{Eu}$		5/2			55B16	${}^{151}/_{153}=\pm2.24$ *3*	2+ SrS phosphor
${}^{151}_{63}\mathrm{Eu}$					57A05	${}^{151}/_{153}=\pm2.264$ *6*	2+ KCl powder
${}^{151}_{63}\mathrm{Eu}$		5/2			57M19	${}^{151}/_{153}=+2.24$	2+ SrS•Eu
${}^{151}_{63}\mathrm{Eu}$			$+3.465^{E}$ *2*		62Ba12	${}^{151}/_{153}=2.2632^{E}$ *26* ${}^{151}/_{153}=2.25313$ *15*	2+ *CaF*$_2$
${}^{151}_{63}\mathrm{Eu}$					69Ab12	${}^{151}/_{153}=2.263$ *14* $Q^{151}/Q^{153}=0.391$ *8*	2+ *ThO*$_2$ at <77°K
${}^{151}_{63}\mathrm{Eu}$			$+3.468\ddagger^{E}$ *2*		70Ki13	${}^{151}/_{153}=2.266^{E}$ *5* $A^{151}/A^{153}=2.2533$ *3* $Q^{151}/Q^{153}=0.39198$ *12*	2+ *CaWO*$_4$
						‡Spherical average; g_I anisotropic. Note: Assuming a linear dependence of g and g_I on $Q^{\circ}_{\circ}$, the spherical average quadrupole coupling, they get $g=2.0027$ and $\mu_{cor}=3.454$ at $Q^{\circ}_{\circ}=0$.	
${}^{152}_{63}\mathrm{Eu}$	13y	3	±1.93 *2*		57A05	${}^{152}/_{151}=\pm0.5574$ *60*	2+ KCl powder
${}^{152}_{63}\mathrm{Eu}$	13y	3	±1.96 *2*		57M19	${}^{151}/_{152}=\pm1.77$ *2*	2+ SrS•Eu
${}^{153}_{63}\mathrm{Eu}$		5/2	±1.55 *2*		55B16	${}^{151}/_{153}=2.24$ *3*	2+ SrS phosphor
${}^{153}_{63}\mathrm{Eu}$			$+1.531^{E}$ *2*		62Ba12		2+ *CaF*$_2$
${}^{153}_{63}\mathrm{Eu}$			$+1.531\ddagger^{E}$ *3*		70Ki13	‡Spherical average; g_I anisotropic.	
${}^{154}_{63}\mathrm{Eu}$	16y	3	±2.000 *6*		57A05	${}^{154}/_{153}=\pm1.308$ *4*	2+ KCl powder
${}^{155}_{64}\mathrm{Gd}$		3/2	±0.23 *2*		56L29	${}^{155}/_{157}=\pm0.75$ *7*	3+ *Bi*$_2$Mg$_3$(NO$_3$)$_{12}$•*24*
${}^{155}_{64}\mathrm{Gd}$		3/2	±0.240 *4*		57M55	${}^{155}/_{157}=\pm0.736$ *12*	3+ SrS•^{155}Gd
${}^{155}_{64}\mathrm{Gd}$					59L63	${}^{155}/_{157}=\pm0.7495$ *45*	3+ ThO$_2$•Gd
${}^{155}_{64}\mathrm{Gd}$					60He17	${}^{155}/_{157}=\pm0.763$ *6*	3+ *CaWO*$_4$
${}^{155}_{64}\mathrm{Gd}$			$\pm0.28^{c}$ *4*		63Bl25		
${}^{155}_{64}\mathrm{Gd}$			-0.254 *3*		65Hu14	(${}^{155}/_{157}=0.7495$ *45*)	3+ *ThO*$_2$
${}^{155}_{64}\mathrm{Gd}$					67Ma56	${}^{155}/_{157}=0.7628$ *8*	3+ *ThO*$_2$ crystal
${}^{155}_{64}\mathrm{Gd}$					68Ma48	${}^{155}/_{157}=0.7624$ *10*	3+ *CaCO*$_3$
${}^{155}_{64}\mathrm{Gd}$			-0.2585^{E} *6*		69Ba15	${}^{155}/_{157}=0.7633^{E}$ *45* $A^{155}/A^{157}=0.7621$ *5*	3+ *CeO*$_2$ crystal
${}^{155}_{64}\mathrm{Gd}$					70Ra42	$Q^{155}/Q^{157}=0.94$ *1*	3+ *YPO*$_4$crystal
${}^{157}_{64}\mathrm{Gd}$		3/2	$\pm0.306\ddagger$		56L29	^{151}Eu/^{157}Gd$=\pm11.3$ ‡Used $\mu({}^{151}\mathrm{Eu})_{uncorrected}=3.440$ *1*	3+ *Bi*$_2$Mg$_3$(NO$_3$)$_{12}$•*24*
${}^{157}_{64}\mathrm{Gd}$		3/2	$\pm0.327\ddagger$ *1*		57M55	^{151}Eu/^{157}Gd$=\pm10.60$ *3* ‡Used $\mu({}^{151}\mathrm{Eu})_{uncorrected}=3.440$ *1*	3+ SrS•^{157}Gd
${}^{157}_{64}\mathrm{Gd}$			$\pm0.38^{c}$ *5*		63Bl25		
${}^{157}_{64}\mathrm{Gd}$			-0.339^{E} *3*		65Hu14		3+ *ThO*$_2$ crystal
${}^{157}_{64}\mathrm{Gd}$			-0.3381^{E} *6*		69Ba15		3+ *CeO*$_2$ crystal
			-0.3395^{E} *6*				3+ *ThO*$_2$
${}^{157}_{65}\mathrm{Tb}$	>30y	[3/2]	±2.0 *1*		68Ea04		3+ *Y*(C$_2$H$_5$SO$_4$)$_3$•9
${}^{158}_{65}\mathrm{Tb}$	150y	3	±1.753 *7*	$+2.7$ *5*	68Ea04		3+ *Y*(C$_2$H$_5$SO$_4$)$_3$•9
${}^{159}_{65}\mathrm{Tb}$		3/2	±1.52 *8*		58B35		3+ *Y*(C$_2$H$_5$SO$_4$)$_3$•9
${}^{159}_{65}\mathrm{Tb}$		3/2	±1.5		58Hu17		3+ *LaCl*$_3$
${}^{159}_{65}\mathrm{Tb}$			$\pm1.90^{c}$		62Li06 (58B35)		
${}^{159}_{65}\mathrm{Tb}$			$\pm1.90^{c}$ *5*		63Bl25		
${}^{159}_{65}\mathrm{Tb}$			±1.6 *2*		63Lo07	Used $\langle r^{-3}\rangle$ of Lindgren	3+ *CaF*$_2$
${}^{159}_{65}\mathrm{Tb}$			$+2.008^{E}$ *4*		65Ba49		4+ *ThO*$_2$
${}^{160}_{65}\mathrm{Tb}$	72d		±1.697 *8*	$+3.0$ *5*	68Ea04		3+ *Y*(C$_2$H$_5$SO$_4$)$_3$•9

Table B: Nuclear Moments by Paramagnetic Resonance — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	μ^1/μ^2	Valence and Lattice
$^{161}_{66}$Dy		5/2	−?0.37 4	+?1.1 4	58P11	$^{163}/_{161}$=−1.39 2 Q^{163}/Q^{161}=+1.18 15	3+ $La_2Mg_3(NO_3)_{12}$•24
$^{161}_{66}$Dy			±0.46^c 5		62Li06		
$^{161}_{66}$Dy			±0.455^c 10	+1.35^c 30	63Bl25		
$^{161}_{66}$Dy			−?0.46^c 4		65Of03		3+ $La_2Mg_3(NO_3)_{12}$•24
$^{161}_{66}$Dy			−0.472^c 12		68Mu01		
$^{163}_{66}$Dy		5/2	+?0.51 6	+?1.3 4	58P11		3+ $La_2Mg_2(NO_3)_{12}$• 24
$^{163}_{66}$Dy			±0.65^c 8		62Li06		
$^{163}_{66}$Dy			+0.635^c 14	+1.62^c 40	63Bl25		
$^{165}_{67}$Ho		7/2	+3.31 17	+0.7 7	58B35		3+ $Y(C_2H_5SO_4)_3$•9
$^{165}_{67}$Ho		7/2	±3.4		58Hu17		3+ $LaCl_3$
$^{165}_{67}$Ho			±3.5^c		62Fr14		
$^{165}_{67}$Ho			±4.1^c		62Li06 (58B35)		
$^{165}_{67}$Ho			+4.03^c 15		63Bl25		
$^{167}_{68}$Er		7/2			51B09		3+ $La(C_2H_5SO_4)_3$•9
$^{167}_{68}$Er			±0.48	±9.4	55Bl51		3+ $La(C_2H_5SO_4)_3$•9
$^{167}_{68}$Er		7/2	±0.11		58Hu17		3+ $LaCl_3$
$^{167}_{68}$Er				±4*^{c}	58Mu08		
$^{167}_{68}$Er			±0.50^c		62Fr14		
$^{167}_{68}$Er			±0.58^c		62Li06 (55Bl51)		
$^{167}_{68}$Er			±0.563^c 6		63Bl25		
$^{167}_{68}$Er			±0.56 5		63Ra24		3+ CaF_2 crystal
$^{167}_{68}$Er			±0.56		65Ab01		3+ Er_2O_3 doped ThO_2 crystal
$^{167}_{68}$Er				+3.0 4	66Be25	μ/Q<0	3+ MgO
$^{169}_{69}$Tm		1/2	±0.24 1		61Ha37		3+ Tm doped CaF_2
$^{169}_{69}$Tm		1/2	±0.23 2		63Lo07	Used $<r^{-3}>$of Lindgren	2+ CaF_2
$^{169}_{69}$Tm			±0.236‡^{E}3		65Be34		2+ CaF_2
						‡$g_I$corrected for admixture of Γ_8−excited state to Γ_7−ground state	
$^{171}_{70}$Yb		1/2	±0.43 5		56C21	$^{173}/_{171}$=±1.39 1	3+ $Y(CH_3COO)_3$•4
$^{171}_{70}$Yb		1/2	±0.41 5		60Lo01	$^{173}/_{171}$=1.3749 50	3+ CaF_2; site I
$^{171}_{70}$Yb			±0.52^c 6		62Li06 (56C21)		
$^{171}_{70}$Yb			±0.52 5		63Lo07, 62Lo08	Used $<r^{-3}>$of Lindgren	3+ CaF_2; site II
$^{171}_{70}$Yb			±0.50		65Ab01		3+ Yb doped ThO_2
$^{171}_{70}$Yb					69Ba10	A^{171}/A^{173}=−3.6302^E 4	3+ CaF_2
$^{173}_{70}$Yb		5/2	±0.60 5		56C21		3+ $Y(CH_3COO)_3$•4
$^{173}_{70}$Yb		5/2	±0.57 5		60Lo01		3+ CaF_2; site I
$^{173}_{70}$Yb			±0.63^c		62Fr14		
$^{173}_{70}$Yb			±0.72^c 7		62Li6 (56C21)		
$^{173}_{70}$Yb			±0.70 5	±2.6 2	63Lo07, 62Lo08	$^{173}/_{171}$=1.362 Used $<r^{-3}>$of Lindgren	3+ CaF_2; site II
$^{173}_{70}$Yb			±0.68		65Ab01	$^{173}/_{171}$=1.378 3	3+ Yb doped ThO_2
$^{173}_{70}$Yb					66Ti04	$^{173}/_{171}$=1.383 8	3+ (Yb+P) doped ZnTe
$^{173}_{70}$Yb					68Re06	$^{173}/_{171}$=1.378 2	3+ $SrCl_2$

Table B: Nuclear Moments by Paramagnetic Resonance — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	μ^1/μ^2	Valence and Lattice
$^{191}_{77}$Ir			+0.147^E *8*		69Dal1	$^{191}/_{193}$=0.9165 *3*	4+ $(NH_4)_2PtCl_6$ at 4°K
$^{191}_{77}$Ir					70Su11	$^{191}/_{193}$=0.936 *26*	4+ $IrCl_4$ in MgO at 77°K, irradiated
$^{193}_{77}$Ir			+0.163^E *6*		69Dal1	Q^{193}/Q^{191}=+0.92 *9*	4+ $(NH_4)_2PtCl_6$ at 4°K
$^{197}_{79}$Au			+0.1453^E *4*		60Wo02		0 (Cr,Au) doped Si
$^{231}_{91}$Pa	34ky	3/2			60Ky1		4+ $PaCl_4$ in Cs_2ZrCl_6
$^{231}_{91}$Pa	34ky	3/2	±1.98^E *2*		61Ax1		4+ Cs_2ZrCl_6 crystal
$^{233}_{92}$U	162ky	5/2	±0.54	±3.5 *7*	57D40	$^{235}/_{233}$=±0.651 *2* Q^{235}/Q^{233}=±1.17 *20* μ/Q=±0.152 *15*	3+ $LaCl_3$
$^{235}_{92}$U	710My	7/2	±0.38 or ±0.31		56H26		3+ $LaCl_3$
$^{235}_{92}$U	710My		+?0.35	−?3.8 *8*	56Bl29		3+ $LaCl_3$ and $^{235}UCl_3$
$^{235}_{92}$U	710My		±0.35	±4.1	57D40	$^{235}/_{233}$=0.651 *2*	3+ $LaCl_3$
$^{237}_{93}$Np	2.1My	5/2	±6.0 *25*		54B73		$(NpO_2)^{2+}$ $UO_2Rb(NO_3)_3$
$^{237}_{93}$Np	2.1My		±2.70‡		60Hu14	‡Used $<r^{-3}>$=50x10^{24}cm^{-3}	UF_6; NpF_6
$^{237}_{93}$Np	2.1My		±3.2^c *9* or ±2.6^c‡ *7*		65Ei05	‡Using $<r^{-3}>$=50x10^{24}cm^{-3}	$Rb(NpO_2)(NO_3)_3$
$^{237}_{93}$Np	2.1My		±2.1 *4* ±2.9 *6*		69Le11	 B/P<0 A/P<0	$(NpO_2)^{2+}$ $Cs_2UO_2Cl_4$ at 4°K $Cs_2UO(NO_3)_3$ at 4°K
$^{239}_{93}$Np	2.3d	>1/2			58A18		$(NpO_2)^{2+}$ $UO_2Rb(NO_3)_3$
$^{239}_{94}$Pu	24ky	1/2	±0.4 *2*		54B72	$^{241}/_{239}$=±3.53 *2*	$(PuO_2)^{2+}$ $UO_2Rb(NO_3)_3$
$^{239}_{94}$Pu	24ky	1/2			58A18		$(PuO_2)^{2+}$ $UO_2Rb(NO_3)_3$
$^{239}_{94}$Pu	24ky				70Ko32	$^{249}/_{239}$=3.590^E *10*	3+ CaF_2
$^{241}_{94}$Pu	13y	5/2	±1.4 *6*		54B72		$(PuO_2)^{2+}$ $UO_2Rb(NO_3)_3$
$^{241}_{95}$Am	460y	5/2			68Ed01 67Ea04	$^{241}/_{243}$=1.0088 *15*	2+ CaF_2 crystal
$^{241}_{95}$Am	460y				70Ab03	$^{241}/_{243}$=1.008 *1*	2+ $SrCl_2$ crystal
$^{243}_{96}$Cm	28y	5/2	≈±0.40‡		73Ab03	$^{243}/_{245}$=0.79 *1* $^{243}/_{247}$=1.105 *8* ‡Using $\mu(^{241}Am)$ of 66Ar04. Not corrected for differences in $<r^{-3}>$ between Am^{2+} and Cm^{3+}.	3+ $SrCl_2$ crystal at liquid He temperatures
$^{245}_{96}$Cm	8.26ky	7/2	±0.5‡ *1*		70Ab03	‡Using $\mu(^{241}Am)$ of 66Ar04	3+ $SrCl_2$ crystal
$^{247}_{96}$Cm	15.4My	9/2	≈±0.36‡		73Ab03	$^{245}/_{247}$=1.41 *1* ‡Using $\mu(^{241}Am)$ of 66Ar04	3+ $SrCl_2$ crystal
$^{253}_{99}$Es	20.5d	7/2	±3.62 *50*		71Ed04 70Ed02		2+ CaF_2; cubic sites

* Polarization or Sternheimer correction included

c Recalculation of earlier data

E ENDOR (electron–nuclear double resonance) experiment

m Metastable or excited state

P Preliminary value from meeting abstract, thesis, private communication, etc.

Table C: Nuclear Moments by Microwave Spectroscopy

Introduction

The technique of microwave spectroscopy is used in the study of the pure rotational spectrum of gas molecules which usually are in the ground electronic state. The rotational states are split by the interaction of the nuclear electric quadrupole moment with the nonuniform molecular electric field at the nucleus.

One can infer the nuclear spin from the number, relative spacing, and relative intensities of the absorption lines observed in the microwave region. The spacing of the lines enables one to calculate the quadrupole coupling constant, from which the electric quadrupole moment can be determined. In view of the difficulties associated with calculating the electric field inhomogeneity and the effect of the polarization of the atomic electron core (Sternheimer effect), the computed values of the quadrupole moment are subject to appreciable uncertainties. No attempt has been made here to evaluate these uncertainties.

If the substance being studied is placed in an external magnetic field, the rotational magnetic moments and the nuclear magnetic moment interact with this field giving rise to a Zeeman splitting in the spectrum from which μ can be determined.

Detailed discussions of the technique can be found in *Microwave Spectroscopy*, W. Gordy, W. V. Smith, and R. F. Trambarulo [53Go38] and *Microwave Spectroscopy*, C. H. Townes and A. L. Schawlow [55To31]. Some of the more recent techniques and applications as well as general theory are described in *Microwave Molecular Spectroscopy* by W. Gordy and R. L. Cook [70Go50].

The last systematic literature search for information included in the table was in early 1971.

Explanation of Table C

Nucleus	Chemical symbol with $Z-$ and $A-$numbers
I	Nuclear spin, in units of $h/2\pi$
μ	Nuclear magnetic dipole moment, in nuclear magnetons, given with diamagnetic correction. See Policies, Diamagnetic corrections, for factors used
Q	Nuclear electric quadrupole moment, in barns, as given by the experimenter Values marked by an asterisk, *, indicate that the experimenter has made some polarization or Sternheimer correction in computing the moment.
Refer.	Reference key
eqQ ratio	Ratio of the electric quadrupole coupling constants for the two nuclei indicated
eqQ	Electric quadrupole coupling constant in MHz When the quantity is enclosed in parentheses, ( ), the value has not been measured by the author quoted, but has been used by him to calculate the value of Q.
Compound	Compound used

Table C: Nuclear Moments by Microwave Spectroscopy

Nucleus	I	μ	Q	Refer.	eqQ ratio	eqQ	Compound
$^{10}_{5}B$	3		≈+0.06	50G10	$^{10}/_{11}$=+2.17	+3.36 *10*	$BH_3{}^{12}CO$
$^{10}_{5}B$	3			50W03		+3.44 *1*	$H_3{}^{10}BCO$
$^{11}_{5}B$	3/2		≈+0.03	50G10		+1.55 *8*	$BH_3{}^{12}CO$
$^{14}_{7}N$	1			46C10		+10	NH_3
$^{14}_{7}N$	1		+0.02	48T10		−3.63 *10*	ClCN
$^{14}_{7}N$			+0.01	50S51		−7.07	NF_3
$^{14}_{7}N$			+0.0071[c]	55B54		(+4.58 *5*)	HCN
$^{14}_{7}N$			+0.016[c] *7*	60Li10		eqQ=−1.7 $eq'Q$=22	NO
$^{14}_{7}N$			+0.0094[c]	61Ka31		(−4.10)	ND_3
$^{17}_{8}O$	5/2			52G26		−1.32 *7*	$^{17}O^{12}C^{32}S$
$^{17}_{8}O$	5/2			52M26			$^{16}O^{17}O$
$^{17}_{8}O$			−0.026 *9*	57S93		−8.1 *1*	HDO
$^{18}_{8}O$	0♦		<0.004	48T10		<1	OCS
$^{18}_{8}O$	0▪			51M20			$^{16}O^{18}O$; $^{18}O_2$
$^{19}_{9}F$	1/2♦		<0.0003	49G28		<0.5	PF_3
$^{28}_{14}Si$	0♦			49T09			SiH_3Cl
$^{29}_{14}Si$	1/2♦		<0.0001	53W39		<0.05	SiD_3F
$^{30}_{14}Si$	0♦			49T09			SiH_3Cl
$^{31}_{15}P$	1/2♦			49G28			PF_3
$^{33}_{16}S$	3/2		-0.05^{+5}_{-3}	48T13		−28.5 *7*	OCS
$^{33}_{16}S$	3/2	+0.634 *10*		52E07		−29.07 *1*	$^{16}O^{12}C^{33}S$
$^{33}_{16}S$			−0.06*	53B92		+40	H_2S
$^{33}_{16}S$			−0.058 *10*	54B40			Several
$^{33}_{16}S$			−0.056[c]	62Ko22 (54B40)			
$^{34}_{16}S$	0♦		<0.002	48T10		<1	OCS
$^{35}_{16}S$	3/2		$+0.06^{+6}_{-3}$	51W11	$^{33}/_{35}$ negative	+20.5 *2*	OCS
$^{35}_{16}S$		+1.00 or −1.07 *4*		54B05		+21.90 *4*	OCS
$^{35}_{16}S$			+0.045* *10*	54B40	($^{35}/_{33}$=−0.695)		Several
$^{36}_{16}S$	0♦		<0.01	49L21		<5	OCS
$^{35}_{17}Cl$	3/2		−0.077	48T10 49T17			Several
$^{35}_{17}Cl$				49G25	$^{35}/_{37}$=+1.2704 *4*	−145.94 *26*	FCl
$^{35}_{17}Cl$				50S56	$^{35}/_{37}$=+1.2768 *40*	−103.60 *15*	BrCl
$^{35}_{17}Cl$				51G06	$^{35}/_{37}$=1.2670 *5* $^{35}/_{37}$=+1.2682 *6* $^{35}/_{37}$=+1.2691 *3*		GeH_3Cl ClCN CH_3Cl
$^{36}_{17}Cl$	2		−0.0172 *4*	49T10			$^{36}Cl^{12}C^{14}N$
$^{36}_{17}Cl$	2		−0.0168 *1*	51J21		−15.87 *9*	CH_3Cl
$^{36}_{17}Cl$	2		−0.0164 *8*	52G04		−15.6 *6*	$CH_3{}^{36}Cl$
$^{36}_{17}Cl$	2	+1.31 *8*		55A23	g^{36}/g^{35}=±1.20 *7*	−15.83 *20*	$CH_3{}^{36}Cl$
$^{37}_{17}Cl$	3/2		−0.061	48T10		−65.7 *5*	$^{37}Cl^{12}C^{14}N$
$^{37}_{17}Cl$				49G25		−114.92 *26*	FCl
$^{55}_{25}Mn$	5/2		$+0.55^{+50}_{-25}$	54J16		+16.8	MnO_3F
$^{69}_{31}Ga$				70Ho23	$^{69}/_{71}$=1.5871 *10*	−107.07 *8*	^{69}GaF
$^{71}_{31}Ga$				70Ho23		−67.46 *8*	^{71}GaF

Table C: Nuclear Moments by Microwave Spectroscopy — Continued

Nucleus	I	μ	Q	Refer.	eqQ ratio	eqQ	Compound
$^{70}_{32}$Ge	0♦		<0.007	49T09			GeH_3Cl
$^{72}_{32}$Ge	0♦		<0.007	49T09			GeH_3Cl
$^{73}_{32}$Ge	9/2		−0.21 *10*	49T09		−95 *3*	GeH_3Cl
$^{73}_{32}$Ge			-0.21^c	62Ko22 (49T09)			
$^{74}_{32}$Ge	0♦		<0.007	49T09			GeH_3Cl
$^{76}_{32}$Ge	0♦		<0.007	49T09			GeH_3Cl
$^{75}_{33}$As	3/2			48D08		−235	AsF_3
$^{74}_{34}$Se	0♦			49S07		<0.5	OCSe
$^{74}_{34}$Se	0♦		<0.002	50G05			OCSe
$^{75}_{34}$Se	5/2		+1.1 *2*	55A06	$^{75}/_{79}$=+1.25783 *62*	+946.0	$OC^{75}Se$
$^{76}_{34}$Se	0♦			49S07		<0.5	OCSe
$^{76}_{34}$Se	0♦		<0.002	50G05			OCSe
$^{77}_{34}$Se	1/2♦			49S07		<0.5	OCSe
$^{77}_{34}$Se	1/2♦		<0.002	50G05		<1.0	OCSe
$^{78}_{34}$Se	0♦			49S07		<0.5	OCSe
$^{78}_{34}$Se	0♦		<0.002	50G05			OCSe
$^{79}_{34}$Se	7/2	−1.018 *15*	+0.7 *2*	53H50		+752.09 *5*	OCSe
$^{79}_{34}$Se			+0.9* *2*	54B40		(752.09)	OCSe
$^{79}_{34}$Se			$+0.8^c$	62Ko22 (54B40)			
$^{80}_{34}$Se	0♦			49S07		<0.5	OCSe
$^{80}_{34}$Se	0♦		<0.002	50G05			OCSe
$^{82}_{34}$Se	0♦			49S07		<0.5	OCSe
$^{82}_{34}$Se	0♦		<0.002	50G05			OCSe
$^{79}_{35}$Br			+0.28	48G25	$^{79}/_{81}$=+1.197	+686.0	BrCN
			+0.24		$^{79}/_{81}$=+1.197	+577.0	CH_3Br
$^{79}_{35}$Br	3/2		+0.28	48T10		+686.5 *5*	BrCN
$^{79}_{35}$Br				50S56	$^{79}/_{81}$=+1.1963 *14*	+876.8 *9*	BrCl
$^{79}_{35}$Br			+0.31	51G37			Several
$^{79}_{35}$Br				54R43	$^{79}/_{81}$=+1.19711 *12*		PBr_2
$^{81}_{35}$Br			+0.23	48G25	$^{79}/_{81}$=1.197	+573.0	BrCN
			+0.19			+482.0	CH_3Br
$^{81}_{35}$Br	3/2		+0.23	48T10		+573.5 *5*	BrCN
$^{81}_{35}$Br				50S56		+732.9 *5*	BrCl
$^{81}_{35}$Br			+0.26	51G37			Several
$^{115}_{49}$In				70Ho23	$^{115}/_{113}$=1.0139 *4*		^{115}InF
$^{121}_{51}$Sb	5/2			51L24	$^{121}/_{123}$=+0.791	−455	SbH_2D
$^{121}_{51}$Sb			-0.8^{+1}_{-6}	55J30	$^{121}/_{123}$=0.784 *2*	458.7 *8*	SbH_3
						465.4 *8*	SbD_3
$^{123}_{51}$Sb	7/2			51L24		−575	SbH_2D
$^{123}_{51}$Sb			-1.0^{+1}_{-8}	55J30		586.0 *8*	SbH_3
						592.8 *8*	SbD_3
$^{125}_{53}$I	5/2	±3.0 *10*	-0.89^b	58F39	$^{125}/_{127}$=1.127	−2179 *1*	$CH_3{}^{125}I$
$^{127}_{53}$I	5/2		−0.59	48G25		−1934	CH_3I
$^{127}_{53}$I		±2.807		49G19			CH_3I
$^{127}_{53}$I			−0.75	49T17			Several
$^{127}_{53}$I			−0.65	51G37			Several
$^{129}_{53}$I		±2.74 *14*		49G19			CH_3I
$^{129}_{53}$I	7/2		-0.58^b	49L09	$^{129}/_{127}$=+0.7353	−1422	CH_3I
$^{129}_{53}$I			-0.47^c	51G37			

Table C: Nuclear Moments by Microwave Spectroscopy — Continued

Nucleus	I	μ	Q	Refer.	eqQ ratio	eqQ	Compound
$^{131}_{53}I$	7/2		−0.40[b]	53L24	$^{131}/_{127}$=+0.5031	−973 *9*	$CH_3{}^{131}I$
$^{131}_{53}I$	7/2	+2.56 *12*	−0.40	58F39	$^{131}/_{127}$=+0.5036	−974 *1*	CH_3I
$^{185}_{75}Re$	5/2		+2.8	54J16	$^{185}/_{187}$=+1.067 *45*	+270 *6*	ReO_3Cl
$^{187}_{75}Re$	5/2			54J16		+253 *6*	ReO_3Cl

* Polarization or Sternheimer correction included
♦ No hyperfine structure observed
[a] Do not see K=8, 6, and 4 lines of $^{18}O_2$ spectrum, which indicates the spin is zero
[b] Calculated from eqQ−ratio and Q^{127}=0.79 as measured by atomic beams
[c] Recalculation of earlier data

Table D: Nuclear Moments by Quadrupole Resonance

Introduction

In a diamagnetic molecule or crystal, a nucleus possessing an electric quadrupole moment will interact with a nonuniform electric field arising from the charge distribution of its environment. This interaction causes a splitting of electronic energy levels resulting from the possible orientations of the nuclear spin with respect to a reference axis. For an electric field with axial symmetry, the levels for $+m_I$ and $-m_I$ are degenerate and the spacing between levels with $m_I=\pm I, \pm(I-2)$ . . . is given by $[3eqQ/4I(2I-1)]\cdot(2I-1)$, $(2I-3)$ . . ., where m_I is the projection of I on the axis and q is the electric field gradient at the nucleus. Transitions between the levels can be induced and detected by radio-frequency absorption techniques similar to those used in magnetic resonance. The values of the quadrupole coupling constants can be determined from the resonant frequencies.

Ratios of quadrupole moments of two isotopes can be obtained quite accurately from the ratios of the resonant frequencies for the respective isotopes. The determination of the quadrupole moment from the coupling constant depends upon a calculation of the field inhomogeneity at the nucleus which may be uncertain by a few percent. In addition, the nuclear electric quadrupole moment causes a polarization of the atomic core electrons (Sternheimer effect) which can affect the evaluation of the field gradient by tens of percent.

In several cases the magnetic dipole moment has been determined from the Zeeman splitting of the quadrupole resonance which is produced when the sample is placed in a strong external magnetic field.

Details of this method are described by Krüger [51Kr51] and Dehmelt [53De42]. A discussion of the theory and instrumentation of nuclear quadrupole resonance spectroscopy and its application to solid state physics as well as tables of interaction constants for several elements in many compounds can be found in Das and Hahn [58Da20]. Tables of quadrupole interaction constants can be found in [68Se12] and [69Lu11].

The last systematic literature search for information included in the table was in early 1971.

Explanation of Table D

Nucleus	Chemical symbol with Z– and A–number
μ	Nuclear magnetic dipole moment, in nuclear magnetons, given with diamagnetic correction. See Policies, Diamagnetic corrections, for factors used
Q	Nuclear electric quadrupole moment, in barns, as given by the experimenter. Values marked by an asterisk, *, indicate that the experimenter has made some polarization or Sternheimer correction in computing the moment.
Refer.	Reference key
eqQ ratio	Ratio of the electric quadrupole coupling constants for the two isotopes noted
eqQ	Electric quadrupole coupling constant in MHz
Compound	Compound used

Table D: Nuclear Moments by Quadrupole Resonance

Nucleus	μ	Q	Refer.	eqQ ratio	eqQ	Compound
$^{10}_{5}B$		+0.111*	53D13	$^{10}/_{11}$=2.084 *2*	10.31	BC_3
$^{11}_{5}B$		±0.05	53B91		(4.87)	$B(CH_3)_3$
$^{11}_{5}B$		+0.053*	53D13		4.95	BC_3
$^{33}_{16}S$		−0.050	53D16		45.8	S_8(rhombic)
$^{35}_{16}S$		+0.035	53D16	($^{35}/_{33}$=−0.695 Mic)		
$^{35}_{17}Cl$			51D13	$^{35}/_{37}$=1.2688 *2*	37.5	CHCl=CHCl
$^{35}_{17}Cl$			51L09	$^{35}/_{37}$=1.26878 *15*		5 compounds
$^{35}_{17}Cl$	±0.8224 *10*		53T29			$NaClO_3$
$^{35}_{17}Cl$			55W24	$^{35}/_{37}$=1.268736 to 1.268973		4 compounds at several temp.
$^{35}_{17}Cl$			66Ca15	$^{35}/_{37}$=1.2685 *3*		$GdCl_3$ (ferromagnetic)
$^{35}_{17}Cl$			70Ka25	$^{35}/_{37}$=1.26877 *3*		$LiClO_3$ dried
$^{37}_{17}Cl$			51D13		29.5	CHCl=CHCl
$^{40}_{19}K$		±0.066*[d] *10*	69Jo06	$^{40}/_{39}$=1.244[d] *2*		$^{40}KClO_3$ crystal
$^{63}_{29}Cu$			52K29	$^{63}/_{65}$=1.0806 *3*	65.3	$KCu(CN)_2$
$^{63}_{29}Cu$	±2.231 *7*		57C48	$^{63}/_{65}$=1.0811 *12*	51.96 *4*	Cu_2O
$^{63}_{29}Cu$			66De17	$^{63}/_{65}$=1.0806 *6*		Cu_2O
$^{65}_{29}Cu$	±2.382 *7*		57C48		48.06 *4*	Cu_2O
$^{69}_{31}Ga$			53D22	$^{69}/_{71}$=1.5867 *4*	58.120 *4*	$GaCl_3$
$^{69}_{31}Ga$			56K66	$^{69}/_{71}$=1.589 *2*		Ga metal
$^{71}_{31}Ga$			53D22		36.630 *4*	$GaCl_3$
$^{75}_{33}As$	±1.44 *3*		52K28		232.52 *4*	As_4O_6
$^{79}_{35}Br$		±0.30	51D16	$^{79}/_{81}$=1.1968 *2*	764.86 *8*	Br_2 (crystal)
$^{79}_{35}Br$			53K22	$^{79}/_{81}$=1.1970 *1*	497.0	C_2H_5Br
$^{79}_{35}Br$			54Sc10	$^{79}/_{81}$=1.19707 *3*		average for 6 compounds
$^{81}_{35}Br$		±0.25	51D16		638.92 *6*	Br_2 (crystal)
$^{121}_{51}Sb$			51D15	$^{123}/_{121}$=1.2751* *2*	383.66* *4*	$SbCl_3$
$^{121}_{51}Sb$			55W24	$^{123}/_{121}$=1.274745 *10* Q_4^{123}/Q_4^{121}~0.8 *3*	321.93223 eq_4Q_4=0.030 *5* eqQ/eq_4Q_4<0	$SbBr_3$
$^{121}_{51}Sb$			57O11	$^{123}/_{121}$=1.274755 *2* Q_4^{123}/Q_4^{121}~1.5 *10*	551.3822 *5* eq_4Q_4=0.012 *5*	Sb_2O_3
$^{121}_{51}Sb$			63He02	$^{123}/_{121}$=1.27492 *2*	76.867 *1* eq_4Q_4=+0.015 *5*	powdered Sb
$^{123}_{51}Sb$			51D15		489.21* *5*	$SbCl_3$
$^{123}_{51}Sb$			55W24		410.3814 eq_4Q_4=0.024 *5* eqQ/eq_4Q_4<0	$SbBr_3$
$^{123}_{51}Sb$			57O11		702.8773 *5* eq_4Q_4=0.018 *10*	Sb_2O_3
$^{123}_{51}Sb$			63He02		97.999 *1* eq_4Q_4=+0.013 *30*	powdered Sb
$^{127}_{53}I$		±0.69*	52K43		2156*	solid I_2
$^{127}_{53}I$			53L16	$^{127}/_{129}$=1.42610 *3*	1389.678(site A) 1399.949(site B)	SnI_4
$^{129}_{53}I$		±0.55[b]	53L16	$^{127}/_{129}$=1.42610 *3*	974.481 (site A) 981.654 (site B)	SnI_4

Table D: Nuclear Moments by Quadrupole Resonance — Continued

Nucleus	μ	Q	Refer.	eqQ ratio	eqQ	Compound
$^{133}_{55}Cs$		$Q_4 < 100^E b^2$	67Tz01			CsI
$^{135}_{56}Ba$			62Wil0	$^{137}/_{135}=1.543$ *3*		$BaBr_2 \cdot 2H_2O$
$^{135}_{56}Ba$	±0.840		63Nal1	$^{137}/_{135}=1.542$ *2* $\mu^{137}/\mu^{135}=1.123$	8.55 *1* $\gamma/\gamma_H=0.0997$	$Ba(ClO_3)_2 \cdot H_2O$
$^{137}_{56}Ba$	±0.944		63Nal1		13.18 *1* $\gamma/\gamma_H=0.112$	$Ba(ClO_3)_2 \cdot H_2O$
$^{185}_{75}Re$			57S32	$^{185}/_{187}=+1.056$ *5*		$Re_2(CO)_{10}$
$^{185}_{75}Re$			68Se09	$^{185}/_{187}=1.0565$ *3*		7 compounds
$^{185}_{75}Re$			70Bu09	$^{185}/_{187}=1.059^E$ *14*		Rh metal crystal
$^{201}_{80}Hg$		±0.6	54D01		720	$HgCl_2$
$^{209}_{83}Bi$			53R33		669.06 *13*	$Bi(C_6H_5)_3$

* Polarization or Sternheimer correction included
[a] Corrected for non-rotationally symmetric field
[b] Calculated from eqQ-ratio and $Q^{127}=0.79$ as measured by atomic beams
[c] Recalculation of earlier data
[d] Double resonance experiment
[E] Nuclear acoustic resonance experiment

Table E: Nuclear Moments by Nuclear Magnetic Resonance

Introduction

A nucleus with spin I and an associated magnetic moment μ, when placed in a magnetic field H_o, will precess so that its spin axis rotates about H_o with a (Larmor) frequency

$$\nu_L = \mu H_o / hI.$$

If the nucleus is in a medium (gas, liquid, or solid) which does not contain a large concentration of unpaired electrons, then the field due to the neighboring atoms is small compared to the value of H_o, which is generally of the order of several kilogauss. The field H_o will cause a splitting of the ground state into $2I + 1$ magnetic states, separated in energy by $\mu H_o/I$, with relative population given by the Boltzmann distribution function characteristic of the temperature of the sample. The application of a rotating field H_1, perpendicular to H_o, induces transitions between the levels when its frequency resonates with the Larmor frequency. Because of the differences in level occupation, there is a net absorption of energy from the field H_1 at frequency ν_L. This absorption can be observed electronically.

In order that this method be applicable, not only must the sample be diamagnetic, but also: 1) the spin–lattice relaxation time, i.e., the time taken for the spin system to come into approximate thermal equilibrium with the lattice, must be a reasonable figure (0.1 to 0.001 s); 2) the nuclear interaction should be free from large electric quadrupole effects; 3) the spin density should be high enough so that a reasonable signal can be observed. In practice this might mean 10^{18} to 10^{20} spins in a volume of 0.1 to 1 cc in a field of about 10^4 gauss.

The precision with which nuclear magnetic resonance frequencies have been measured ranges up to a few parts in 10^7. The corresponding nuclear magnetic moments, however, are known to a much lower precision. The uncertainty is introduced in part because of two small contributions to the effective magnetic field at the nucleus which cannot be precisely evaluated.

The effective field can be expressed as

$$H_{eff} = H_o + H' + H'' = H_o(1 + H'/H_o + H''/H_o),$$

where H_o is the externally applied field, H' is the diamagnetic effect due to the currents induced in the atomic electrons by the external field, and H'' is the contribution due to the molecular environment.

Prior to any precise measurements of nuclear resonance, H'/H_o was evaluated (approximately) by Lamb [41La03] by means of a simple calculation based upon the Fermi–Thomas model. This calculation was extended by Dickinson [50Di10] using Hartree–Fock functions. No account was taken of relativity or other possible high–order corrections. Dickinson had estimated that the accuracy of the correction was about 5%. Since this correction varies from about 0.2% for hydrogen to about 1.2% for uranium, the quoted uncertainty in the tabulated value of μ is, in many cases, due to the uncertainty in the diamagnetic correction. Newer calculations based on Hartree–Fock relativistic electron wavefunctions show these earlier values of the diamagnetic correction are too small. They differ by about 1% at low Z, while for Z about 90, they are off by a factor of two. Diamagnetic correction factors for some closed–shell and closed sub–shell ions can be found in a paper by Feiock and Johnson [68Fe05]. Average correction factors for neutral atoms have been calculated by Lin, Johnson and Feiock [72Jo18]. These values take into account the contributions of the closed–shell core of the atom and an average shielding for the valence electrons in the ground state configuration. This average is made over the ground state multiplet assigning statistical weights to the sub–shells. Such average diamagnetic correction factors do not include possible large contributions for individual valence electrons. Values of the diamagnetic correction factors, $(1-\sigma)^{-1} = (1+H'/H_o)^{-1}$, used in the tables are tabulated under Diamagnetic Corrections (see Policies) along with the newer calculated values of Lin, Johnson and Feiock.

The term H''/H_o, the so–called "chemical shift," is associated with the induced field in the molecular environment. This effect has been evaluated theoretically in only a few simple cases. If the magnetic moment can be measured in a free atom in a well defined state, such as by atomic beams or optical double resonance, the value of H''/H_o can be determined empirically. While differences in H''/H_o between different compounds have been observed to be as high as 10^{-2}, the more common values appear to be near 10^{-4} (see Walchli [53W63]). In addition, in aqueous solutions H'' may also be a function of concentration. Much work has been done recently by Lutz, Schwenk and collaborators at Tübingen on the effect of concentrations and of added paramagnetic salts on the resonance frequency in aqueous solutions. For example, see [67Lu06], [67Lu10], and [68Lu07]. In the table, no attempt has been made to consider quantitatively the chemical effects. Therefore, the significance of any limits of precision for the magnetic moments stated to less than 10^{-4}, except for the very light elements, should be questioned.

In view of the difficulty of measuring the absolute value of H, the tabulated value of μ_a of the nucleus has been calculated by use of the relation

$$\mu_a = \mu'_p(\nu_a/\nu_b)(\nu_b/\nu_p)(I_a/I_p)(1 + H'/H_o)_a^{-1},$$

where the subscript "a" refers to the nucleus under consideration, "p" to the proton, and "b" to a reference standard. The value used for μ_p' for a spherical water sample, 2.79270, is the weighted average of the values of Bloch and Jeffries [50Bl73], Sommer et al. [51So34], Collington et al. [55Co36], and Trigger [56Tr19], whose experiments yield the magnetic moment directly in nuclear magnetons without application of correction factors. Our value agrees well with the value $\nu_p' = 2.79268\ 2$ (for a proton in water) in the adjustment of Cohen and DuMond [65Co20]. Newer measurements, see [73CoTa], indicate that the magnetic moment of the proton, measured directly in nuclear magnetons for a spherical sample of water, should be increased to 2.7927740 *11*, well outside the previously quoted uncertainties.

Values of the frequency ratios, ν_b/ν_p, which were adopted in order to calculate the magnetic moments from relative measurements, are tabulated below:

^{2}H	0.15350609† *2*	^{45}Sc	0.24291623 *10*
^{7}Li	0.38863618† *8*	^{50}V	0.0997015♦ *10*
^{11}B	0.3208377♦ *2*	^{55}Mn	0.24789167 *6*
^{14}N	0.07226261 *1*	^{73}Ge	0.03488401 *14*
^{23}Na	0.26451775† *7*	^{85}Rb	0.096552095♦ *54*
^{27}Al	0.26056752 *7*	^{127}I	0.200080♦ *14*
^{35}Cl	0.09797858 *5*	^{199}Hg	0.178788 *15* (NMR
^{39}K	0.0466636♦ *7*		0.1782706 *3* (OP)
^{41}K	0.02561295 *12*		

†From a least squares adjustment for the g-factors for ^{2}H, ^{7}Li, ^{23}Na with g_p'=5.58540 fixed.
♦Weighted average.

These were calculated from the measured ratios which are marked with a † in the table. A least squares adjustment was made for $g'(^{2}\mathrm{H})$, $g'(^{7}\mathrm{Li})$, and $g'(^{23}\mathrm{Na})$ with g_p'=5.58540 fixed. The other values are either weighted averages of the measured ratios or particular measured ratios. A diagram of the most precisely measured frequency ratios between pairs of these isotopes is given in figure 1. The intensity of the line joining the isotopes represents the relative uncertainty of the measured frequency ratios.

In the calculation of the nuclear magnetic moments, no error in the value of μ_p' was assumed. The uncertainties quoted in the tabulated moments represent a composite of uncertainties in the experimental values, conversion factors, standard frequency ratios, and the assumed 5% uncertainty in the diamagnetic corrections.

While the technique of nuclear resonance is primarily useful for the determination of the ratio μ_I/I, in some cases it is possible to determine the value of the nuclear spin. If the electric quadrupole interaction in a single crystal is of the right order of magnitude, the magnetic resonance line may be split into $2I$ components. If these are clearly resolved, then the spin and electric quadrupole interaction, eqQ, can be determined unambiguously. Several spins have been measured or confirmed in this way. The width and intensity of a resonance line in a polycrystalline or noncrystalline medium is related to the nuclear spin. In principle, therefore, the spin can be determined from measurements of line shape. However, distortions due to power saturation and field inhomogeneities subject these measurements to some

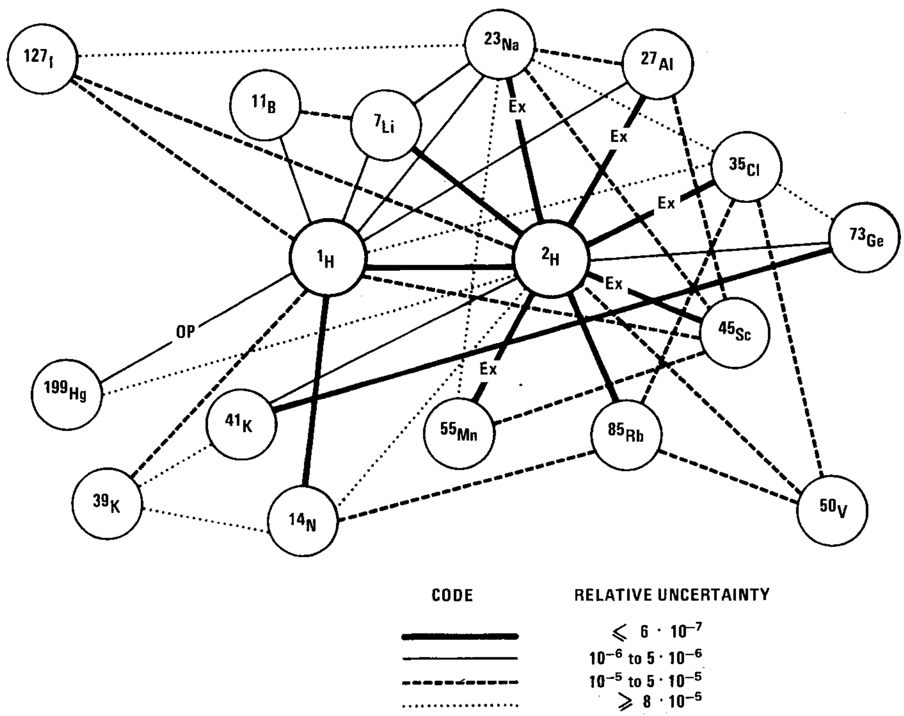

FIGURE 1. Diagram of relative uncertainities of the more precise frequency ratios for the ground states of the corresponding isotopes. The ratios for those connections marked with "Ex" have been determined by extrapolation to zero concentration. The connection marked with "OP" represents an optical pumping measurement.

question. The electric quadrupole moments listed in this table have been determined either by splitting of the resonance line in a single crystal or by line broadening in a noncrystalline medium.

In preparing the table, the compilers omitted data with accuracy about an order of magnitude less than that of the other values available.

Detailed discussions of these techniques can be found in Bloembergen et al. [48Bl32], Pound and Knight [50Po15], Andrew [55An65], Pake [56Pa60], Abragam [61Ab08], and Slichter [63Sl03] as well as in the references given in the general introduction.

The last systematic literature search for information included in the table was in early 1971.

Explanation of Table E

Nucleus	Chemical symbol with $Z-$ and $A-$number
I	Nuclear spin, in units of $h/2\pi$ Values not measured but assumed in order to calculate μ are enclosed in brackets, [ ].
μ	Nuclear magnetic dipole moment, in nuclear magnetons, given with diamagnetic correction. See Policies, Diamagnetic corrections, for factors used Moment values which have been obtained by combining optical pumping or nuclear alignment with NMR have been tabulated here as well as in Tables H or J, respectively. Uncorrected magnetic dipole moment values, based on adopted frequency ratios quoted above, have also been tabulated along with a reference to the procedure used to obtain the ratio.
Diam. Cor.	Diamagnetic correction in nuclear magnetons $\times 10^4$ which has been added to the observed magnetic moment to give value quoted in table The uncertainty in the diamagnetic correction is assumed to be 5%.
Q	Nuclear electric quadrupole moment, in barns, as given by experimenter
Refer.	Reference key
$\nu/\nu'_{standard}$	Ratio of the measured resonance frequency for the nucleus under consideration to that of a standard nucleus Values marked with a † were used to obtain adopted frequency ratios above.
Standard	Nucleus used as standard
Chemical Forms	Chemical formulae of substances containing the nuclide under consideration and the standard The formulae have been separated by a plus sign when the substances were physically mixed and by a semicolon when they were in separate samples.

Table E: Nuclear Moments by Nuclear Magnetic Resonance

Nucleus	$T_{1/2}$	I	μ	Diam. Cor. (nm x 10^4)	Q	Refer.	$\nu/\nu'_{standard}$	Standard	Chemical Forms
μ^+			±8.89013[r] *2*			70Ha74	3.183347 *9*	^1H	$NaOH+H_2O$; H_2O; $CH_2(CN)_2$
μ^+			±8.89009[r] *12*			70Hu19	3.183330 *44*	^1H	spherical sample H_2O
^2_1H		1	+0.857415 *4*	0.24		50L06	0.15350585 *75*	^1H	D_2O; H_2O
^2_1H			±0.857416 *1*	0.24		51S72	†0.153506083 *60*	^1H	D_2O+H_2O
			±0.857417 *1*	0.24			†0.153506125 *50*	^1H	D_2+H_2
^2_1H			±0.857420 *1*	0.24		52L18	†0.15350668 *12*	^1H	D_2O; H_2O
^2_1H			±01857416 *1*	0.24		53W23	†0.153506096 *8*	^1H	HD
^2_1H			±0.857415 *1*	0.24		61Bo11	†0.15350581 *7*	^1H	D_2O; H_2O
^2_1H			±0.85739292[1] *14*	—		Adj.	0.15350609 *2*	^1H	Least squares adj. of ^2H, ^7Li, and ^{23}Na ratios
^3_1H	12y		±2.97894 *30*	0.83		47A09	1.06666 *10*	^1H	T_2O+H_2O
^3_1H	12y	1/2	+2.978877 *30*	0.83		47B32	1.066636 *10*	^1H	T_2O; H_2O
^3_1H	12y		±2.978887 *4*	0.83		59D80	1.06663975 *2*	^1H	T_2O; H_2O; HTO
^3_1H	12y		±2.978860 *4*	0.83		65Hu13	1.0666315 *30*	^1H	0.5% T_2O at
							1.0666298 *5*	^1H	23.5, 10800G
^3_2He		1/2	±2.127569 *7*	1.28		49A11	0.7617866 *12*	^1H	$^3He+H_2+O_2$
^3_2He			negative			57K31			^3He; H_2O
^3_2He			±2.127574‡ *1*	1.28		69Wi19	0.76178685 *8*	^1H	$He+H_2+O_2$ at 10 to
							0.76181237‡ *46*	^1H	30 atmospheres
							‡Used $\sigma(^3He)$=59.935 and $\sigma(H_2)$=26.43 *60*ppm		
^6_3Li			±0.822030 *4*	0.83		51A27	0.37865725 *72*	^7Li	LiCl
^6_3Li		1			$\pm4.6\times10^{-4}$[q]	51S07	Q^6/Q^7=0.023[q] *2*	^7Li	$LiAl(SiO_3)_2$ single crystal
^6_3Li			±0.822030 *5*	0.83		51W24	0.3786573 *15*	^7Li	LiCl
^6_3Li						53C40	Q^6/Q^7=0.019[q] *1*	^7Li	$LiAl(SiO_3)_2$
^6_3Li			+0.822012 *33*	0.83		54W37	0.958638 *38*	^2H	$LiCl+D_2O$
^6_3Li			±0.822031 *4*	0.83		67Lu06	0.9586599[E] *3*	^2H	$LiCl+D_2O$
^7_3Li			±3.25613 *17*	3.3		49S56	0.388609 *20*	^1H	$LiNO_3$; H_2O
^7_3Li			±3.25636 *8*	3.3		52K06	0.388637 *10*	^1H	$LiCl+H_2O$
^7_3Li			±3.25634 *2*	3.3		52L18	†0.3886341 *10*	^1H	$LiNO_3$; H_2O
									$LiNO_3+H_2O$
^7_3Li			+3.25636 *2*	3.3		54W37	†1.469225 *3*	^{23}Na	LiCl; not given
^7_3Li					±0.069*[q] *21*	61An17			$LiNO_3$ crystal
^7_3Li			±3.25636 *4*	3.3		62Ya06	†0.3886357 *16*	^1H	$LiCl+H_2O$
^7_3Li			±3.256366 *18*	3.29		65Hu13	†0.38863668 *90*	^1H	saturated LiF in
							†0.3886375 *13*	^1H	H_2O at 23.5, 10800G
^7_3Li			±3.25636 *2*	3.3		67Lu06	†2.5317314[E] *3*	^2H	$LiCl+D_2O$
^7_3Li			±3.2560328[1] *6*	—		Adj.	0.38863618 *8*	^1H	Least squares adj. of ^2H, ^7Li and ^{23}Na ratios
^8_3Li	0.8s	[2]	±1.6532[a] *8*	2		59C68	ν_L=3.413 *1*MHz H_o=5418 *1*gauss		LiF crystal
^8_3Li	0.8s		positive[ah]			62Co08			LiF
^8_3Li	0.8s	[2]	±1.6532[a] *8*	2		67Gu14	ν=2.0570 *7*MHz H_o=3264.9 *4* gauss		^7LiF
^8_3Li	0.85s	[2]	±1.65362[anp] *22*, ±1.65288[anp] *20*, ±1.65270[anp] *30*			71Ha67			$^7Li(d,p)$ recoils in Au, Pt, Pd foils

Table E: Nuclear Moments by Nuclear Magnetic Resonance — Continued

Nucleus	$T_{1/2}$	I	μ	Diam. Cor. (nm x 10^4)	Q	Refer.	$\nu/\nu'_{standard}$	Standard	Chemical Forms
$^{9}_{4}Be$			±1.17745 *2*	1.8		49D25	0.1405187 *20*	^{1}H	BeF_2+H_2O
$^{9}_{4}Be$			negative			51A11			$Be(NO_3)_2$+H_2O
$^{9}_{4}Be$		$3/2^{q}$			≈±0.02^{q}	51H50	$Q/Q(^{27}Al)\approx0.1$	^{27}Al	$Be_3Al_2Si_6O_{18}$
$^{9}_{4}Be$		$3/2^{q}$				51S17			$BeAl_2O_4$ crystal
$^{9}_{4}Be$			±1.17756 *9*	1.8		51S33	0.915475 *70*	^{2}H	$BeCl_2$; D_2O
$^{9}_{4}Be$		$3/2^{q}$			≈±0.02^{q}	53K50			Be powdered
$^{9}_{4}Be$		$3/2^{q}$	±1.1776 *2*	2		56B48	eqQ=±0.504 *4*MHz		$Be_3Al_2Si_6O_{18}$ crystals
$^{9}_{4}Be$					±0.032^{cq}	60Po09	(eqQ=48kHz)		(powdered Be)
$^{8}_{5}B$	0.77s	[2]	±1.03551^{aj} *25*	2.1		73Mi26	ν=1.90438MHz		$^{6}Li(^{3}He,n)^{8}B$–recoils in Pt foil
							ν_p=20.5493‡ *55* and 20.5434‡ *100* (for H_o) ‡Corrected using $\sigma_p(H_2O)$=26.5ppm		
$^{10}_{5}B$			±1.80105 *18*	3.6		53T01	0.700065 *70*	^{2}H	$Na_2B_2O_4$; D_2O
			±1.80073 *8*				1.11282 *5*	^{85}Rb	$Na_2B_2O_4$; RbCl
$^{10}_{5}B$			±1.80059 *2*	3.6		58B187	0.3348636 *22*	^{11}B	$NaBO_2$
$^{11}_{5}B$			±2.68845 *4*	5.3		49A12	0.320827 *4*	^{1}H	KBO_2+$K_2B_2O_4$+H_2O
$^{11}_{5}B$			±2.68875 *13*	5.3		51S33	0.825615 *40*	^{7}Li	$Na_2B_2O_4$; $LiC_2H_3O_2$
$^{11}_{5}B$			±2.68854 *3*	5.3		52L18	†0.3208381 *8*	^{1}H	$Na_2B_2O_4$; H_2O $K_2B_2O_4$; H_2O
$^{11}_{5}B$			±2.68854 *3*	5.3		65Hu13	†0.3208366 *18* †0.32083766 *22*	^{1}H ^{1}H	BF_3•$2H_2O$ at 23.5, 10800G
$^{11}_{5}B$			±2.6880102^{l} *17*	—		Wtd.Ave.	0.3208377 *2*	^{1}H	
$^{12}_{5}B$	20.4ms	(1)	+1.003^{aj} *1*			67Su03, 68Su05	1.79641‡ *32*, 1.79637‡ *39*; 1.79510‡ *25*, 1.79526‡ *29*; 1.79639‡ *22* ‡Corrected using $\sigma_p(H_2O)$=26.5ppm	^{1}H	$^{11}B(d,p)$ recoils in Cu; Pt; and Au foils
$^{12}_{5}B$	20.4ms	1			±0.017‡^{a}*2*	70Su04 71Mi06	eqQ=154 *16*; 49 *5*kHz Q^{12}/Q^{11}=±0.42 *4* ‡Used Q^{11}=+0.04065 *26*(70Ne21)		powdered TiB_2; ZrB_2
$^{12}_{5}B$	20.4ms	(1)	$+1.00285^{akn}{}^{+15}_{-14}$			70Wi17			$^{11}B(d,p)$ recoils in Au; Cu; Pd; Pt. Knight shift estimated from relaxation times.
					+0.030^{a} *8*				Recoils in Be foils; used $\gamma_\infty(B^{3+})$=−0.145
$^{12}_{5}B$	20.4ms	(1)			≈±0.0346^{ap}	71Wi28	eqQ=54.9 *6*kHz		^{12}B recoils in Be single crystal
$^{13}_{5}B$	19ms	[3/2]	±3.17712^{akn} *51*			71Wi09	0.379104 *25*	^{1}H	$^{11}B(t,p)$ recoils in Pd, Au, Pt
$^{13}_{5}B$	19ms	[3/2]			≈±0.08	73Ha71	Q^{13}/Q^{12}=2.79 *6* eqQ^{13}=130 *2*, eqQ^{12}=46.5 *5*kHz		$^{11}B(d,p)$ and $^{11}B(t,p)$ recoils in Mg crystal
$^{13}_{6}C$		1/2	±0.702388^{d} *9*	1.83		54R34	0.2514431^{d} *5*	^{1}H	$^{13}CH_3I$
$^{13}_{6}C$			±0.70234 *14*	1.8		49P08	0.25143 *5*	^{1}H	$^{13}CH_3I$; oil

Table E: Nuclear Moments by Nuclear Magnetic Resonance — Continued

Nucleus	$T_{1/2}$	I	μ	Diam. Cor. (nm x 10^4)	Q	Refer.	$\nu/\nu'_{\text{standard}}$	Standard	Chemical Forms
$^{12}_{7}$N	12ms	(1)	+0.4572[a,j] *1*	1		68Su05	0.081817‡ *23*;	^{1}H	^{10}B(^{3}He,n) recoils in
							0.081850‡ *23*,	^{1}H	Al; Cu; Pt
							0.081869‡ *23*;	^{1}H	
							0.081836‡ *13*	^{1}H	
							‡Includes correction of 26.5ppm for proton resonance in H_2O		
$^{12}_{7}$N	12ms	1‡[a]				71Mi06			^{10}B(^{3}He,n) recoils
									in bcc metals
							‡From eqQ spectra		
$^{14}_{7}$N			+0.40370 *4*	1.31		51P02	0.47070 *5*	^{2}H	HNO_3; D_2O
$^{14}_{7}$N			±0.40371 *2*	1.31		53T01	0.74837 *4*	^{85}Rb	HNO_3; RbCl
$^{14}_{7}$N			+0.403603[d] *7*	1.31		59A134	0.072236947[d] *80*	^{1}H	NH_4Cl
$^{14}_{7}$N			+0.403602[d] *7*	1.31		62Ba63	0.072236749[d] *10*	^{1}H	NH_4^+
$^{14}_{7}$N			+0.403565[g] *10*			64Ba11	(0.072236749 *10*)	^{1}H	NH_4^+
$^{14}_{7}$N			±0.403747 *7*	1.31		68Sc03	†0.072262607[c]‡ *13*	^{1}H	10M aqueous
						(62Ba63)	(0.072236749 *10*)	^{1}H	$(NH_4)(NO_3)$
							‡Used measured ratios for: ^{14}N: $\nu(NO_3)/\nu(NH_4)$=1.0003556 *1* ^{1}H: $\nu(NH_4)/\nu(H_2O)$=1.00000236 *5* to correct to HNO_3 value		
$^{14}_{7}$N			±0.40361558[l] *6*	—		68Sc03	0.07226261 *1*	^{1}H	
$^{15}_{7}$N			−0.28305 *2*	0.92		50P06	0.66004 *4*	^{2}H	$^{15}NH_3$; D_2O
$^{15}_{7}$N			−0.28317 *2*	0.92		51P02	1.4027 *1*	^{14}N	$NaNO_3$
$^{15}_{7}$N			−0.283078[d] *5*	0.92		59A134	0.101330930[d] *80*	^{1}H	NH_4Cl
			−0.283179[d] *5*				1.4027576 *15*	^{14}N	NH_4Cl
$^{15}_{7}$N			±0.283179 *5*	0.92		61Br13	1.4027566 *10*	^{14}N	liquid N
$^{15}_{7}$N			−0.283077[d] *5*	0.92		62Ba63	0.101330447[d] *10*	^{1}H	NH_4^+
			−0.283179[d] *5*				1.40275480[d] *20*	^{14}N	NH_4^+
$^{15}_{7}$N			−0.283051[g] *7*			64Ba11	(0.101330447 *10*)	^{1}H	NH_4^+
$^{17}_{8}$O		5/2	−1.89372 *10*	7.5		51A08	†0.88313 *4*	^{2}H	$H_2{}^{17}O+D_2O$
$^{17}_{9}$F	66s	[5/2]	±4.7224[a] *12*	24		66Su01	0.33797,	^{1}H	^{16}O(d,n)F recoils
							0.33804		in CaF_2
$^{19}_{9}$F			±2.62896 *7*	12.2		49S56	0.940934 *15*	^{1}H	$C_2F_3Cl_3$; H_2O
$^{19}_{9}$F			±2.62861 *6*	12.2		50G65	0.940807 *10*	^{1}H	$HF+H_2O$
$^{19}_{9}$F			±2.6285 *2*	12.2		51B82	0.940760 *50*	^{1}H	BeF_2+H_2O
$^{19}_{9}$F			±2.62863 *6*	12.2		51K25	0.940814 *9*	^{1}H	$HF+H_2O$
$^{19}_{9}$F			±2.62874 *6*	12.2		52L18	0.9408545 *30*	^{1}H	$CHFCl_2$; H_2O
			±2.62896 *6*	12.2			0.9409330 *30*	^{1}H	$CFCl_3$; H_2O
$^{19}_{9}$F			+2.628383[g] *5*			64Ba11	(0.9407714 *14*)	^{1}H	HF
$^{19}_{9}$F			±2.62880 *6*	12.2		65Hu13	0.9408762 *22*	^{1}H	$C_6H_5CF_3$ at
							0.94087636 *10*	^{1}H	23.5, 10800G
$^{20}_{9}$F	11s	[2]	+2.094[a] *2*	10		63Ts01			CaF_2 crystal
$^{20}_{9}$F	11s	[2]	±2.0935[a] *9*	10		67Gu14	ν=2.1820 *7*MHz		CaF_2
							H_o=2735.8 *4*gauss		
$^{20}_{9}$F	11s	[2]			±0.064[a] *20*	73Ac03	eqQ=5.77 *2*MHz		MgF_2 crystal(polar.n,);
							Q/Q^{19}(197keV)=		H_o=4.35kG
							±0.108 *4*		
$^{23}_{11}$Na			±2.21736 *12*	13.9		51S33	1.08883 *5*	^{45}Sc	$Na_2B_2O_4$; $ScCl_3$
			±2.21713 *14*	13.9			1.08872 *6*	^{45}Sc	NaBr; $ScCl_3$
$^{23}_{11}$Na			±2.21751 *10*	13.9		52K06	0.264514 *9*	^{1}H	$NaI+H_2O$
$^{23}_{11}$Na			±2.21754 *7*	13.9		52L18	†0.2645182 *7*	^{1}H	$Na_2B_2O_4$; H_2O
									NaBr; H_2O
$^{23}_{11}$Na			+2.21753 *8*	13.9		54W37	1.723167 *34*	^{2}H	$NaCl+D_2O$

Table E: Nuclear Moments by Nuclear Magnetic Resonance — Continued

Nucleus	$T_{1/2}$	I	μ	Diam. Cor. (nm x 10⁴)	Q	Refer.	$\nu/\nu'_{\text{standard}}$	Standard	Chemical Forms
$^{23}_{11}$Na			±2.21755 *7*	13.9		67Lu06	†1.7231746[E] *4*	^{2}H	$NaCl+D_2O$
$^{23}_{11}$Na			±2.2161562[1] *6*	—		Adj.	0.26451775 *7*	^{1}H	Least squares adj. of ^{2}H, ^{7}Li and ^{23}Na ratios
$^{25}_{12}$Mg			−0.85540 *9*	6.1		51A11	0.84714 *8*	^{14}N	$MgCl_2$; HNO_3
$^{27}_{13}$Al			±3.6412 *4*	29		49B07	0.26056 *3*	^{1}H	not given
$^{27}_{13}$Al			±3.64161 *14*	28.9		50G65	0.985143 *10*	^{23}Na	$NaAlO_2$
$^{27}_{13}$Al		5/2[q]				50P66			Al_2O_3 crystal
$^{27}_{13}$Al			±3.6411 *2*	29		51S33	1.07261 *5*	^{45}Sc	$AlCl_3$; $ScCl_3$
$^{27}_{13}$Al			±3.64148 *18*	28.9		52K06	0.260579 *8*	^{1}H	$AlCl_3+H_2O$
$^{27}_{13}$Al			±3.64135 *14*	28.9		52L18	0.2605694 *10*	^{1}H	$AlCl_3+H_2O$ $AlCl_3$; H_2O
$^{27}_{13}$Al			+3.64128 *15*	28.9		54W37	0.985055 *12*	^{23}Na	$AlCl_3+NaBr$
$^{27}_{13}$Al		5/2[q]	±3.6414 *3*	29		56B48			$2(Be_3Al_2Si_6O_{18})$
$^{27}_{13}$Al					+0.377*[cq]	66Ar11			(Al_2O_3 crystal)
$^{27}_{13}$Al			±3.64132 *14*	28.9		68Ep01	†1.69744096[E] *30*	^{2}H	$AlCl_3+D_2O$
$^{27}_{13}$Al					+0.155*[c]‡	70Sa08	‡Used eqQ=2.40MHz(Pound), $1-R$=1.005, $1-\gamma$=3.59		Al_2O_3
$^{27}_{13}$Al					+0.148*[c]‡	70Sh16	‡Used eqQ=2.40MHz(Pound), $1-R$=1.005, $1-\gamma$=3.59		Al_2O_3
$^{27}_{13}$Al			±3.6384346[1] *9*	—		(68Ep01)	0.26056752 *7*	^{1}H	
$^{28}_{14}$Si		0♦				54W08	$g^{28}/g^{29}<0.04$[d], if I=1	^{29}Si	$^{28}SiF_4$
$^{29}_{14}$Si			−0.55526 *4*	4.9		53W51	1.29410 *7*	^{2}H	cobalt glass; D_2O
$^{29}_{14}$Si		1/2[d]				54O01			SiH_4 liquid
$^{29}_{14}$Si		1/2[d]				54W08			$^{29}SiF_4$
$^{29}_{15}$P	4.2s	[1/2]	±1.2349[a] *3*	13		71Su13	μ_{unc}=1.23374 *9*; 1.23356 *3*		Si on Cu(d,n) recoils in red P; Si
$^{31}_{15}$P			±1.1321 *2*	11		48P09	1.5310 *3*	^{23}Na	P_2O_5; NaI
$^{31}_{15}$P			±1.13161 *12*	11.0		49B07	0.40481 *4*	^{1}H	not given
$^{31}_{15}$P			±1.13183 *8*	11.0		51S33	1.04182 *5*	^{7}Li	H_3PO_4; $LiC_2H_3O_2$
$^{31}_{15}$P			±1.13159 *6*	11.0		52K06	0.404804 *10*	^{1}H	$P_2O_5+H_2O$
$^{31}_{15}$P			+1.13161 *6*	11.0		54W37	1.530366 *40*	^{23}Na	H_3PO_4; NaBr
			+1.13160 *6*	11.0			1.041611 *30*	^{7}Li	H_3PO_4; LiCl
$^{31}_{15}$P			±1.13177 *12*	11.0		55F45	0.404868 *40*	^{1}H	H_3PO_4
$^{31}_{15}$P			±1.13176 *6*	11.0		63Ba23	0.404862808 *5*	^{1}H	$(CH_3O)_3P$; H_2O
$^{33}_{16}$S			+0.64348 *9*	6.8		53W51	1.06174 *13*	^{14}N	CS_2; HNO_3
$^{35}_{17}$Cl			+0.82180 *9*	9.4		51P02	0.63827 *6*	^{2}H	HCl; D_2O
$^{35}_{17}$Cl			±0.82186 *5*	9.4		52W08	^{50}V/^{2}H= 0.649527 *70* ^{50}V/^{35}Cl= 1.01758 *10*	^{2}H thru ^{50}V	$^{50}VOCl_3$; D_2O+RbCl
$^{35}_{17}$Cl			±0.82185 *6*	9.4		53T01	1.01481 *5*	^{85}Rb	LiCl; RbCl
$^{35}_{17}$Cl			+0.82186 *5*	9.4		54W37	0.638302 *8*	^{2}H	$RbCl+D_2O$
			+0.82183 *5*	9.4			^{85}Rb/^{35}Cl= 0.985431 *18* ^{85}Rb/^{2}H= 0.628985 *5*	^{2}H thru ^{85}Rb	$RbCl+D_2O$

Table E: Nuclear Moments by Nuclear Magnetic Resonance – Continued

Nucleus	$T_{1/2}$	I	μ	Diam. Cor. (nm x 10^4)	Q	Refer.	$\nu/\nu'_{standard}$	Standard	Chemical Forms
$^{35}_{17}Cl$			±0.821818 *47*	9.44		70Bl08	†0.6382716^{E} *3*	^{2}H	$NaCl+D_2O$
$^{35}_{17}Cl$			±0.8208743^{I} *4*	—		(70Bl08)	0.09797858 *5*	^{1}H	
$^{36}_{17}Cl$	0.3My		+1.28539 *9*	14.8		55S110	0.74873 *3*	^{2}H	HCl; D_2O
$^{37}_{17}Cl$			+0.68407 *7*	7.8		51P02	0.83236 *7*	^{35}Cl	HCl
$^{37}_{17}Cl$			±0.68413 *7*	7.8		51W24	0.83243 *7*	^{35}Cl	LiCl
$^{37}_{17}Cl$			±0.68414 *6*	7.8		53T01	0.84477 *5*	^{85}Rb	LiCl; RbCl
			±0.68412 *5*	7.8			0.832445 *4*	^{35}Cl	LiCl
$^{37}_{17}Cl$			±0.684075 *40*	7.85		70Bl08	0.5312927^{E} *3*	^{2}H	$NaCl+D_2O$
$^{37}_{17}Cl$						70Lu03	0.83239448 *8*‡	^{35}Cl	6.00M NaCl in H_2O
							‡3×–rms error + transform uncertainty		
$^{39}_{19}K$			±0.39150 *4*	5.2		50C65	†0.64580 *6*	^{14}N	KNO_3; HNO_3
$^{39}_{19}K$			+0.39140 *3*	5.2		54B09	not given	^{1}H	KCO_2H; H_2O
$^{39}_{19}K$			±0.39155 *4*	5.2		55B11	†0.64588 *6*	^{14}N	KF; HNO_3
$^{39}_{19}K$						57K07	Q^{41}/Q^{39}=1.22^{q}		$KClO_3$ crystals
$^{39}_{19}K$			±0.39147 *3*	5.2		68Br16	†0.0466634 *5*	^{1}H	H_2O+15M KCOOH
									H_2O+0.1M $MnCl_2$
$^{39}_{19}K$			±0.390952^{I} *6*	—		Wtd.Ave.	0.0466636 *7*	^{1}H	
$^{41}_{19}K$			+0.21486 *3*	2.85		54B09	†0.54886 *8*	^{39}K	KCO_2H; H_2O
$^{41}_{19}K$			±0.214873 *14*	2.85		67Lu02	†0.1668530 *8*‡	^{2}H	aqueous KF; D_2O
						71Ka30			two spectrometers
							‡Uncertainty is 3×–rms error ± 2ppm field inhomogeniety ± 2ppm field uncer-tainty at 2 probe sites		
$^{41}_{19}K$			±0.2145879^{I} *10*	—		(67Lu02) (71Ka30)	0.02561295 *12*	^{1}H	
$^{41}_{20}Ca$	110ky	7/2	−1.5946 *1*	22.6		62Br30	0.530631 *3*	^{2}H	$Ca(NO_3)_2$; not given
$^{43}_{20}Ca$		7/2	−1.31721 *15*	18.7		53J06	0.43832 *4*	^{2}H	$CaBr_2+D_2O$
$^{41}_{21}Sc$	0.59s	[7/2]	±5.43^{ap} *2*			72Su05	0.2772	^{1}H	^{40}Ca(d,n) recoils in Pt foil at 4.2°K
$^{45}_{21}Sc$			±4.7564 *4*	72		50H15	0.242939 *3*	^{1}H	$ScCl_3$; not given
$^{45}_{21}Sc$			±4.7557 *10*	72		50S58	0.96954 *6*	^{79}Br	$ScCl_3$; NaBr
$^{45}_{21}Sc$			±4.7564 *4*	72		51H54	0.242939 *3*	^{1}H	$Sc(NO_3)_3$; not given
$^{45}_{21}Sc$			+4.7557 *6*	72		51P02	0.9183 *1*	^{23}Na	$Sc(NO_3)_3$; NaCl
$^{45}_{21}Sc$			±4.75591 *36*	71.7		69Lu01	†1.5824534^{E} *6*	^{2}H	$ScCl_3+D_2O+H_2O+HCl$
$^{45}_{21}Sc$			±4.748745^{I} *2*	—		(69Lu01)	0.24291623 *10*	^{1}H	
$^{47}_{22}Ti$		5/2	−0.78838 *14*	12.7		53J16	0.36721 *6*	^{2}H	$^{47}TiCl_4$ liquid; D_2O
$^{47}_{22}Ti$			±0.78846 *6*	12.7		65Dr03	1.20811 *1*	^{39}K	$TiCl_4$; HCO_2K
$^{49}_{22}Ti$		7/2	−1.10402 *20*	17.7		53J16	0.36731 *6*	^{2}H	$^{49}TiCl_4$ liquid; D_2O
$^{49}_{22}Ti$			±1.10414 *9*	17.7		65Dr03	1.20844 *1*	^{39}K	$TiCl_4$; HCO_2K
$^{50}_{23}V$	40Jy		+3.3471 *3*	57		54W37	0.649518 *8*	^{2}H	$VOCl_3$; D_2O
			+3.3469 *3*	57			†1.017583 *11*	^{35}Cl	$VOCl_3$; RbCl
			+3.3470 *3*	57			†1.032631 *29*	^{85}Rb	$VOCl_3$; RbCl
$^{50}_{23}V$	40Jy		±3.34124^{I} *3*	—		Wtd.Ave.	0.0997015 *10*	^{1}H	
$^{51}_{23}V$			±5.1484 *5*	88		49K24	0.99394 *3*	^{23}Na	V_2O_5+NaCl
									$Pb(VO_3)_2$; NaCl
$^{51}_{23}V$			positive			51P02			$Na^{51}VO_3$
$^{51}_{23}V$			±5.1448 *5*	88		51S33	1.08156 *5*	^{45}Sc	V_2O_5; $ScCl_3$
$^{51}_{23}V$			+5.1480 *5*	88		52W21	0.993855 *35*	^{23}Na	$NaVO_3$
			+5.1506 *5*	88			0.994358 *26*	^{23}Na	$VOCl_3$; $NaVO_3$
$^{51}_{23}V$			±5.15062 *43*	87.8		64Ho20	2.638122 *1*	^{50}V	liquid $VOCl_3$
							Q^{50}/Q^{51}=1.27^{b}		

Table E: Nuclear Moments by Nuclear Magnetic Resonance — Continued

Nucleus	$T_{1/2}$	I	μ	Diam. Cor. (nm x 10^4)	Q	Refer.	$\nu/\nu'_{\text{standard}}$	Standard	Chemical Forms
$^{51}_{23}V$					$\pm0.0073*^{q}$	64Na05	$(1-\gamma)eqQ$=752kHz		V_2O_5
$^{51}_{23}V$					$\pm0.26*^{cq}$	66Ar11	($(1-\gamma)eqQ\approx$6.4MHz)		(V_2O_3)
$^{51}_{23}V$					$\approx$0.04	67Sa10	eqQ=740kHz $eqQ\approx$3.3MHz		V_2O_5 NH_4VO_3; $NaVO_3$; Na_3VO_4•*14*; $Na_4V_2O_7$•*16*
$^{53}_{24}Cr$			−0.47445 *5*	8.6		53A06	0.78226 *5*	^{14}N	Na_2CrO_4; HNO_3
$^{53}_{24}Cr$			−0.47440 *6*	8.6		53J14	0.36820 *3*	^{2}H	Na_2CrO_4; D_2O
$^{53}_{24}Cr$		3/2				54H39			Na_2CrO_4; D_2O
$^{53}_{24}Cr$					$\pm0.022*^{q}$	64Ru07			$^{53}Cr_2O_3$ powder
$^{53}_{24}Cr$					$\pm0.026*^{cq}$	66Ar11			(Cr_2O_3 powder)
$^{52}_{25}Mn$	5.7d		+3.059^{a}‡ *2* or +3.0764^{a}‡ *6*	59	+0.53^{a}‡ *7*	70Ni11	0.36961 *7* Q/Q^{55}=+1.5 *2*	^{55}Mn	$(Ce,La)_2Mg_3(NO_3)_{12}$•*24* at 0.1°K
							‡Using μ^{55}_{unc}=3.442 or 3.4614, Q^{55}=+0.35 *5*		
$^{54}_{25}Mn$	312d		±3.284^{a}‡ *5* or ±3.302^{a}‡ *5*	63		67Te01			^{54}Mn in Fe
							‡Using μ^{55}_{unc}=3.442 or 3.4614		
$^{54}_{25}Mn$	312d		+3.278^{a}‡ *2* or +3.2959^{a}‡ *2*	63	+0.35^{a}‡ *4*	70Ni11	0.79199 *6* Q/Q^{55}=+0.99 *10*	^{55}Mn	$(Ce,La)_2Mg_3(NO_3)_{12}$•*24* at 0.1°K
							‡Using μ^{55}_{unc}=3.442 or 3.4614, Q^{55}=+0.35 *5*		
$^{55}_{25}Mn$			+3.4682 *5*	66		51P02	0.9372 *1*	^{23}Na	$LiMnO_4$; NaCl
$^{55}_{25}Mn$			±3.4674 *4*	66		51S33	1.02028 *5*	^{45}Sc	$Ca(MnO_4)_2$; ScCl
$^{55}_{25}Mn$			±3.4680 *3*	66		69Lu06	†1.6148654^{E} *4*	^{2}H	$KMnO_4+D_2O$ at 25°C
$^{55}_{25}Mn$			±3.4614353^{l} *8*	—		(69Lu06)	0.24789167 *6*	^{1}H	
$^{57}_{26}Fe$			±0.09030 *13*	1.8		67Go11	$\gamma/2\pi$= 137.4 *2*Hz/G		YIG, magnetically saturated
$^{57}_{26}Fe$			±0.090604 *9*	1.83		70Sc11	0.9281533 *9*‡	^{73}Ge	$Fe(CO_5)$; $GeCl_4$
							‡3×−rms error + 0.4ppm field inhomogeneity		
$^{57}_{27}Co$	270d		+4.722^{a}‡ *17*		+0.49‡ *9*	72Ni01	1.023 *3* Q/Q^{59}=1.29 *18*	^{59}Co	$(Ce,La)_2Mg_3(NO_3)_{12}$•*25* crystal
							‡Used μ^{59}=4.616 *9*, Q^{59}=+0.38		
$^{58}_{27}Co$	71.3d	[2]	+4.035^{a}‡ *8*		+0.21‡ *3*	72Ni01	1.59298 *2* Q/Q^{59}=0.54 *3*	^{59}Co	$(Ce,La)_2Mg_3(NO_3)_{12}$•*24* crystal
							‡Used μ^{59}=4.616 *9*, Q^{59}=+0.38		
$^{59}_{27}Co$			+4.6488 *7*	99		51P02	0.89709 *9*	^{23}Na	$K_3Co(CN)_6$; NaCl
$^{59}_{27}Co$			±4.583^{c} *5*			57F20			several
$^{59}_{27}Co$			±4.626^{k} *9*	99		67Wa16	$\gamma/2\pi$= 1.0054^{k} *20*kHz/G		crushed intermetallic CoSi; $CoSi_2$
$^{59}_{27}Co$			±4.616^{k}‡	99		70Sw05	$\gamma/2\pi$=1.003‡kHz/G		$TiFe_{1-x}Co_x$ Measured fields using $\mu(^{39}K)$=0.39090 for aqueous KI
							‡Includes data of 67Wa16		
$^{60}_{27}Co$	5.26y		+3.790^{a}‡ *8*		+0.42‡ *5*	72Ni01	0.5747 *2* Q/Q^{59}=1.11 *6*	^{59}Co	$(Ce,La)_2Mg_3(NO_3)_{12}$•*24* crystal
							‡Used μ^{59}=4.616 *9*, Q^{59}=+0.38		
$^{61}_{28}Ni$			≈±0.54			62Bu08			Ni metal
$^{61}_{28}Ni$			±0.70 *4*			63St08	$\gamma/2\pi$= 0.354 *20*kHz/G		^{61}Ni powder

Table E: Nuclear Moments by Nuclear Magnetic Resonance – Continued

Nucleus	$T_{1/2}$	I	μ	Diam. Cor. (nm x 10^4)	Q	Refer.	$\nu/\nu'_{standard}$	Standard	Chemical Forms
$^{61}_{28}Ni$			−0.74984‡ *10*	16.9		64Dr02	0.658944 *5*	^{17}O	^{17}O in liquid $Ni(CO)_4$
							‡Includes a chemical shift correction for O in $Ni(CO)_4$ of −362ppm [62Br46]		
$^{61}_{28}Ni$			±0.75173^{j} *9*	16.9		65Dr03	0.91371 *4*	^{35}Cl	Ni−Al alloy; $CaCl_2$
$^{63}_{29}Cu$			±2.2263 *5*	53		48P11	1.0022 *2*	^{23}Na	CuCl powder; NaBr powder
$^{63}_{29}Cu$			±2.2260 *5*	53		49B07	0.265056 *52*	^{1}H	not given
$^{63}_{29}Cu$			±2.2267 *5*	53		49Z02	0.26515 *5*	^{1}H	Cu_2Cl_2+$CuCl_2$; H_2O
$^{63}_{29}Cu$					±0.2^{q} *1*	51B98	Q^{63}/Q^{65}=1.081 *3*		$K_3[Cu(CN)_4]$ crystal
$^{63}_{29}Cu$			±2.2262 *3*	53		51S33	1.09125 *6*	^{45}Sc	Cu_2Cl_2 powder; $ScCl_3$
$^{63}_{29}Cu$			+2.2259 *3*	53		54W37	1.002008 *16*	^{23}Na	Cu_2Cl_2+$CuCl_2$; NaBr
$^{63}_{29}Cu$			±2.2259	53		72Me25	$\gamma/2\pi$=1.1285kHz/G		CuBr in KCN
$^{65}_{29}Cu$			±2.3846 *7*	57		48P11	1.0711 *2*	^{63}Cu	CuCl powder
$^{65}_{29}Cu$			±2.3843 *6*	57		49B07	0.28391 *6*	^{1}H	not given
$^{65}_{29}Cu$			±2.3854 *8*	57		49Z02	0.28404 *8*	^{1}H	Cu_2Cl_2+$CuCl_2$; H_2O
$^{65}_{29}Cu$			±2.3858 *3*	57		51S33	1.16951 *6*	^{45}Sc	Cu_2Cl_2 powder; $ScCl_3$
$^{65}_{29}Cu$			+2.3846 *3*	57		54W37	1.073475 *10*	^{23}Na	$CuCl_2$+Cu_2Cl_2; NaBr
$^{65}_{29}Cu$			±2.3847‡	57		72Me25	‡Using μ^{65}/μ^{63}=1.07132 *2*[54W37]		
$^{65}_{29}Cu$						74Lo12	1.0712107‡ *7*	^{63}Cu	powdered CuCl, CuI and $CuRh_2Se_4$
							‡Average for three materials at H_o=12.5 or 14.0 kG and T=77 to 494°K		
$^{67}_{30}Zn$		5/2	+0.8755‡ *11*	21.8		53W51	0.86580 *1*	^{14}N	$Zn(NH_3)_4^{++}$
							‡Includes calculated chemical shift correction of 290ppm [64Ba11] to correct for N in NH_3 to N in NO_3		
$^{67}_{30}Zn$			±0.87524^{i} *11*	21.8		67Sp04	0.0625241^{i} *6*	^{1}H	^{67}Zn vapor; mineral oil
$^{69}_{31}Ga$			+2.0161 *3*	53		54W37	0.907349 *20*	^{23}Na	$GaCl_3$; NaCl
$^{69}_{31}Ga$			±2.0161 *3*	53		55R35	0.7870148 *13*	^{71}Ga	$GaCl_3$
$^{71}_{31}Ga$			±2.5617 *9*	67		48P09	1.1529 *4*	^{23}Na	$GaCl_3$; NaI
$^{71}_{31}Ga$			+2.5616 *3*	67		54W37	1.152872 *8*	^{23}Na	$GaCl_3$; NaCl
$^{71}_{31}Ga$						71Lu15	1.2706243 *3*‡	^{69}Ga	saturated solution of $Ga(NO_3)_3$ in H_2O
							‡3×−rms error + transform uncertainty		
$^{73}_{32}Ge$			−0.8792 *3*	24		53J16	0.35572 *4*	^{35}Cl	$GeCl_4$; $TiCl_4$
							$\nu(^{35}Cl$ in $TiCl_4)/\nu(^{35}Cl$ in RbCl) =1.00088 *25*		
$^{73}_{32}Ge$			±0.87915 *15*	24.0		54A27	0.22724 *2*	^{2}H	$GeCl_4$; D_2O+$MnCl_2$
$^{73}_{32}Ge$			±0.87919 *12*	24.0		71Ka30	†0.2272486 *10*‡	^{2}H	$GeCl_4$; D_2O
						70Sc11	†1.3619664 *5*‡	^{41}K	$GeCl_4$; 9M aqueous KF
							Earlier data of [67Lu07] incorrect due to field inhomogeneities		
							‡3×−rms error + 0.4ppm field uncertainty		
$^{73}_{32}Ge$			±0.8767852^{l} *4*	—		(71Ka30)	0.03488401 *14*	^{1}H	
$^{73m}_{33}As$	5.8μs	[9/2]	+5.157^{akn} *32*			69Qu03	$\|g\|(1+K)$=1.1495 *57*		liquid metal $^{71}Ga(\alpha,2n)$; assumed K=+0.0032 *10*
$^{75}_{33}As$		3/2	+1.4392 *3*	41		52J05	0.17129 *3*	^{1}H	Na_3AsS_4; H_2O
$^{75}_{33}As$			±1.4390 *2*	41		53T01	1.11569 *5*	^{2}H	Na_2HAsO_4; D_2O
$^{75}_{33}As$			+1.4390 *4*	41		53W51	0.64745 *15*	^{23}Na	Na_2HAsO_4; NaCl

Table E: Nuclear Moments by Nuclear Magnetic Resonance – Continued

Nucleus	$T_{1/2}$	I	μ	Diam. Cor. (nm x 10^4)	Q	Refer.	$\nu/\nu'_{standard}$	Standard	Chemical Forms
$^{77}_{34}$Se			+0.53488 *8*	15.8		53W51	0.72193 *2*	^{23}Na	H_2SeO_3; NaCl
$^{77}_{34}$Se			+0.53406 *8*	15.8		54W37	1.242100 *19*	^{2}H	H_2Se; D_2O
$^{78m}_{35}$Br	100μs	[4]	±4.113[a,i] *12*	127		71Br31			molten Se–Tl alloy (pulsed p,n); H_o=6.5G
$^{79}_{35}$Br			±2.1056 *9*	65		47P16	0.9278 *3* Q^{79}/Q^{81}=1.75[b]	^{81}Br	LiBr or NaBr
$^{79}_{35}$Br					≈0.4[b]	48P09	Q^{79}/Q^{127}≈0.57[b]	^{127}I	LiBr; NaI
$^{79}_{35}$Br			±2.1059 *5*	65		49Z02	0.25059 *5*	^{1}H	NaBr; H_2O
$^{79}_{35}$Br			±2.1057 *3*	65		51S33	1.03145 *5*	^{45}Sc	NaBr; $ScCl_3$
$^{79}_{35}$Br			+2.1055 *3*	65		54W37	0.947140 *9*	^{23}Na	NaBr
$^{79}_{35}$Br			±2.1055 *3*	65		70Bl08	1.632111[E] *3*‡	^{2}H	KBr+D_2O
							‡3×–rms error + systematic errors		
$^{81}_{35}$Br			±2.2695 *8*	70		47P16	1.0209 *3*	^{23}Na	LiBr; not given NaBr
$^{81}_{35}$Br			±2.2693 *8*	70		49B07	0.27003 *8*	^{1}H	not given
$^{81}_{35}$Br			±2.2702 *6*	70		49Z02	0.27014 *5*	^{1}H	NaBr; H_2O
$^{81}_{35}$Br			±2.2694 *4*	70		51S33	1.11165 *6*	^{45}Sc	NaBr; $ScCl_3$
$^{81}_{35}$Br			+2.2696 *4*	70		54W37	1.020965 *14*	^{23}Na	NaBr
$^{81}_{35}$Br			±2.2696 *4*	70		70Bl08	1.759309[E] *3*‡	^{2}H	KBr+D_2O
							‡3×–rms error + systematic errors		
$^{81}_{35}$Br						70Lu02	1.0779355 *3*‡	^{79}Br	7.31M NH_4Br in H_2O; H_o≈18.07kG
							‡3×–rms error		
$^{81m}_{35}$Br	35μs	[9/2]	±5.86[a] *7*	180		71Br31			molten Se–Tl alloy (pulsed p,n); H_o=10.4G
$^{83}_{36}$Kr			+‡0.97017 *16*	31.1		54B03	not given		Kr gas
							‡Atomic spectra and beams measurements determine μ to be negative		
$^{83}_{36}$Kr			±0.97034 *16*	31.1		68Br16	0.8246789[E] *24* ^{39}K/^{1}H=0.0466634 *5*	^{39}K	Kr gas; KCOOH
			±0.97033 *16*	31.1			0.0384825[E] *6*	^{1}H	Kr gas; H_2O
$^{85}_{37}$Rb			±1.3527 *2*	45		51Y03	†0.09655207 *30*	^{1}H	RbCl; H_2O
$^{85}_{37}$Rb			±1.3528 *2*	45		52W08	^{50}V/^{2}H= 0.649527 *70* ^{50}V/^{85}Rb= 1.03262 *10*	^{2}H	$VOCl_3$; RbCl+D_2O
$^{85}_{37}$Rb			+1.3527 *2*	45		54W37	0.628985 *5*	^{2}H	RbCl+D_2O
$^{85}_{37}$Rb			±1.3527 *2*	45		61Bl08	†0.6289789 *4*	^{2}H	RbCl; D_2O
$^{85}_{37}$Rb			±1.3482052[1] *8*	—		Wtd.Ave.	0.096552095 *54*	^{1}H	
$^{87}_{37}$Rb	47Gy		±2.7503 *7*	92		49B07	0.32718 *6*	^{1}H	not given
$^{87}_{37}$Rb	47Gy		±2.7503 *14*	92		49Z02	0.32718 *16*	^{1}H	Rb_2CO_3; H_2O
$^{87}_{37}$Rb	47Gy		±2.7506 *5*	92		51A31	3.388966 *47*	^{85}Rb	RbCl
$^{87}_{37}$Rb	47Gy		±2.7495 *5*	92		51S33	1.25529 *6*	^{27}Al	Rb_2CO_3; $AlCl_3$
$^{87}_{37}$Rb	47Gy		±2.7506 *5*	92		51Y03	0.32721338 *55*	^{1}H	RbCl; H_2O
$^{87}_{37}$Rb	47Gy		+2.7506 *5*	92		54W37	1.237041 *8*	^{23}Na	RbCl; NaCl
$^{87}_{37}$Rb	47Gy		±2.7507 *5*	92		61Bl08	2.1315984 *2*	^{2}H	RbCl; D_2O
$^{87}_{37}$Rb	47Gy		±2.7505 *5*	92		67Lu06	2.1315419[E] *15*	^{2}H	RbCl+D_2O
$^{87}_{38}$Sr			−1.0930 *2*	38		53J14	0.28232 *3*	^{2}H	$^{87}SrBr_2$; D_2O
$^{89}_{39}$Y			−0.13732 *3*	4.9		54B09	0.048994 *1*	^{1}H	$Y(NO_3)_3$; H_2O
$^{89}_{39}$Y			±0.137344 *26*	4.91		65Ba42	0.678141 *18*	^{14}N	YCl_3; HNO_3

Table E: Nuclear Moments by Nuclear Magnetic Resonance — Continued

Nucleus	$T_{1/2}$	I	μ	Diam. Cor. (nm x 10⁴)	Q	Refer.	$\nu/\nu'_{\mathrm{standard}}$	Standard	Chemical Forms
$^{91}_{40}Zr$		5/2	−1.3028 *2*	48		57Br26	0.60557 *1*	^{2}H	$(NH_4)_2ZrF_6+D_2O$
$^{93}_{41}Nb$			±6.1672 *12*	236		51S33	1.00613 *5*	^{45}Sc	Nb_2O_5; $ScCl_3$
$^{95}_{42}Mo$			−0.9136 *2*	36		51P02	0.97943 *10*	^{97}Mo	K_2MoO_4
$^{95}_{42}Mo$					±0.12[f] *3*	66Na04			Mo metal
$^{97}_{42}Mo$			−0.9328 *2*	37		51P02	0.9208 *1* $\lvert Q^{97}/Q^{95}\rvert>1$[f]	^{14}N	K_2MoO_4; HNO_3
$^{97}_{42}Mo$						65Ka03	$Q^{97}/Q^{95}=9.2$[b] *8*		K_2MoO_4 solution
$^{97}_{42}Mo$					±1.1 *2*	66Na04	($Q^{97}/Q^{95}=9.2$[b] *8*)		
$^{96}_{43}Tc$	4.3d	(6‡)	±4.60‡[an] *14*			71Fo24			Tc−Fe; $H_{int}=-298$ *10*kG
							‡Obtained g from slope of ν vs H; spin measured by ABMR (1974)		
$^{99}_{43}Tc$	210ky		+5.6807 *12*	234		52W02	1.46628 *10*	^{2}H	$NH_4TcO_4+D_2O$
$^{103}_{45}Rh$			−0.088321[k] *19*	3.87		55S110	0.205574 *7*	^{2}H	Rh metal; D_2O
$^{103}_{45}Rh$			−0.08825[k] *2*	3.9		65Se11	not given		$RhSn_2$
$^{105}_{46}Pd$			±0.6015[j] *6*	26		62Go25	0.04388 *4*	^{1}H	Pd metal (finely divided); H_2O
$^{105}_{46}Pd$			−0.642[k] *3*	30		64Se13	not given		Pd metal
$^{107}_{47}Ag$			−0.11354 *3*	5.3		54B09	0.040468 *1*	^{1}H	$AgNO_3$; H_2O
$^{107}_{47}Ag$			−0.11358 *3*	5.3		54S105	0.86985 *1*	^{109}Ag	$AgNO_3$
$^{109}_{47}Ag$			−0.13053 *3*	6.1		54B09	0.046523 *1*	^{1}H	$AgNO_3$; H_2O
$^{109}_{47}Ag$			−0.13057 *3*	6.1		54S105	0.30316 *3*	^{2}H	$AgNO_3$; D_2O
$^{109}_{47}Ag$			±0.13124[j] *3*	6.1		67Na13	0.304715 *6* $\gamma/2\pi=0.199150$ *4* kHz/G	^{2}H	Au_xAg_{1-x}; D_2O
$^{110}_{47}Ag$	24.4s		±2.7210[a] *8*	126		69Ac02	$\gamma/2\pi=2.0645$ *6*kHz/G		AgF,AgCl,AgBr, Ag_2O,Ag_2O_2(polar. n,); $T\sim8$°K
$^{107}_{48}Cd$	6.7h		±0.61444[i] *15*	29.4		66Mc17	0.0437924[i] *20*	^{1}H	Cd vapor; mineral oil
$^{109}_{48}Cd$	470d		±0.82701[i] *20*	39.5		66Mc17	0.0589435[i] *20*	^{1}H	Cd vapor; mineral oil
$^{111}_{48}Cd$		1/2	−0.59499 *16*	28.4		50P51	0.8016 *1*	^{23}Na	$CdCl_2$; NaCl
$^{111}_{48}Cd$			±0.59429[i]‡ *14*	28.4		66Le21	1.1879850[i] *5*	^{199}Hg	$^{111}Cd+^{199}Hg$ vapor
							‡Based on $\nu(^{199}Hg)/\nu(^{1}H)$ from optical pumping measurements		
$^{111}_{48}Cd$			±0.59428[i] *14*	28.4		66Mc16	0.211782[i] *2*	^{1}H	Cd vapor; mineral oil
$^{113}_{48}Cd$	>3Jy	1/2	−0.62245 *17*	29.7		50P51	0.8386 *1*	^{23}Na	$CdCl_2$; NaCl
$^{113}_{48}Cd$	>3Jy					59K39	1.046083[d] *3*	^{111}Cd	$Cd(CH_3)_2$
$^{113}_{48}Cd$	>3Jy		±0.62167[i]‡ *15*	29.7		67Le22	1.0460840[i] *2*	^{111}Cd	$^{111}Cd+^{113}Cd$ vapor
							‡Based on $\nu(^{199}Hg)/\nu(^{1}H)$ from optical pumping measurements		
$^{113}_{48}Cd$	>3Jy		±0.62167[i] *15*	29.7		66Mc16	0.221543[i] *2*	^{1}H	Cd vapor; mineral oil
$^{113}_{49}In$			±5.5232 *15*	271		51P02	0.82667 *8*	^{23}Na	$In(NO_3)_3$; NaCl
$^{113}_{49}In$			±5.5223 *15*	271		53T01	0.99787 *4*	^{115}In	$In(NO_3)_3$
$^{113}_{49}In$			±5.5229 *16*	271		57R42	0.9978609 *12*	^{115}In	$In(ClO_4)_3$
$^{113}_{49}In$			±5.5229 *14*	271		71Lu15	0.9978610 *3*‡	^{115}In	1.6m% $In(ClO_4)_3$ + 0.5m% $H(ClO_4)$ + 97.9m% H_2O; $H_o=18.07$kG
							‡3×−rms error + Fourier Transform error		

Table E: Nuclear Moments by Nuclear Magnetic Resonance — Continued

Nucleus	$T_{1/2}$	I	μ	Diam. Cor. (nm x 10^4)	Q	Refer.	$\nu/\nu'_{standard}$	Standard	Chemical Forms
$^{115}_{49}$In	600Ty		±5.5348 *15*	272		51P02	0.82841 *8*	^{23}Na	$In(NO_3)_3$; NaCl
$^{115}_{49}$In	600Ty		±5.5336 *15*	272		53T01	0.901877 *50*	^{45}Sc	$In(NO_3)_3$; $ScCl_3$
$^{115}_{49}$In	600Ty		±5.5348 *14*	272		60F103	0.219128 *8*	^{1}H	$In_2(SO_4)_3$; glycerin
$^{115}_{49}$In	600Ty		observed ultrasonically–induced Δm=±3 transitions due to hexadecapole moment			66Ma55			InAs crystal
$^{116}_{49}$In	14s		±2.7859ᵃ *12*	137	±0.09‡ᵃ *2*	71Wi12	$\gamma/2\pi$=2.1132 *8*kHz/G ‡From temperature dependence of τ_{relax}; used Q^{115}=+0.83b		InP(polar. th n,); T=77°K
$^{115}_{50}$Sn		1/2	−0.9178 *2*	46		50P51	1.2362 *1*	^{23}Na	$SnCl_2$; NaCl
$^{115m}_{50}$Sn	159μs		±1.368ᵃʲ *4*	69		71Br03	$\gamma/2\pi$=0.1887, 0.1880,0.1893 kHz/G		liquid In metal (pulsed p,n)
$^{115m}_{50}$Sn	159μs				±0.8ᵃᶠ *3*	72Ri13			liquid In metal (pulsed p,n)
$^{117}_{50}$Sn		1/2	−0.9999 *3*	50		50P51	1.3468 *1*	^{23}Na	$SnCl_2$; NaCl
$^{119}_{50}$Sn		1/2	−1.0461 *3*	53		50P51	1.4090 *1*	^{23}Na	$SnCl_2$; NaCl
$^{121}_{51}$Sb			±3.3589 *9*	174		50C57	0.90469 *4*	^{23}Na	$HSbCl_6$; solid NaCl
$^{121}_{51}$Sb			+3.3593 *9*	174		51P02	0.90480 *9*	^{23}Na	$NaSbF_6$; NaCl
$^{121}_{51}$Sb						58E03	1.84661 *1*	^{123}Sb	$KSbF_6$
$^{123}_{51}$Sb			±2.5465 *7*	132		50C57	0.8442 *1*	^{2}H	$HSbCl_6$; D_2O
$^{123}_{51}$Sb			+2.5466 *7*	132		51P02	0.84423 *8*	^{2}H	$NaSbF_6$; D_2O
$^{125}_{51}$Sb	2.7y	7/2‡	±2.63 *6*	136		68Ba70	$\gamma/2\pi$=0.570 *14*kHz/G ‡Spin determined by μ(68St16) and g(68Ba70)		^{125}Sb–Fe at 0.015°K
$^{123}_{52}$Te	>50Ty		−0.7359 *2*	39		53W51	0.99085 *3*	^{23}Na	TeO_2; NaCl
$^{125}_{52}$Te			−0.8872 *2*	47		53W51	1.19457 *4*	^{23}Na	TeO_2; NaCl
$^{127}_{53}$I			±2.8100 *11*	153		48P09	†0.75664 *20*	^{23}Na	solid NaI
$^{127}_{53}$I			±2.8084 *13*	153		49Z02	0.20003 *8*	^{1}H	KI; H_2O
$^{127}_{53}$I			±2.8086 *8*	153		51S33	†1.30317 *6*	^{2}H	KI+H_2O; D_2O+ H_2O+$NiCl_2$
$^{127}_{53}$I			±2.8091 *9*	153		51W12	†1.30337 *20*	^{2}H	NaI+$(NH_2)_2$+D_2O
$^{127}_{53}$I			±2.8093 *8*	153		51Y03	†0.200095 *6*	^{1}H	KI; H_2O
$^{127}_{53}$I			±2.79382ˡ *18*	—		Wtd.Ave.	0.200080 *14*	^{1}H	
$^{129}_{53}$I	16My		+2.6173 *8*	143		51W12	0.86744 *10*	^{2}H	NaI+$(NH_2)_2$+D_2O
$^{129}_{54}$Xe			−0.77681 *23*	43.4		51P02	1.0457 *1*	^{23}Na	Xe gas; NaCl
$^{129}_{54}$Xe			−0.77689 *22*	43.4		54B03	0.276633 *5*	^{1}H	Xe gas; H_2O
$^{129}_{54}$Xe			−0.77682 *22*	43.4		68Br12	1.80192ᴱ *2*	^{2}H	Xe gas; D_2O
$^{131}_{54}$Xe			+0.69066 *19*	38.6		54B03	0.081976 *1*	^{1}H	Xe gas; H_2O
$^{131}_{54}$Xe			+0.69083 *19*	38.6		68Br12	0.534155ᴱ *3*	^{2}H	Xe gas; D_2O
$^{133}_{55}$Cs			±2.5784 *11*	148		49B07	0.33743 *10*	^{7}Li	not given
$^{133}_{55}$Cs			±2.5790 *8*	148		51S33	0,85449 *4*	^{2}H	CsCl; D_2O
$^{133}_{55}$Cs			+2.5790 *7*	148		54W37	0.854496 *18*	^{2}H	$CsNO_3$+D_2O
$^{133}_{55}$Cs					±<0.004ᶠ	58B158			CsI; CsBr
$^{133}_{55}$Cs			±2.5789 *7*	148		67Lu06	0.8544377ᴱ *5*	^{2}H	$CsNO_3$+D_2O

Table E: Nuclear Moments by Nuclear Magnetic Resonance — Continued

Nucleus	$T_{1/2}$	I	μ	Diam. Cor. (nm x 10⁴)	Q	Refer.	$\nu/\nu'_{standard}$	Standard	Chemical Forms
$^{133}_{55}Cs$					±3.5 *10*mb	68Ha43			Cs_2CuCl_4; Cs_2CoCl_4 single crystals at room T; used $1-\gamma_\infty$=120 *30*
$^{133}_{55}Cs$					$\pm 2.3^{Efp}$ *3* mb	70Or08			aqueous CsI at 297°K
$^{135}_{56}Ba$			±0.83717 *25*	49.1		56W20	1.01387 *2*	^{35}Cl	$^{135}BaCl_2$
$^{137}_{56}Ba$			±0.93653 *27*	54.9		56W20	1.13420 *5*	^{35}Cl	$^{137}BaCl_2$
$^{138}_{57}La$	0.1Ty	5	+3.7073 *12*	223	$\approx\pm1^{f}$	55S31	0.93407 *3* $Q^{138}/Q^{139}\approx\pm3.5$ *5*	^{139}La	not given
$^{139}_{57}La$			±2.7780 *9*	167		49D13	0.141251 *14*	^{1}H	$LaCl_3+H_2O$
$^{139}_{57}La$			±2.7783 *9*	167		51S33	0.92025 *6*	^{2}H	$LaCl_3$; D_2O
$^{153}_{63}Eu$						64Ch26	0.4438	^{151}Eu	EuS powder at 4.2°K
$^{155}_{64}Gd$						64Bo09	0.753 *5*	^{157}Gd	GdN
$^{155}_{64}Gd$						65Bu14	0.763	^{157}Gd	$GdAl_2$
$^{163}_{66}Dy$						66Ko14	1.40‡ *1* Q^{163}/Q^{161}=1.06‡ *1* ‡Used spin-echo technique	^{161}Dy	powdered Dy-metal in ferromagnetic state
$^{171}_{70}Yb$			+0.4930 *5*	40		64Go06	1.7874 *15*	^{35}Cl	$YbCl_2$; NaCl YbS; NaCl
$^{173}_{70}Yb$			±0.6791 *6*	54		64Go06	(0.275497ⁱ *12*)	^{171}Yb	
$^{175}_{71}Lu$			±2.229 *1*	180		62Re02	0.73677 *2*	^{2}H	LuB_{12}
			±2.231 *1*	180			0.73732 *2*	^{2}H	LuSb
$^{181}_{73}Ta$			±2.360‡ *2*	200		60Be23	not given ‡Determined magnetic field using ^{7}Li resonance		$KTaO_3$
$^{183}_{74}W$			$+0.1167^{k}$ *10*	10		55S110	0.27395 *3*	^{2}H	W powder; D_2O
$^{183}_{74}W$			±0.11722 *5*	10.1		61Kl01	not given		WF_6
$^{185}_{75}Re$			+3.1718 *14*	281	large[b]	51A11	0.85114 *9*	^{23}Na	$NaReO_4$; NaCl
$^{187}_{75}Re$	60Gy		+3.2044 *14*	284	large[b]	51A11	0.85987 *9*	^{23}Na	$NaReO_4$; NaCl
$^{187}_{75}Re$	60Gy					68Na12	1.01007 *5*	^{187}Re	ReO_3 metal
$^{187}_{75}Re$	60Gy					70Be75	1.01008 *8*	^{187}Re	$Be_{22}Re$ at 300°K
$^{187}_{76}Os$			±0.06432 *3*	5.8		68Sc06	0.8910814 *3* 0.8910825‡ *5* ‡Corrected for susceptibilities of $OsO_4(-0.211x10^{-6})$ and $KF(-0.83x10^{-6})$	^{41}K ^{41}K	molten OsO_4; aqueous KF
$^{189}_{76}Os$		3/2	+0.65655‡ *30*	59		54L36	0.791896 *93* ‡Used ν(^{35}Cl in $TiCl_4$)/ν(^{35}Cl in RbCl) =1.00088 *25* of 53J16	^{35}Cl	molten OsO_4; $TiCl_4$
$^{189}_{76}Os$			±0.65652 *30*	59		68Sc03	1.074639 *5*	^{14}N in NO_3^-	molten OsO_4; $NH_4(NO_3)$ solution (cylindrical samples)

Table E: Nuclear Moments by Nuclear Magnetic Resonance — Continued

Nucleus	$T_{1/2}$	I	μ	Diam. Cor. (nm x 10⁴)	Q	Refer.	$\nu/\nu'_{standard}$	Stan-dard	Chemical Forms
$^{191}_{77}Ir$			+0.1453[k]‡ *6*	13.5		68Na01	ν/H(in kHz/G) =0.074133 *18*		Ir metal; used K=+0.013 *4*
							‡Used $\nu(^{109}Ag)/H$=0.199150kHz/G for Ag−metal		
$^{191m}_{77}Ir$	4.9s	[11/2]	±6.08[a] *36*	560		71Es03	ν=389.690‡ *13*;		0.08% ^{191}Os in Ni, H_{int} =−467 *3*kG;
							1174.85‡ *12*MHz		0.04% ^{191}Os in Fe; H_{int} =−1405 *8*kG
							‡Extrapolated to H_o=0		
$^{192}_{77}Ir$	74d		±1.901[a] *11*	174		71Es03	ν=167.661‡ *35*;		0.03% Ir in Ni, H_{int} =−467 *3*kG;
							504.192‡ *50*MHz		0.03% Ir in Fe, H_{int} =−1405 *8*kG
							‡Extrapolated to H_o=0		
$^{193}_{77}Ir$			+0.1583[k]‡ *6*	14.7		68Na01	ν/H(in kHz/G) =0.080732 *6*		Ir metal; used K=+0.013 *4*
							‡Used $\nu(^{109}Ag)/H$=0.199150kHz/G for Ag−metal		
$^{195}_{78}Pt$		1/2	+0.6060 *3*	57		51P02	0.81273 *8*	^{23}Na	H_2PtCl_6; NaCl
$^{195}_{78}Pt$			±0.6060‡ *3*	57		63Dr05	0.812667 *4*	^{23}Na	H_2PtCl_6
							‡Not corrected for chemical shift which may be as large as +0.7%		
$^{195}_{78}Pt$			±0.6022‡ *3*	57		68Ze04 (63Dr05)			$H_2PtI_6+H_2O$; least paramagnetic compound tested
							‡Chemical shift with respect to H_2PtCl_6 is −0.63%		
$^{195m}_{78}Pt$	4.1d	[13/2]	±0.602[a]‡ *15*	56		72Ba22	ν=89.5 *5*MHz		Pt−Fe,^{60}Co; H_{hf}= −1280 *26*kG
							‡Uncorrected for possible hyperfine anomaly		
$^{197}_{79}Au$			+0.14726[j] *7*	14.0		67Na13	ν/H(in kHz/G) =0.074125 *4*		Au_xAg_{1-x}
$^{200m}_{79}Au$	18.7h	[12]	±6.10[a]‡ *10*	600		73Ba83	‡2.5% hyperfine anomaly included		
$^{183}_{80}Hg$	8.8s	1/2	+0.518[a] *9*	50		72Bo09			Also measured by optical pumping
$^{185}_{80}Hg$	50s	1/2	+0.504[a] *4*	49		72Bo09			Also measured by optical pumping
$^{199}_{80}Hg$		1/2	+0.50416 *24*	48.6		51P02	†1.1647 *1*	^{2}H	$Hg_2(NO_3)_2$; D_2O
$^{199}_{80}Hg$			+0.50272[i] *24*	48.6		61Ca21	†0.1782706[i] *3*	^{1}H	Hg gas; H_2O
$^{199}_{80}Hg$			±0.49930[l] *4*	—		(51P02)	0.178788 *15*	^{1}H	NMR−value
			±0.4978563[u] *8*	—		(61Ca21)	0.1782706 *3*	^{1}H	OP−value
$^{201}_{80}Hg$			−0.55671[i] *27*	53.7		61Ca21	0.0658066[i] *3*	^{1}H	Hg gas; H_2O
$^{203}_{81}Tl$			±1.6118 *8*	158		49P08	0.571499 *50*	^{1}H	$TlC_2H_3O_2$; H_2O
$^{203}_{81}Tl$		1/2	+1.6116 *8*	158		50P51	0.5714 *1*	^{1}H	$TlC_2H_3O_2+H_2O$
$^{203}_{81}Tl$			±1.6116 *8*	158		51S33	0.99026 *5*	^{205}Tl	$TlC_2H_3O_2$
$^{203}_{81}Tl$			±1.6115 *8*	158		63Ba23	0.57139145 *4*	^{1}H	$TlC_2H_3O_2$; H_2O
$^{205}_{81}Tl$			±1.6277 *8*	160		49P08	0.577135 *50*	^{1}H	$TlC_2H_3O_2$; H_2O
$^{205}_{81}Tl$		1/2	+1.6274 *8*	160		50P51	0.5770 *1*	^{1}H	$TlC_2H_3O_2+H_2O$
$^{205}_{81}Tl$			±1.6274 *8*	160		51S33	0.57702 *3*	^{1}H	$TlC_2H_3O_2$; H_2O
$^{205}_{81}Tl$						53G12	1.009838 *1*	^{203}Tl	$Tl_2O_3+HCl+HNO_3$
$^{205}_{81}Tl$						54W37	1.009816 *22*	^{203}Tl	$TlC_2H_3O_2$
$^{205}_{81}Tl$			±1.6274 *8*	160		63Ba23	0.57701173 *4*	^{1}H	$TlC_2H_3O_2$; H_2O
							1.00983613 *6*	^{203}Tl	$TlC_2H_3O_2$

Table E: Nuclear Moments by Nuclear Magnetic Resonance — Continued

Nucleus	$T_{1/2}$	I	μ	Diam. Cor. (nm x 10⁴)	Q	Refer.	$\nu/\nu'_{standard}$	Standard	Chemical Forms
$^{207}_{82}Pb$		1/2	+0.5895 *3*	59		50P51	0.7901 *1*	^{23}Na	$Pb(C_2H_3O_2)_2$; NaCl
$^{207}_{82}Pb$			±0.5902[d] *3*	59		57Ba34	0.2092198[d] *10*	^{1}H	$Pb(C_2H_5)_4$
$^{207}_{82}Pb$			±0.5883‡ *3*	59		58Pi48			$Pb(SO_4)$ powder, most ionic compound
							‡Chemical shift with respect to $Pb(C_2H_3O_2)_2$=0.21%		
$^{207}_{82}Pb$			±0.5880 *4*	59		59Ro45	1.3580‡ *4*	^{2}H	$Pb(SO_4)$ powder; D_2O $Pb(NO_3)_2$·*1*; D_2O
							‡Studied chemical shifts; these two most ionic		
$^{209}_{83}Bi$	>2Ay		+4.0800 *21*	412		51P02	1.0468 *1*	^{2}H	$Bi(NO_3)_3$; D_2O
$^{209}_{83}Bi$	>2Ay		±4.0802 *20*	412		53T01	1.04684 *5*	^{2}H	$Bi(NO_3)_3$; D_2O
$^{209}_{83}Bi$	>2Ay		±4.0809 *20*	412		59F39	0.160722 *14*	^{1}H	$Bi(NO_3)_3 \cdot 5H_2O$; glycerine

* Polarization or Sternheimer correction included
♦ No splitting observed
† Value used in average or least squares adj.
[a] Resonance observed by depolarization of polarized nuclei (γ–anisotropy or β–asymmetry
[b] Determined from broadening of resonance lines
[c] Recalculation of earlier data
[d] Measured by double resonance technique
[E] Extrapolated to zero concentration or density
[f] Determined from relaxation times
[g] Computed corrections for atomic diamagnetism and molecular paramagnetic shielding included
[h] Used circularly polarized rf fields
[i] Used optical pumping to align nuclei
[j] Without Knight shift correction
[k] Includes estimated correction for Knight shift
[l] Value uncorrected for diamagnetism
[m] Metastable or excited state
[n] Not certain if authors corrected for diamagnetism, therefore not corrected by compilers
[p] Preliminary value from meeting abstract, report, thesis, or private communication
[q] Determined from quadrupole splitting of the magnetic resonance
[r] Resonance observed by asymmetry of μ–decay

Table F: Nuclear Moments by Atomic and Molecular Beams

Introduction

The atomic–beam magnetic–resonance apparatus is a device for observing certain types of transitions between atomic energy states. These transitions, usually associated with ground–state levels, can be studied in fields ranging from weak (small fractions of a gauss) to strong (several kilogauss). The basic principles of the method are discussed extensively in *Atomic and Molecular Beam Spectroscopy*, P. Kusch and V. W. Hughes [59Ku94], *Nuclear Moments*, H. Kopfermann [58Ko90], *Molecular Beams*, N. F. Ramsey [56Ra58], and *Molecular Beams*, K. F. Smith [55Sm12].

The precision attainable by this method is associated with the factors: (1) the atom is not perturbed by adjacent atoms or collisions with apparatus walls, (2) the natural lifetime of the energy state is usually extremely long compared with any time constant of the apparatus, and (3) the transit time through the transition region can be made as long as many tens of milliseconds.

The total energy of an atomic level, neglecting interactions with an applied magnetic field, can be expressed as

$$W = W_J + W_{M1} + W_{E2} + W_{M3} + \ldots.., \quad (1)$$

where W_J is the energy independent of the interactions with the nuclear moments and W_{M1}, W_{E2}, W_{M3} are the energies due to the interaction of the electrons with the nuclear magnetic dipole, electric quadrupole, and magnetic octupole moments, respectively.

The magnetic dipole term can be expressed as

$$W_{M1}/h = aIJ\cos(IJ) = (a/2)[F(F+1) - I(I+1) - J(J+1)]. \quad (2)$$

The existence of this term causes a particular atomic level to be split into $2I+1$ or $2J+1$ hyperfine levels depending upon whether $I<J$ or $J<I$. The hyperfine–structure splitting is defined by $\Delta\nu=\Delta W/h$, where ΔW is the energy separation of a pair of hyperfine levels with total spins F and $(F-1)$ measured at zero magnetic field. From eq. (2), the hyperfine–structure splitting between such a pair of levels for a state with no quadrupole interaction is just $\Delta\nu(F,F-1)=Fa$.

The magnetic interaction constant a can be shown to be equivalent to $\mu_I H(0)/hIJ$ where $H(0)$ represents the time–averaged magnetic field at the nucleus due to the electron distribution. The precision with which μ_I can be determined from a is limited by the precision with which the atomic wavefunctions are known to permit the calculation of $H(0)$. The uncertainty in $H(0)$ may be of the order of a few percent.

In practice, the magnetic moment of a nucleus can be determined indirectly provided one isotope of that element has been studied by another method such as nuclear resonance. The relationship $\mu_1/\mu_2=a_1I_1/a_2I_2$, which is based on the assumptions that the electronic wavefunctions and nuclear fields are the same for both isotopes, can be used to evaluate μ. It has been shown experimentally that these two ratios are not exactly equal. The hyperfine–structure anomaly, which is defined by ${}^1\Delta^2=(a_1I_1\mu_2/a_2I_2\mu_1)-1$, has been found to be as large as 1% for some pairs of isotopes. A tabulation of experimentally determined magnetic hyperfine structure anomalies may be found in a report by Fuller and Cohen [70FuCo]. More precise methods of determining μ will be discussed later.

The electric quadrupole term in (1) is given by

$$W_{E2}/h = (b/4)[(^3/_2)K(K+1) - 2I(I+1)J(J+1)] \times [I(2I-1)J(2J-1)]^{-1} \quad (3)$$

which, in the classical limit, becomes

$$W_{E2}/h=(b/4)[(3/2)\cos^2(IJ)-1/2]$$

where $b = e(\partial E/\partial z)(Q/h)$ and

$$K = F(F+1)-I(I+1)-J(J+1).$$

The calculation of Q from the quadrupole interaction constant b is limited by the accuracy in the determination of $\partial E/\partial z$ at the nucleus. The uncertainty in the atomic wavefunctions may introduce uncertainties in $\partial E/\partial z$ of a few percent. In addition, the nuclear quadrupole moment causes a polarization of the atomic core electrons (Sternheimer effect). The effect of this polarization on the calculation of $\partial E/\partial z$ at the nucleus may be included as a correction factor which can amount to tens of percent. In compiling the following table, no attempt has been made to apply the Sternheimer correction where the authors have not done so. For any precise application of quadrupole data, one should refer to the original experimental work and to the references on the necessary corrections [66St23].

A severe limitation of the atomic–beam method for the measurement of electric quadrupole interactions is due to the fact that most beam experiments are performed on atoms in the ground state, which in many cases is an S state. In such a state, there is no interaction with the nuclear quadrupole moment. It is possible, however, to perform atomic–beam experiments on such atoms if they have been excited by absorption of optical resonance radiation or by electron impact.

The magnetic octupole term in (1) is given by

$$W_{M3}/h = (5c/4)[K^3 + 4K^2 + (4/5)K\{-3I(I+1)J(J+1) + I(I+1) + J(J+1) + 3\} - 4I(I+1)J(J+1)] \times [I(I-1)(2I-1)J(J-1)(2J-1)]^{-1} \quad (4)$$

where c is the magnetic octupole interaction constant from which the magnetic octupole moment Ω can be calculated. In the classical limit, equation (4) can be written as

$$W_{M3} = (1/3)\Omega(\partial^2 H(0)/\partial z^2)_{ave}[(5/2)\cos^3(IJ) - (3/2)\cos(IJ)].$$

The magnetic octupole interactions so far reported are of the order of 100 Hz or less than 10^{-6} times the dipole interactions. It is therefore necessary to evaluate the first two moments to a very high precision and include perturbation effects of low-lying excited states in order to compute Ω from c.

In the presence of a magnetic field H, additional terms for the direct interaction of the electronic and nuclear magnetic moments with the field must be included. The direct interaction term is given by

$$W_H = \mu_B g_J \, J \cdot H + \mu_B g'_I \, I \cdot H, \quad (5)$$

where $g_J = -\mu_J/J\mu_B$ [1], $g'_I = -\mu_I/I\mu_B$ [1], and μ_B is the Bohr magneton.

Energy differences between two states are given by the measured frequencies of the oscillating field (described below) which produces transitions between those states. By measuring these energy differences, I, g_J, a, b, and sometimes g'_I and c can be determined. In principle, these can then be used to calculate the nuclear moments μ, Q, Ω.

In the relatively simple case of an atom in an $S_{1/2}$ state, the energy dependence of a hyperfine level as a function of H can be expressed by the Breit–Rabi equation

$$W = -(\Delta W/[2(2I+1)]) + m_F g'_I \mu_B H \pm (\Delta W/2)[1 + 4m_F x/(2I+1) + x^2]^{1/2},$$

where ΔW is the energy splitting of the $^2S_{1/2}$ state caused by the nuclear field and $x = (g_J - g'_I)\,\mu_B H/\Delta W$. Figure 2 illustrates graphically the function $W/\Delta W$ for an atom in the $^2S_{1/2}$ state with a nucleus with $I = 4$, and $\mu > 0$.

[1] Since the orientation of the spin and the associated magnetic moment are antiparallel for the electron and parallel for the proton, there is much confusion regarding the convention for signs of g_S and g'_I, the g-factors of an electron and a nucleus, and of μ_S and μ_I, the corresponding magnetic moments. There are variations in the literature, and some authors are not self-consistent. The convention adopted here is that g_S is positive for the electron (where μ_S is negative, i.e. antiparallel to the spin) and g'_I is positive for a nucleus when μ_I is negative or antiparallel to the nuclear spin.

A common arrangement of an atomic–beam magnetic–resonance system is shown in figure 1. The apparatus consists essentially of

(1) A source of neutral atoms at thermal energies.

(2) A detector of atomic–beam intensity.

(3) A pair of deflecting magnets (A and B of figure 1). In the regions A and B, the magnetic fields have a large field gradient so that the atoms will experience a transverse force, $F = -\partial W/\partial z = -(\partial W/\partial H) \times (\partial H/\partial z)$.

(4) A uniform adjustable magnetic field (C–field in figure 1). In this region, oscillating magnetic radiation can be introduced to cause transitions from one magnetic state to another.

In a strong field, the atomic state is characterized by magnetic quantum numbers m_I and m_J. For an atom in an $S_{1/2}$ state, m_J can take on the values $+{}^1/_2$ or $-{}^1/_2$. In the nonuniform A and B magnetic fields, atoms in the $m_J = +{}^1/_2$ states will be deflected toward the weak field (paths a, figure 1), while those in the $m_J = -{}^1/_2$ states will be deflected toward the strong field (paths b, figure 1). If, while in the C–region, an atom undergoes a transition from any of the magnetic substates associated with $m_J = \pm{}^1/_2$ to one with $m_J = \mp{}^1/_2$ (such as transitions α, β, γ, δ, or ϵ, figure 2), the deflection in the B–field will be opposite to that in the A–field and the atom will then be focused onto the detector. Such a transition can be induced if the frequency ν of the applied oscillating field satisfies the condition $W_1 - W_2 = h\nu$, where $W_1 - W_2$ is the energy separation of the two levels. This resonant frequency condition is observed by the accompanying maximum in beam intensity at the detector. From the observed resonant frequencies, the energy differences between pairs of states are determined and the quantities I, g_J, a, b, and sometimes g'_I and c can be derived. The nuclear moments μ, Q, and Ω can then be calculated from the interaction constants by use of the best available atomic wavefunctions. The magnetic dipole is the only moment which interacts directly with the applied magnetic field H and can thus be determined by very precise measurements of the appropriate energy separations.

In a magnetic field of a few gauss, where the variation of the energies of the individual m_F–states with respect to H is practically linear, the level separation is a function of I and H only. The observation of a transition such as α, in figure 2, can serve to determine I with no ambiguity.

In the intermediate field region, the energy expression for the transition β, figure 2, has terms non-linear in H which are functions of ΔW, the hyperfine–structure splitting. A measurement of this transition at such fields can permit calculation of ΔW

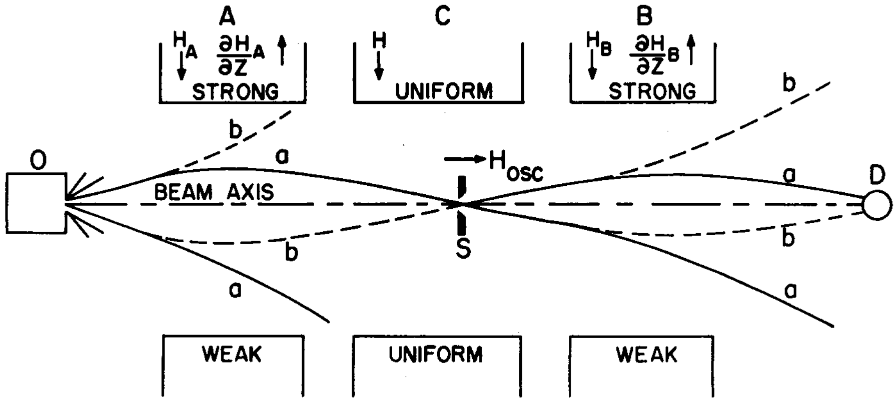

FIGURE 1. Schematic diagram of atomic beam apparatus. O—oven; S—slit; D—detector: A and B—regions with fields and field gradients in directions indicated; C—region with uniform field H and oscillating field H_{osc} in directions indicated: "a" and "b" represent paths of atoms with negative and positive effective magnetic moments, respectively.

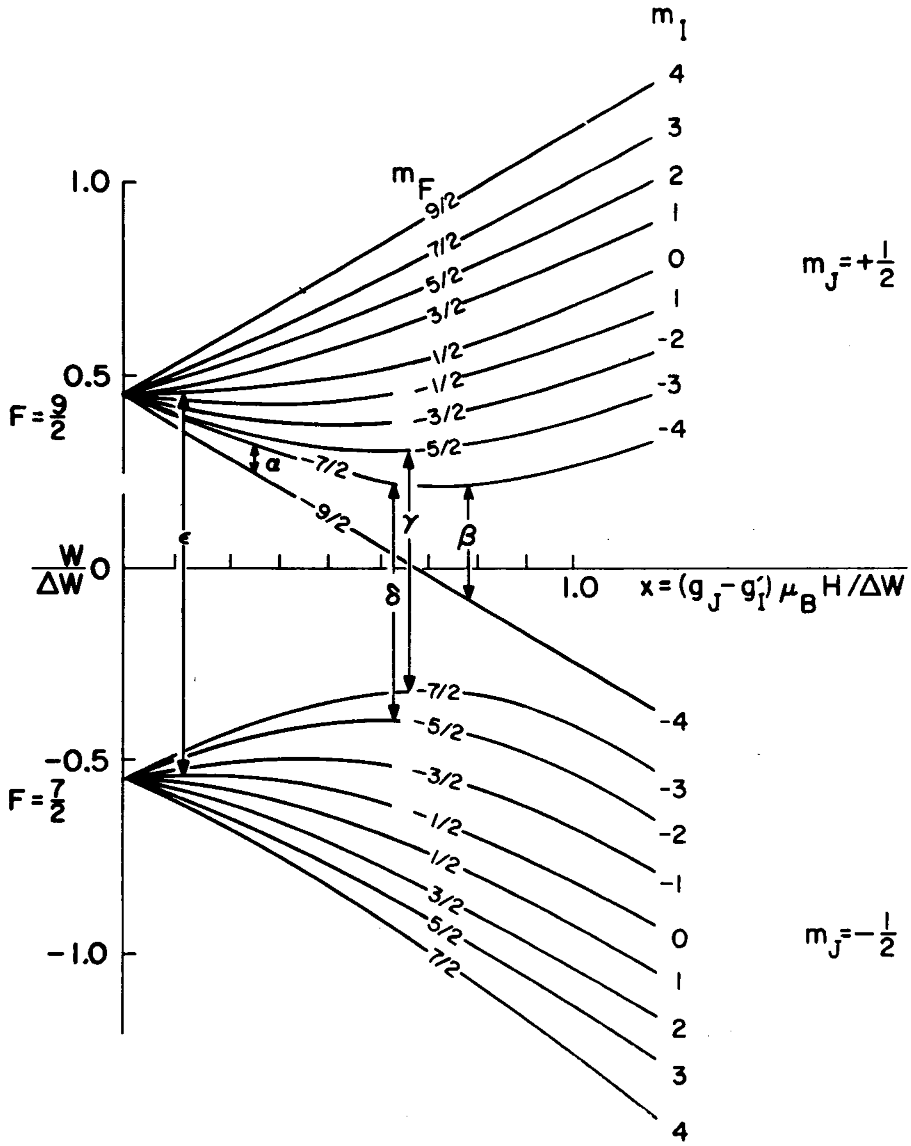

FIGURE 2. Breit-Rabi diagram of the energy levels of an atom in a $^2S_{1/2}$ state with a nucleus with $I=4$ and $\mu>0$. α, β, γ, δ, and ϵ represent some of the observable transitions which are useful for the determination of nuclear properties as explained in text.

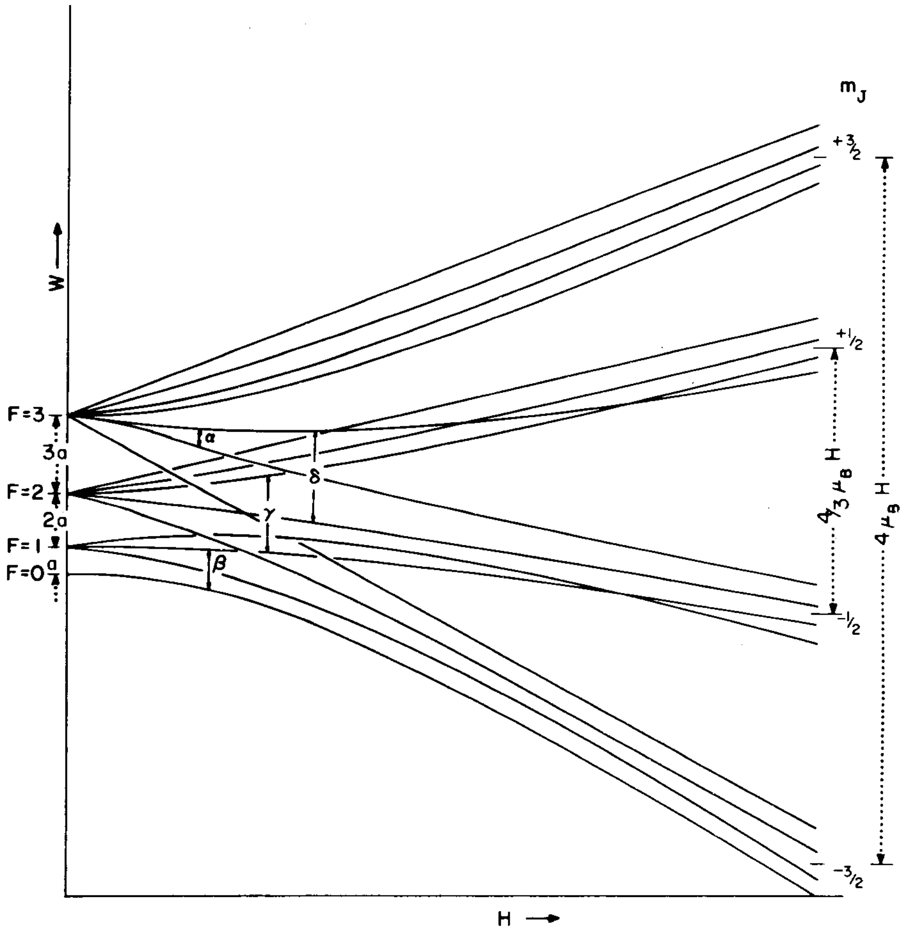

FIGURE 3. Schematic diagram of the energy levels of an atom in a $^2P_{3/2}$ state with a nucleus with $I=3/2$, $\mu>0$, $Q=0$. Transitions α, β, γ, and δ may be used to determine the nuclear moments.

with moderate accuracy. Measurement of the field independent transition ϵ, figure 2 [$F={}^9/_2$, $m_F=+{}^1/_2$ $\leftrightarrow$ $F={}^7/_2$, $m_F=-{}^1/_2$], at very low field gives a measure of ΔW good to a precision of 1 part in 10^{10}.[2]

At intermediate fields the transitions γ and δ, figure 2, pass through frequency minima and at such fields their low field dependence permits very sharp lines to be obtained. For $J={}^1/_2$ states, the difference between these two lines is exactly $2g'_I\mu_B H$ so that g'_I can be determined directly. In practice this evaluation of g'_I is limited by the precision with which one can evaluate H. Since H is usually measured in terms of a transition such as β, which depends on g_J, the determination of g'_I can be reduced to a measurement of the ratio g'_I/g_J.

In all nuclear magnetic moment measurements the measured quantity is $\mu_I H/I$ where H is the field at the nucleus. H differs from the applied field by the field induced by the core electrons. Unfortunately, this effect cannot be measured and the early general calculations of the diamagnetic corrections [41La03], [50Di10], [64Bo38] were assumed to have uncertainties of the order of 5%. The values of this correction range from 0.0006% for He to 1.16% for U. The tabulated magnetic moments include the corrections based on values in [50Di10]. More recent calculations of Lin, Feiock, and Johnson [72Jo18] yield values of the diamagnetic correction which are larger than those used (up to a factor of 2 larger for the heaviest atoms). The values of the correction factors used in the tables, as well as those of [72Jo18], have been tabulated in section 2 under Diamagnetic corrections.

A more complex case is illustrated in figure 3 drawn for a $^2P_{3/2}$ state and a nucleus with a spin of ${}^3/_2$, positive magnetic moment, and no quadrupole moment. The field dependence of transition α can be used to determine the nuclear spin I. Transitions β,

[2] The measurement of a frequency with a stated accuracy in terms of Hz presupposes that the second is determinate to an accuracy greater than that of the measurement. The second of time defined in terms of the rotation of the earth (Universal Time, UT1) is subject to difficult corrections for varying angular velocity of the earth, which can amount to 50 parts in 10^{10} per year. Measurements of the $^{133}Cs(4,0 \leftrightarrow 3,0)$ hyperfine-structure splitting made in 1955 gave an approximate value of 9,192,631,840 Hz of UT [57Es32] which was adopted as a provisional definition of the second. Since then, however, a more precise measurement has been made in terms of Ephemeris Time (ET) which is not subject to the fluctuations in the earth's rotation. The value of the ^{133}Cs hyperfine-structure splitting has been determined as 9,192,631,770 ± 20 Hz of ET as measured at the year 1957.0 [58Ma18]. The definition of the second of Atomic Time (AT), adopted by the 13th General Conference of Weights and Measures (Paris, October 1967) and reported by Terrien [68Te02], is given in terms of $\Delta\nu(^{133}Cs)=9,192,631,770$ Hz.

γ, and δ can be used to evaluate the separations $\Delta W(0,1)$, $\Delta W(1,2)$, and $\Delta W(2,3)$, respectively. If there were an electric quadrupole moment, the zero-field separations would be modified as shown in equation (3). In the $P_{3/2}$ state the evaluation of μ from doublet separations is not as simple as in the $^2S_{1/2}$ case.

The last systematic literature search for information included in the table was in early 1971.

Explanation of Table F

Nucleus	Chemical symbol with Z- and A-number States, other than ground states, are designated by "m" following the A-number.
$T_{1/2}$	Half-life of radioactive nucleus
I	Nuclear spin, in units of $h/2\pi$
μ	Nuclear magnetic dipole moment, in nuclear magnetons, given with diamagnetic correction. See Policies, Diamagnetic corrections, for factors used A 5% uncertainty in the diamagnetic correction is assumed. Values of μ calculated from $\Delta\nu$- or a-ratios do not include a hyperfine-structure anomaly correction unless so designated by a footnote. This correction can be the order of 0.001% to 1%. See [70FuCo]. Values of the magnetic octupole moment, in nuclear magneton-barns, are also tabulated in this column with the notation "Ω=...."
Q	Nuclear electric quadrupole moment, in barns, as given by the experimenter Values marked by an asterisk, *, indicate that the experimenter has made some polarization or Sternheimer correction in computing the moment. Values of the electric hexadecapole moment, given in $10^{-2}b^2$, are also tabulated in this column with the notation "Q_4=...".
Refer.	Reference key
Atomic State	Atomic state for which the hyperfine-structure splitting and the interaction constants are listed
F,F'	Total angular momentum quantum numbers which characterize hyperfine levels of the atomic state at zero magnetic field
$\Delta\nu(F,F')$	The zero-field hyperfine-structure splitting between levels of total spin F and F', given without sign Values are given in MHz unless otherwise noted.
Molecule Used	For molecular beam experiments, the formulae of the compounds used
Interaction Constants	Values of the interaction constants, a, b, and c, as given by the experimenter Values are given in MHz unless otherwise noted. When the nuclear g-factor is measured directly from the resonance frequencies or doublet separations, it is also tabulated, in Bohr magnetons.
Moment Ratios	Magnetic and electric moment ratios as determined by molecular beam techniques Superscripts on the moment symbols designate A-values of isotopes Quadrupole interactions, eqQ/h, are also tabulated in MHz

Table F: Nuclear Moments by Atomic and Molecular Beams

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{1}_{1}$H			+2.785 2		39K12		H_2, HD	
$^{1}_{1}$H			±2.79287 14		49T01		NaOH	g=30.4206x10^{-4} 15
$^{1}_{1}$H					55K48	$^2S_{1/2}$:1,0	1420.40573 5	
$^{1}_{1}$H					56H94	$2^2S_{1/2}$:1,0	177.55686 5	
$^{1}_{1}$H					62Me09	$^2S_{1/2}$:1,0	1420.4057500[l] 4	
$^{1}_{1}$H					63Cr12	$^2S_{1/2}$:1,0	1420.405751800[l] 28	
$^{1}_{1}$H					63Ma31	$^2S_{1/2}$:1,0	1420.40575173[l] 2	
$^{2}_{1}$H			+0.855 6		39K12		H_2, HD, D_2	μ^1/μ^2=3.257 1
$^{2}_{1}$H				+0.00273	40K10		D_2, HD	
$^{2}_{1}$H				+0.002766[c] 25	50N03			(from 40K10)
$^{2}_{1}$H			±0.857415 7		52B40		HD, D_2	μ^2/μ^1=0.3070115 24
$^{2}_{1}$H				±0.002738 14	52K22		H_2, D_2	
$^{2}_{1}$H					55K48	$^2S_{1/2}$:$^3/_2$,$^1/_2$	327.384302 30	
$^{2}_{1}$H					56R57	$2^2S_{1/2}$:$^3/_2$,$^1/_2$	40.924439 20	
$^{2}_{1}$H				±0.002738 19	58Q02		HD	eqQ=−0.22454 6
$^{2}_{1}$H				±0.00282[c]	61Au01			(from 40K10,52K22)
$^{2}_{1}$H					66Cr08	$^2S_{1/2}$:$^3/_2$,$^1/_2$	327.38435230[l] 25	
$^{2}_{1}$H				±0.002796[c] 5	66Na06			
$^{3}_{1}$H	12y				57P46	$^2S_{1/2}$:1,0	1516.70170 7	
$^{3}_{1}$H	12y				67Ma16	$^2S_{1/2}$:1,0	1516.7014708087[l]‡ 71	
							‡Based on $\Delta\nu(^1H)$=1420.4057518MHz	
$^{3}_{2}$He		1/2			53W01			
$^{3}_{2}$He					59W56	$^3S_1$:$^3/_2$,$^1/_2$	6739.7013 4	
$^{3}_{2}He^+$					58N39	$2^2S_{1/2}$:1,0	1083.35499 20	
$^{3}_{2}He^+$					66Fo14	$1^2S_{1/2}$:1,0	8665.649905[l] 50	
$^{6}_{2}$He	0.8s	0♦[b]	<±0.16, if I=1		58C68			
$^{6}_{3}$Li		1[b]	±0.840 4		37M06			μ^6/μ^7=0.258 1
$^{6}_{3}$Li			±0.82202 2		49K31		LiI, LiBr	g^7/g^6=2.64094 5
$^{6}_{3}$Li				≠0	53K43		^{6}LiCl	eqQ^6 positive Q^6/Q^7 positive
$^{6}_{3}$Li				−0.00080[E] 8	64Wh01		^{6}LiF	Q^6/Q^7=+0.0176 10 eqQ=+0.00725 40
$^{6}_{3}$Li					66Sc29	$^2S_{1/2}$:$^3/_2$,$^1/_2$	228.20528 8	
$^{6}_{3}$Li					73Co35	$^2S_{1/2}$:$^3/_2$,$^1/_2$	228.2052592 80	
$^{7}_{3}$Li		3/2[b]	±3.20		35F03			
$^{7}_{3}$Li			+3.254 3		41M08		Li_2, LiCl	g=2.169 2nm
$^{7}_{3}$Li				≈+0.02‡	49K29		Li_2, LiCl	eqQ=+0.060, +0.192
							‡Calculation of the magnitude and sign of Q is extremely sensitive to the assumed atomic wavefunctions	
$^{7}_{3}$Li				≈−0.04[c]‡	53H80		‡Calculation of the magnitude and sign of Q is extremely sensitive to the assumed atomic wavefunctions	
$^{7}_{3}$Li				negative?[c]‡	53S67		Li_2	
							‡Calculation of the magnitude and sign of Q is extremely sensitive to the assumed atomic wavefunctions	
$^{7}_{3}$Li				−0.03[c]‡	58Ma20		Li_2	
							‡Calculation of the magnitude and sign of Q is extremely sensitive to the assumed atomic wavefunctions	
$^{7}_{3}$Li				−0.016[c]	59Bu18			
$^{7}_{3}$Li				−0.044[cE]	63Ka32			(eqQ=+346 2)

Table F: Nuclear Moments by Atomic and Molecular Beams – Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{7}_{3}$Li				-0.043^{c}	64Br36		LiD, LiH	
$^{7}_{3}$Li					64Br37		Li_2	eqQ=0.068‡ *2*
							‡Zero external field	
$^{7}_{3}$Li				-0.045^{E} *4*	64Wh01		^{7}LiH	eqQ=0.355 *2*
							^{7}LiF	eqQ=0.41602 *6*
$^{7}_{3}$Li					66Sc29	$^{2}S_{1/2}$: 2,1	803.50404 *48*	
$^{7}_{3}$Li				$-0.043*^{c}$ *3*	70Lu04		LiH	
$^{9}_{4}$Be			−1.176 *5*		39K09		$NaBeF_3$, $KBeF_3$	$g/g(^{7}Li)$=0.3613 *1*
$^{9}_{4}$Be				+0.049 *3*	67Bl09	$^{3}P_2$: $^{7}/_{2}$, $^{5}/_{2}$	435.4773 *21*	a=−124.5368 *17*
				+0.053* *3*		$^{5}/_{2}$, $^{3}/_{2}$	312.0226 *21*	b=+1.429 *8*
						$^{3}/_{2}$, $^{1}/_{2}$	187.6157 *42*	
						$^{3}P_1$: $^{5}/_{2}$, $^{3}/_{2}$	354.4365 *27*	a=−139.373 *12*
						$^{3}/_{2}$, $^{1}/_{2}$	202.9529 *15*	b=−0.753 *44*
$^{10}_{5}$B			+1.794 *9*		39M05		several molecules	$g/g(^{7}Li)$=0.2755 *15*
$^{10}_{5}$B				+0.0740 *5*	53W46 (52D21)			(Q^{10}/Q^{11}=2.084 *2*)
$^{10}_{5}$B					60Le05	$^{2}P_{1/2}$: $^{7}/_{2}$, $^{5}/_{2}$	429.048 *3*	
$^{10}_{5}$B				+0.0804*^{c} *16*	68Sc18			
$^{10}_{5}$B				+0.08745*^{c}	69Sc34			
$^{10}_{5}$B				+0.08472*^{c} *56*	70Ne21			
$^{11}_{5}$B			+2.686 *8*		39M05		several molecules	$g/g(^{7}Li)$=0.825 *2*
$^{11}_{5}$B				+0.0355 *2*	53W46	$^{2}P_{3/2}$:3,2	222.737 *10*	a=+73.347 *6*
						2,1	144.00 *2*	b=+2.695 *16*
						1,0	70.66 *20*	
						$^{2}P_{1/2}$:2,1	732.4 *1*	
$^{11}_{5}$B					60Le05	$^{2}P_{1/2}$:2,1	732.153 *3*	
$^{11}_{5}$B				+0.0357^{c}	62Ko22			
$^{11}_{5}$B				+0.0386*^{c} *8*	68Sc18			
$^{11}_{5}$B				+0.037*^{c} *4*	69Go12			
$^{11}_{5}$B				+0.04196*^{c}	69Sc34			
$^{11}_{5}$B				+0.04065*^{c} *26*	70Ne21			
$^{11}_{6}$C	21m	3/2			61Sn01			
$^{11}_{6}$C	21m		±1.027 *10*	±0.0308 *6*	64Ha46	$^{3}P_2$: $^{7}/_{2}$, $^{5}/_{2}$	243.080 *30*	a=68.203 *7*
			μ/Q negative			$^{5}/_{2}$, $^{3}/_{2}$	167.402 *30*	b=4.949 *28*
						$^{3}P_1$: $^{5}/_{2}$, $^{3}/_{2}$	−0.200 *50*	a=1.242 *10*
							or +0.062 *50*	or 1.200 *10*
$^{11}_{6}$C	21m		±0.997^{c}	±0.0322*^{c} *6*	68Sc18			
$^{11}_{6}$C	21m		±0.97^{c} *6*	±0.031*^{c}‡ *3*	69Go12		‡For μ<0	
$^{11}_{6}$C	21m		±1.015^{c}	±0.03426*^{c}	69Sc34			
$^{11}_{6}$C	21m		(−?)0.964^{c}‡*1*		70Wo11	$^{3}P_1$		a=−1.308^{c} *24*
								or +1.202^{c} *24*
							‡From comparison with $a(^{3}P_1)/a(^{3}P_2)$ for ^{13}C, find $a(^{3}P_1)$~−1.30	
$^{13}_{6}$C			+0.7018 *20*		41H14		$K^{13}CN$, $Na^{13}CN$	$g/g(^{7}Li)$=0.6464 *18*
$^{13}_{6}$C					70Wo11	$^{3}P_1$: $^{3}/_{2}$, $^{1}/_{2}$	4.257 *25*	a=2.838 *17*
						$^{3}P_2$: $^{5}/_{2}$, $^{3}/_{2}$	372.636 *25*	a=149.055 *10*
$^{13}_{7}$N	10m	1/2			61Sn01			
$^{13}_{7}$N	10m	1/2	±0.32212^{a} *36*		64Be24	$^{4}S_{3/2}$:2,1	33.347 *20*	a=16.673 *10*

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{14}_{7}N$			+0.403 *2*		39K10		NaCN,KCN	$\mu/\mu(^7Li)$=0.1237 *6*
$^{14}_{7}N$					70Cr02	$^4S_{3/2}$		a=10.45092906[l] *19*
								b=+1.32[l] *20*Hz
$^{15}_{7}N$			±0.280 *3*		40Z02		$^{15}N_2$	
$^{15}_{8}O$	2.1m	1/2	±0.7189* *8*		63Co17	$^3P_2$:5/2,3/2	1037.23 *7*	a=414.87 *3*
								$a(^{17}O)$=218.569 *10*
$^{19}_{9}F$			+2.625 *2*		41M08		NaF	g=5.248 *5*nm
$^{19}_{9}F$					61Ra14	$^2P_{3/2}$:2,1	4020.01‡ *2*	
							‡Hyperfine splitting obtained by	paramagnetic resonance experiment
$^{19}_{9}F$			±2.6289 *9*		64Bo37		TlF	
$^{19}_{10}Ne$	18s	1/2[f]	−1.887 *1*		63Co22	$^1S_0$		$\nu/\nu(^1H)$=0.6754 *2*
$^{20}_{10}Ne$		0•	≤4x10^{-4},if I=1		60Lu06			a<250kHz
$^{21}_{10}Ne$		3/2			56H70	$^3P_2$		
$^{21}_{10}Ne$			−0.66176 *2*		57L08		20.5% ^{21}Ne	$g/g(^2H)$=0.514274 *4*
$^{21}_{10}Ne$				+0.093 *10*	58G65	$^3P_2$:7/2,5/2	1034.48 *10*	a=−267.68 *3*
						5/2,3/2	599.44 *10*	b=−111.55 *10*
						3/2,1/2	303.93 *10*	
$^{23}_{10}Ne$	38s		−1.08 *1*		68Do07			
$^{21}_{11}Na$	23s	3/2	+2.38612* *10*		65Am01	$^2S_{1/2}$:2,1	1906.466 *21*	
$^{22}_{11}Na$	2.6y	3	+1.746* *3*		49D01	$^2S_{1/2}$:7/2,5/2	1220.64 *4*	
$^{23}_{11}Na$		3/2[b]			34R01			
$^{23}_{11}Na$			+2.215 *2*		41M08		Na_2	g=1.4761 *15*nm
$^{23}_{11}Na$			±2.2175 *2*		51L28	$^2S_{1/2}$:2,1	1771.631 *2*	$g/g(^1H)$=0.26451 *2*
$^{23}_{11}Na$				+0.108 *12*	55P33	$^2P_{3/2}$		a=19.06 *36*
				or −0.909 *30*				b=+2.58 *30* or
								b=−21.64 *70*
						$^2P_{1/2}$		a=94.45 *50*
$^{23}_{11}Na$				+0.087*[a] *10*	60Be34			
$^{23}_{11}Na$				+0.103[c]	62Ko22			
$^{23}_{11}Na$					64Br37		Na_2	eqQ=0.424‡ *2*
							‡Zero external field	
$^{23}_{11}Na$					70Ch40	$^2S_{1/2}$: 2,1	1771.6261275[p] *5*	
					73Co35			
$^{23}_{11}Na$			±2.21740[dp] *7*		71Co34	$^2S_{1/2}$		
					73Co35			
$^{24}_{11}Na$	15h	4	+1.689* *5*		53B19	$^2S_{1/2}$:9/2,7/2	1139.35 *10*	
$^{24}_{11}Na$	15h		+1.6902[d] *10*		66Ch15	$^2S_{1/2}$:9/2,7/2	1139.33258 *10*	
					73Co36			
$^{25}_{12}Mg$			−0.855 *2*		59K82	$^1S_0$		$g/g(^1H)$=0.612
$^{25}_{12}Mg$				+0.22	62Lu04	$^3P_2$:9/2,7/2	567.291 *10*	a=−128.440 *5*
						7/2,5/2	452.338 *10*	b=16.009 *5*
						5/2,3/2	329.044 *10*	
						3/2,1/2	199.82 *4*	
						$^3P_1$:7/2,5/2	516.140 *10*	a=−144.945 *5*
						5/2,3/2	349.987 *10*	b=−8.029 *5*
$^{27}_{13}Al$		5/2	+3.637 *10*		39M08		NaCl•$AlCl_3$	$g/g(^7Li)$=0.6696
$^{27}_{13}Al$		5/2		+0.156 *3*	49L15	$^2P_{3/2}$:4,3	392.0 *2*	a=94.25 *4*
						3,2	274.3 *1*	b=18.76 *25*
$^{27}_{13}Al$				+0.155[c]	52K10			

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{27}_{13}$Al				+0.149 *2*	53L15	$^2P_{1/2}$:3,2	1506.14 *5*	a=502.05 *2*
$^{27}_{13}$Al				+0.150^c	62Ko22 (53L15)			
$^{27}_{13}$Al					68Ma23	$^2P_{3/2}$		a=94.27767^E *10* b=18.9153^E *7*
$^{27}_{13}$Al				±0.140*^{c} *2*	71St44			
$^{30}_{15}$P	2.6m	1			68Ph02			
$^{31}_{15}$P					64Pe11	$^4S_{3/2}$		a=+55.061 *10*
$^{35}_{17}$Cl		3/2	positive	−0.0795 *5*	49D14	$^2P_{3/2}$		a=205.288 *10* b=55.347 *20*, $b/a>0$
$^{35}_{17}$Cl				−0.07894 *2*	51J20	$^2P_{3/2}$		a=205.050 *5* b=54.873 *5* Q^{35}/Q^{37}=1.2686 *4*
$^{35}_{17}$Cl			±0.82 *8*		51K31	$^2P_{1/2}$: 2,1	2074.383 *8*	
$^{35}_{17}$Cl				−0.0782^c	52K10			
$^{35}_{17}$Cl			Ω=−0.0191 *32*		56Ho02	$^2P_{3/2}$: 3,2 2,1 1,0	670.013455 *90* 355.221030 *70* 150.173560 *75*	a=205.046870 *30* b=54.872905 *55* c=−7.15 *120*Hz (c=9.3^j *12*Hz)
$^{35}_{17}$Cl			Ω=−0.0188^c *30*		57S28			c=−6.95 *120*Hz
$^{35}_{17}$Cl				−0.0793^c	62Ko22 (51J20)			
$^{35}_{17}$Cl			Ω=−0.0188^c Ω=−0.0162*^{c}	−0.108^c −0.104*^{c}	71Am02 (49D14)	$^2P_{3/2}$		a=205.046860^c b=54.872934^c c=−7.015^{c}Hz
$^{37}_{17}$Cl		3/2		−0.0621 *5*	49D14	$^2P_{3/2}$		a=170.686 *10* b=43.256 *20*, $b/a>0$
$^{37}_{17}$Cl				−0.06213 *2*	51J20	$^2P_{3/2}$		a=170.681 *10* b=43.255 *10*
$^{37}_{17}$Cl			±0.68^a *7*		51K31	$^2P_{1/2}$:2,1	1726.700 *15*	
$^{37}_{17}$Cl				−0.0616^c	52K10			
$^{37}_{17}$Cl			Ω=−0.0148 *32*		56Ho02	$^2P_{3/2}$: 3,2 2,1 1,0	555.304315 *90* 298.127655 *70* 127.440815 *75*	a=170.686370 *30* b=43.245245 *55* c=−5.55 *120*Hz (c=5.35^j *120*Hz)
$^{37}_{17}$Cl			Ω=−0.0146^c *30*		57S28			c=−5.41 *120*Hz
$^{35}_{18}$Ar	1.8s	3/2^f	+0.632 *2*		65Ca04			
$^{38}_{19}$K	7.7m	3	+1.3740^a *10*		65Ph02	$^2S_{1/2}$:$^7/_2$,$^5/_2$	1415.292 *9*	
$^{39}_{19}$K		3/2^b	±0.397		35M08	$^2S_{1/2}$		
$^{39}_{19}$K			positive		37T04			
$^{39}_{19}$K			+0.391 *2*		39K10		K_2, KCN	$g/g(^7Li)$=0.120
$^{39}_{19}$K					50O01	$^2S_{1/2}$		g^{39}/g^{41}=1.8218 *2*
$^{39}_{19}$K			±0.39149^d *15*		52E09	$^2S_{1/2}$		g^{40}/g^{39}=1.24346^d *24*
$^{39}_{19}$K				±0.07 *2*	57B19	$P_{1/2}$ $P_{3/2}$		a=28.85 *3* $a_{3/2}$=5$a_{1/2}$ assumed b=2.8 *8*
$^{39}_{19}$K					59M70	$^2S_{1/2}$:2,1	461.71971 *15*	
$^{39}_{19}$K				+0.070^c	62Ko22 (57B19)			
$^{39}_{19}$K					67Da04	$^2S_{1/2}$:2,1	461.719723 *38*	

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{39}_{19}$K				+0.053 *8*	68Sp03	$^4F_{9/2}$:6,5 $^4D_{7/2}$	568.8 *1*	a=103.56 *9* b=78.86 *80*,b/a<0 a=150.03 *90* b=78.5 *32*,b/a<0
$^{39}_{19}$K					69Zi01	$4^2P_{3/2}$		a=+6.10 *25* b=+1.8 *12*
$^{39}_{19}$K					70Ch40 73Co35	$^2S_{1/2}$: 2,1	461.7197204[P] *5*	
$^{39}_{19}$K			±0.391427[dp] *27*		73Co35			
$^{40}_{19}$K	1.3Gy	4	−1.291[a] *5*		49D01	$^2S_{1/2}$:$^9/_2$,$^7/_2$	1285.73 *5*	
$^{40}_{19}$K	1.3Gy		−1.2981[d] *4*		52E09	$^2S_{1/2}$:$^9/_2$,$^7/_2$	1285.790 *7*	
$^{41}_{19}$K		3/2[b]			36M03			
$^{41}_{19}$K				±0.067[E]	53L33		^{39}KCl,^{41}KCl	Q^{41}/Q^{39}=1.220[E] *2*
$^{41}_{19}$K			±0.2153[a] *4*		60Sa23	$^2S_{1/2}$:2,1	254.014 *1*	
$^{41}_{19}$K				+0.067[E]	67Bo40		^{39}KF;^{41}KF	Q^{39}/Q^{41}=+0.8215[E] *1*
$^{41}_{19}$K					70Ch40 73Co35	$^2S_{1/2}$: 2,1	254.0138700[P] *5*	
$^{42}_{19}$K	12h	2	−1.138[a] *5*		53B19	$^2S_{1/2}$:$^5/_2$,$^3/_2$	1258.9 *1*	
$^{42}_{19}$K	12h		−1.141[d] *3*		64Kh01	$^2S_{1/2}$:$^5/_2$,$^3/_2$	1258.877 *4*	
$^{42}_{19}$K	12h		±1.1424[k] *8*		69Ch20 73Co36	$^2S_{1/2}$:$^5/_2$,$^3/_2$	1258.876947 *15*	a=−503.550779 *5* g=3.10672x10^{-4} *45*
$^{43}_{19}$K	22h	3/2	±0.163[a] *2*		59P26	$^2S_{1/2}$:2,1	192.64 *5*	
$^{45}_{19}$K	20m	3/2	±0.1734[a] *4*		67Ga08 68Ga28	$^2S_{1/2}$:2,1	204.5873 *15*	a=102.2936 *7*
$^{43}_{20}$Ca			±1.317 *3*		59K82	$^1S_0$		$g/g(^1H)$=0.0673
$^{43}_{21}$Sc	3.9h	7/2	+4.62[a] *4*	−0.26 *6*	66Co13	$^2D_{5/2}$		a=+105.7 *9* b=−44 *10*
$^{44}_{21}$Sc	3.9h	2	+2.56[a] *3*	+0.10 *5*	66Co13	$^2D_{5/2}$		a=+102.5 *12* b=+18 *8*
$^{44m}_{21}$Sc	2.4d	6	+3.88[a] *1*	−0.19 *2*	66Co13	$^2D_{5/2}$		a=+51.7 *2* b=−33 *3*
$^{45}_{21}$Sc				−0.22 *1*	59F53	$^2D_{3/2}$:5,4 4,3 $^2D_{5/2}$:6,5 5,4 4,3	1328.96 *10* 1085.772 *15* 635.003 *50* 543.841 *50* 444.652 *50*	a=+269.560 *20* b=−26.37 *10* a=+109.034 *10* b=−37.31 *10* c=−3.5 *35*kHz
$^{46}_{21}$Sc	84d	4	+3.03 *2*	+0.119 *6*	62Pe21	$^2D_{3/2}$:$^{11}/_2$,$^9/_2$ $^9/_2$,$^7/_2$ $^7/_2$,$^5/_2$ $^2D_{5/2}$:$^{13}/_2$,$^{11}/_2$ $^{11}/_2$,$^9/_2$ $^9/_2$,$^7/_2$ $^7/_2$,$^5/_2$ $^5/_2$,$^3/_2$	838.06 *11* 674.12 *6* 517.13 *10* 405.84 *6* 336.19 *2* 270.14 *3* 207.05 *3* 146.25 *3*	a=+150.576 *9* b=+14.38 *14* a=+60.906 *4* b=+20.41 *10*
$^{47}_{21}$Sc	3.4d	7/2	+5.34[a] *2*	−0.22 *3*	66Co13	$^2D_{5/2}$		a=+122.2 *5* b=−38 *6*
$^{48}_{21}$Sc	1.8d	6			67Re06	$^2D_{5/2}$		
$^{45}_{22}$Ti	3.1h	7/2	±0.095[a] *2* μ/Q positive	±0.015 *15*	66Co19	J=3:$^{13}/_2$,$^{11}/_2$ $^{11}/_2$,$^9/_2$	30.5 *3* 25.4 *3*	a=4.59 *7* b=1.5 *15*

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{47}_{22}$Ti				+0.29 *1*	65Ch19	$^{3}F_{2}$		a=−85.7033^{j} *3*
								b=+25.700^{j} *3*
						$^{3}F_{3}$		a=−52.9047^{j} *7*
								b=+28.082^{j} *9*
						$^{3}F_{4}$		a=−37.9918^{j} *6*
								b=+37.681^{j} *10*
$^{49}_{22}$Ti				+0.24 *1*	65Ch19	$^{3}F_{2}$		a=−85.7261^{j} *3*
								b=+21.070^{j} *3*
						$^{3}F_{3}$		a=−52.9183^{j} *5*
								b=+23.030^{j} *10*
						$^{3}F_{4}$		a=−38.0042^{j} *5*
								b=+30.842^{j} *13*
								Q^{49}/Q^{47}=+0.819 *1*
$^{47}_{23}$V	31m	3/2			67Re06	$^{4}F_{9/2}$, ^{6}D		
$^{48}_{23}$V	16d	4			66Re06	$^{4}F_{9/2}$, $^{4}F_{7/2}$		
$^{51}_{23}$V				−0.052 *1*	67Ch10	$^{4}F_{9/2}$		a=227.136 *1*
								b=8.259 *60*
								c=0.002 *2*
						$^{4}F_{7/2}$		a=249.752 *2*
								b=5.595 *60*
								c=−0.001 *2*
						$^{4}F_{5/2}$		a=321.251 *3*
								b=3.964 *55*
								c=0.000 *2*
						$^{4}F_{3/2}$		a=560.069 *2*
								b=3.982 *24*
				−0.052 *1*		$^{6}D_{9/2}$		a=406.852 *2*
								b=14.344 *65*
								c=0.006 *9*
						$^{6}D_{7/2}$		a=382.369 *1*
								b=2.442 *30*
								c=0.001 *3*
						$^{6}D_{5/2}$		a=373.529 *1*
								b=−4.942 *35*
								c=0.000 *2*
						$^{6}D_{3/2}$		a=405.648 *2*
								b=−6.916 *50*
						$^{6}D_{1/2}$		a=751.545 *3*
$^{49}_{24}$Cr	42m	5/2	±0.476^{a} *3*		70Jo27	$^{7}S_{3}$: $^{11}/_{2}$, $^{9}/_{2}$	273.657 *20*	a=49.754 *2*
						$^{9}/_{2}$, $^{7}/_{2}$	223.893 *9*	b=0.018 *17*
						$^{7}/_{2}$, $^{5}/_{2}$	174.134 *12*	b/a>o
$^{51}_{24}$Cr	28d	7/2			59C24			
$^{51}_{24}$Cr	28d		±0.934^{a} *5*		70Ad07	$^{7}S_{3}$		a=69.701 *2*
								b=0.015 *23*
								b/a<0
$^{53}_{24}$Cr					63Ch17	$^{7}S_{3}$: $^{9}/_{2}$, $^{7}/_{2}$	371.691 *11*	a=82.5985 *15*
						$^{7}/_{2}$, $^{5}/_{2}$	289.095 *7*	b=0.003 *8*
						$^{5}/_{2}$, $^{3}/_{2}$	206.499 *7*	b/a<0
$^{53}_{24}$Cr					64Pe11	$^{7}S_{3}$		a=−82.5994 *16*
								b=+0.008 *12*

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{51}_{25}$Mn	45m	5/2	±3.56[a]		68Jo19	$^6S_{5/2}$		a=74.835 *2* b=0.024 *7*
$^{52}_{25}$Mn	5.7d	6	±3.058[a] *1*		66Ad03	$^6S_{5/2}$ + admixtures		a=26.759 *3* $\|b\|$<0.100
$^{52m}_{25}$Mn	21m	2	±0.0076[a] *4*		65Ph04	$^6S_{5/2}$		a=±0.200 *4*
$^{52m}_{25}$Mn	21m	2	±0.0076[a] *3*		65Sa22	$^6S_{5/2}$		a=0.200 *3*
$^{55}_{25}$Mn		5/2			57W46	$^6S_{5/2}$		
$^{55}_{25}$Mn					65Ev07	$^6S_{5/2}$		a=−72.42083 *7* b=−0.0183 *8* (c=0 assumed)
$^{56}_{25}$Mn	2.6h	3	+3.223[a] *2*		61Ch05	$^6S_{5/2}$: $^{11}/_2$, $^9/_2$ $^9/_2$, $^7/_2$ $^7/_2$, $^5/_2$	310.173 *15* 253.766 *10* 197.375 *8*	a=56.3924 *23* b≤0.050
$^{57}_{26}$Fe					66Ch16	$^5D_4$ $^5D_3$ $^5D_2$ $^5D_1$		a=+38.0795 *10* a=+26.351 *2* a=+18.762 *2* a=+14.077 *5*
$^{59}_{26}$Fe	45d	3/2			65Do11	$^5D_4$		
$^{59}_{27}$Co				±0.404 *40*	61Eh01	$^4F_{9/2}$:8,7 7,6 6,5 5,4 4,3	3655.470 *200* 3169.440 *50* 2695.056 *100* 2230.638 *50* 1774.548 *50*	a=450.284 *10* b=139.63 *50*
$^{59}_{27}$Co					65Ch19	$^4F_{7/2}$ $^4F_{5/2}$		a=+490.5779[j] *8* b=+95.153[j] *16* a=+613.3762[j] *8* b=+68.255[j] *14*
$^{59}_{27}$Co			+4.64 *21*	+0.380	68Ch09	$^4F_{9/2}$:($3d^74s^2$)		a=450.283 *1* b=139.230 *30* c=0.000 *3*
						$^4F_{7/2}$		a=490.567 *2* b=94.501 *36* c=0.000 *4*
						$^4F_{5/2}$		a=613.349 *3* b=67.541 *50* c=−0.002 *3*
						$^4F_{3/2}$		a=1042.981 *1* b=67.618 *2*
				+0.345		$^4F_{9/2}$:($3d^84s$)		a=828.799 *4* b=−118.8 *3* c=0.002 *4*
						$^4F_{7/2}$		a=668.919 *1* b=−79.2 *2* c=0.004 *4*
						$^4F_{5/2}$		a=562.183 *3* b=−54.8 *3*
				+0.36‡ *7*			‡Average value	
$^{60m}_{27}$Co	10.5m	2			68Ro08			
$^{60m}_{27}$Co	10.5m	2	+4.40[ap] *9*	+0.3[p] *4*	69Hu12			

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{61}_{28}$Ni				+0.126	68Ch10	$^3F_4$:($3d^84s^2$)		a=−215.040 2
								b=−56.868 18
								c=0.000 1
						$^3F_3$		a=−299.311 2
								b=−42.063 13
				+0.130		$^3D_3$:($3d^94s$)		a=−454.972 3
								b=−102.951 16
								c=0.000 1
						$^3D_2$		a=−171.584 7
								b=−56.347 23
				+0.16*‡ 2			‡Average value	
$^{60}_{29}$Cu	24m	2			58R10			
$^{60}_{29}$Cu	24m		+1.219* 3		68Ph01	$^2S_{1/2}$:$^5/_2$,$^3/_2$	6033 4	a=2413.1 16
$^{61}_{29}$Cu	3.3h	3/2			57N09			
$^{61}_{29}$Cu	3.3h	3/2			58R10			
$^{61}_{29}$Cu	3.3h		+2.13* 4		66Do01	$^2S_{1/2}$:2,1	11225 200	
$^{62}_{29}$Cu	9.9m	1			66Do01	$^2S_{1/2}$		
$^{62}_{29}$Cu	9.9m		−0.380* 4		68Ph01	$^2S_{1/2}$:$^3/_2$,$^1/_2$	2257.2 5	a=−1504.8 3
$^{63}_{29}$Cu					57T12	$^2S_{1/2}$:2,1	11733.83 1	
$^{63}_{29}$Cu			+2.2228 4		67Fi11	$^2S_{1/2}$: 2,1	11733.817412 40	
$^{63}_{29}$Cu					69Bl08	$^4P_{5/2}$		a=2031.239 1
								b=78.993 4
								c=−100 180Hz
						$^4F_{9/2}$		a=1323.891 1
								b=137.874 5
								c=−340 350Hz
								g^{63}/g^{65}=0.933524 5
$^{64}_{29}$Cu	13h	1	±0.216* 4		54L40	$^2S_{1/2}$:$^3/_2$,$^1/_2$	1278 20	
$^{64}_{29}$Cu	13h		−0.216* 2		66Do01	$^2S_{1/2}$:$^3/_2$,$^1/_2$	1282.140 8	
$^{65}_{29}$Cu					57T12	$^2S_{1/2}$:2,1	12568.81 1	
$^{65}_{29}$Cu			+2.3812 4		67Fi11	$^2S_{1/2}$: 2,1	12568.779943 120	
$^{65}_{29}$Cu					69Bl08	$^4P_{5/2}$		a=2175.811 2
								b=73.111 9
								c=−10 32Hz
						$^4F_{9/2}$		a=1418.123 2
								b=127.586 19
$^{66}_{29}$Cu	5.2m	1	±0.283* 5		64Ro04	$^2S_{1/2}$:$^3/_2$,$^1/_2$	1670 15	
$^{66}_{29}$Cu	5.2m	1	−0.281* 2		69Cu09	$^2S_{1/2}$		a=1112.525 4
$^{67}_{30}$Zn				+0.16	62Lu04	$^3P_2$:$^9/_2$,$^7/_2$	2418.111 25	
						$^7/_2$,$^5/_2$	1855.690 15	
						$^5/_2$,$^3/_2$	1312.065 15	
						$^3/_2$,$^1/_2$	781.865 15	
$^{66}_{31}$Ga	9.5h	0♦	<0.00004, if I=1		57W35	$^2P_{1/2}$		
$^{67}_{31}$Ga	78h	3/2			57H86			
$^{67}_{31}$Ga	78h		+1.8488 4	+0.22	68Eh02	$^2P_{1/2}$:2,1	2457.72726 90	a=1228.86582 45
								g=6.705x10^{-4} 13
						$^2P_{3/2}$		a=175.09736 15
								b=71.95750 55
$^{68}_{31}$Ga	68m	1			58H114			
$^{68}_{31}$Ga	68m		±0.01175* 6	±0.0313 16	62Eh02	$^2P_{1/2}$:$^3/_2$,$^1/_2$	17.574 15	a=11.716 10
			μ/Q negative			$^2P_{3/2}$:$^5/_2$,$^3/_2$	8.695 33	(a=1.660* 10)
						$^3/_2$,$^1/_2$	25.611 41	b=10.276 17

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{69}_{31}$Ga			+1.999‡ *5*	+0.186	48B17	$^2P_{1/2}$:2,1	2677.56 *10*	$g=7.239\times10^{-4}$ *15*
						$^2P_{3/2}$:3,2	634.890 *20*	$a=190.790$ *5*
						2,1	319.062 *10*	$b=62.518$ *12*
						1,0	128.274 *10*	$c<100$Hz
							‡Determined from $\Delta m=\pm1$ doublet separation for $J=3/2$ state. Value subject to error due to perturbation effects of nearby states	
$^{69}_{31}$Ga				+0.2318[c]	49D14			
$^{69}_{31}$Ga				+0.190[c]	52K10			
$^{69}_{31}$Ga			$\Omega=\pm0.107$ *20*		54D26	$^2P_{3/2}$:3,2	634.90183 *20*	$a=190.79428$ *15*
						2,1	319.06706 *20*	$b=62.52247$ *30*
						1,0	128.27730 *20*	$c=84$ *6*Hz
$^{69}_{31}$Ga					56L53	$^2P_{1/2}$:2,1	2677.9875 *10*	
$^{69}_{31}$Ga			$\Omega=+0.137$[c] *5*		57S28			($c=50.2$[i] *33*Hz)
								$c=93.0$ *34*Hz
$^{69}_{31}$Ga				+0.183[c]	62Ko22 (54D26)			
$^{69}_{31}$Ga			+2.0145[h] *3*		68Fo10	$^2P_{1/2}$: 2,1	2677.98716 *20*	$g=7.29530\times10^{-4}$ *33*
						$^2P_{3/2}$		$a=190.79436$ *11*
								$b=62.52319$ *23*
								$c=90$ *6*Hz
							$\eta=1.0886$ *290*	$a'''=-107.76$ *98*
$^{70}_{31}$Ga	21m	1			62Eh01	$^2P_{1/2}$		
$^{71}_{31}$Ga			+2.547‡ *5*	+0.117	48B17	$^2P_{1/2}$:2,1	3402.09 *20*	$g=9.218\times10^{-4}$ *15*
						$^2P_{3/2}$:3,2	766.673 *20*	$a=242.424$ *5*
						2,1	455.450 *10*	$b=39.398$ *10*
						1,0	203.028 *10*	$c<100$Hz
							‡Determined from $\Delta m=\pm1$ doublet separation for $J=3/2$ state. Value subject to error due to perturbation effects of nearby states	
$^{71}_{31}$Ga				+0.1461[c]	49D14			
$^{71}_{31}$Ga				+0.120[c]	52K10			
$^{71}_{31}$Ga			$\Omega=\pm0.146$ *20*		54D26	$^2P_{3/2}$:3,2	766.69580 *20*	$a=242.43395$ *20*
						2,1	445.46960 *20*	$b=39.39904$ *40*
						1,0	203.04340 *20*	$c=115$ *7*Hz
$^{71}_{31}$Ga					56L53	$^2P_{1/2}$:2,1	3402.6946 *13*	
$^{71}_{31}$Ga			$\Omega=+0.180$[c] *5*		57S28			($c=86.0$[f] *33*Hz)
								$c=121.9$ *34*Hz
$^{72}_{31}$Ga	14h	3	−0.13210[a] *5*	+0.58 *1*	60Ch13	$^2P_{1/2}$:$^7/_2$,$^5/_2$	153.653 *1*	$a=-43.9009$ *3*
						$^2P_{3/2}$:$^9/_2$,$^7/_2$	117.103 *3*	$a=-6.2593$ *27*
						$^7/_2$,$^5/_2$	89.700 *15*	$b=+193.693$ *16*
$^{72}_{31}$Ga	14h		−0.13211 *3*	+0.59	68Eh02	$^2P_{1/2}$:$^7/_2$,$^5/_2$	153.65266 *53*	$a=-43.90076$ *15*
						$^2P_{3/2}$		$a=-6.25698$ *11*
								$b=193.67365$ *80*
$^{69}_{32}$Ge	38h	5/2	±0.735[a] *7*	±0.028 *6*	70O102	$^3P_1$		$a=23.40$ *3*
			μ/Q positive					$b=8.28$ *8*
$^{71}_{32}$Ge	11d	1/2	+0.65 *20*		63Ch12	$^3P_1$:$^3/_2$,$^1/_2$		$a=87.005$ *3*
						$^3P_2$:$^5/_2$,$^3/_2$		$a=357$ *6*
$^{71}_{32}$Ge	11d		±0.546[a] *5*		66Ch02	$^3P_1$		($a=87.005$ *3*)
$^{71}_{32}$Ge	11d		±0.547[a] *5*		70O102	$^3P_2$		$a=+360.53$ *6*

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{73}_{32}$Ge				−0.18‡ *3*	66Ch02	$^3P_1$		a=+15.5480 *18*
								b=−54.566 *9*
						$^3P_2$		a=−64.4270 *7*
								b=+111.825 *13*
							‡Average value	
$^{73}_{32}$Ge				−0.173[c] *26*	70O102			
$^{75}_{32}$Ge	82m	1/2	+0.509[a] *5*		70O102	$^3P_1$		a=−81.06 *8*
						$^3P_2$		a=+335.94 *9*
$^{70}_{33}$As	55m	4			69Ph04			
$^{72}_{33}$As	26h	2	±2.2[ap]		69Ph04			
$^{75}_{33}$As					64Pe11	$^4S_{3/2}$		a=−66.204 *1*
								b=−0.535 *3*
$^{76}_{33}$As	26h	2		±7 *8*	61Ch10	$^4S_{3/2}$: $^7/_2$, $^5/_2$	117 *4*	a=30.5 *35*
						$^5/_2$, $^3/_2$	69 *16*	b=12 *14*
$^{76}_{35}$Br	17h	1	±0.5479[a] *1*	±0.26 *1*	60Li11	$^2P_{3/2}$: $^5/_2$, $^3/_2$	1256.47 *5*	a=345.422 *14*
			μ/Q negative			$^3/_2$, $^1/_2$	189.11 *5*	b=314.329 *22*
$^{77}_{35}$Br	58h	3/2			59G92			
$^{79}_{35}$Br			±2.110 *21*		47B24		CsBr, LiBr	
$^{79}_{35}$Br					53F33		^{39}KBr	Q^{79}/Q^{81}=1.1973[E] *6*
$^{79}_{35}$Br		3/2	positive	+0.32 *2*	54K11	$^2P_{3/2}$:3,2	2269.552	a=884.810 *3*
						2,1	2154.499	b=−384.878 *8*
						1,0	1269.702	c≤0.0001
$^{79}_{35}$Br				+0.293[c]	62Ko22 (54K11)			
$^{79}_{35}$Br			Ω=+0.116		66Br03	$^2P_{3/2}$:3,2	2269.55564 *10*	a=884.80977 *6*
						2,1	2154.49879 *10*	b=−384.88284 *20*
						1,0	1269.70100 *50*	c=388 *8*Hz
$^{79}_{35}$Br					69He04		LiBr	Q^{79}/Q^{81}=1.197056 *6*
$^{79}_{35}$Br			Ω=+0.123[c]	+0.445[c]	71Am02	$^2P_{3/2}$		a=884.809720[c]
			Ω=+0.0928*[c]	+0.367*[c]				b=−384.882900[c]
								c=393[c]Hz
$^{80}_{35}$Br	18m	1			59L41			
$^{80}_{35}$Br	18m		±0.5138[a] *6*	±0.18 *8*	64Wh05	$^2P_{3/2}$: $^5/_2$, $^3/_2$	525.2 *12*	a=323.9 *4*
			μ/Q positive	±0.19*		$^3/_2$, $^1/_2$	998.0 *10*	b=227.62 *10*
$^{80m}_{35}$Br	4.5h	5			59L41			
$^{80m}_{35}$Br	4.5h		+1.3170 *6*	+0.71 *3*	64Wh05	$^2P_{3/2}$: $^{13}/_2$, $^{11}/_2$	510.62 *25*	a=+166.05 *2*
				+0.74*		$^{11}/_2$, $^9/_2$	1277.80 *18*	b=−874.9 *2*
$^{81}_{35}$Br			±2.271 *23*		47B24		CsBr, LiBr	
$^{81}_{35}$Br		3/2	positive	+0.27 *2*	54K11	$^2P_{3/2}$:3,2	2539.794	a=953.770 *3*
						2,1	2229.056	b=−321.516 *8*
						1,0	1275.271	c≤0.0001
$^{81}_{35}$Br			Ω=+0.129		66Br03	$^2P_{3/2}$:3,2	2539.79156 *10*	a=953.76818 *6*
						2,1	2229.05377 *10*	b=−321.52428 *20*
						1,0	1275.30352 *50*	c=430 *8*Hz
$^{82}_{35}$Br	36h	5	±1.6264[a] *5*	±0.73 *3*	59G12	$^2P_{3/2}$: $^{13}/_2$, $^{11}/_2$	766.82 *60*	a=205.04 *5*
			μ/Q positive			$^{11}/_2$, $^9/_2$	1287.32 *43*	b=870.7 *9*
						$^9/_2$, $^7/_2$	1488.6 *11*	b/a=−4.246 *1*
$^{83}_{36}$Kr		9/2?	−0.971		46K05			
$^{83}_{36}$Kr		9/2		+0.251 *5*	61Ku07	$^3P_2$: $^{13}/_2$, $^{11}/_2$	1830.714 *10*	a=−243.970 *4*
						$^{11}/_2$, $^9/_2$	1341.820 *20*	b=−452.12 *8*
								(c≈−2 *2*kHz assumed)

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{83}_{36}$Kr			Ω=−0.18 6	+0.270 13	63Fa01	$^3P_2$: $^{13}/_2$, $^{11}/_2$	1830.7236 5	a=−243.9693 1
						$^{11}/_2$, $^9/_2$	1341.8217 2	b=−452.1697 36
						$^9/_2$, $^7/_2$	956.5583 2	c=−0.00080 20
						$^7/_2$, $^5/_2$	656.0844 30	
$^{85}_{36}$Kr	11y		±1.005	+0.42 4	61Ku07			(μ^{85}/μ^{83}=1.035 2)
					(55R13)			(Q^{85}/Q^{83}=1.66 10)
$^{81}_{37}$Rb	4.7h	3/2			56H52			
$^{81}_{37}$Rb	4.7h		+2.05[a] 2		57H75	$^2S_{1/2}$:2,1	5097 13	
$^{81}_{37}$Rb	4.7h		+2.42[d] 44		62Fa04	$^2S_{1/2}$:2,1	5111.589 40	
$^{81m}_{37}$Rb	32m	9/2			56H69			
$^{82m}_{37}$Rb	6.3h	5			56H52			
$^{82m}_{37}$Rb	6.3h		+1.50[a] 2		57H75	$^2S_{1/2}$: $^{11}/_2$, $^9/_2$	3094.1 24	
$^{82m}_{37}$Rb	6.3h				62Fa04	$^2S_{1/2}$: $^{11}/_2$, $^9/_2$	3094.084 6	
$^{82m}_{37}$Rb	6.3h		±1.6427 12		68Co18	$^2S_{1/2}$: $^{11}/_2$, $^9/_2$	3094.08265 30	
$^{83}_{37}$Rb	83d	5/2			56H52			
$^{83}_{37}$Rb	83d		+1.42[a] 2		57H75	$^2S_{1/2}$:(3.2)	3183.3 58	
$^{84}_{37}$Rb	33d	2			56H52			
$^{84}_{37}$Rb	33d		−1.32[a] 2		57H75	$^2S_{1/2}$: $^5/_2$, $^3/_2$	3077.5 51	
$^{84}_{37}$Rb	33d				62Kh03	$^2S_{1/2}$: $^5/_2$, $^3/_2$	3083.159 4	
$^{85}_{37}$Rb		5/2[b]			36M01			
$^{85}_{37}$Rb			+1.346 5		39K07		Rb_2	$g/g(^7Li)$=0.247 1
$^{85}_{37}$Rb					54T35		$^{85}Rb^{35}Cl$	Q^{85}/Q^{87}=2.0669[E] 5
$^{85}_{37}$Rb				±0.27 2	56S59	$^2P_{3/2}$:4,3	120.8	a=25.3 2
						3,2	65.0	b=24.4 13
						$^2P_{1/2}$:3,2	362 3	a=120.7 10
$^{85}_{37}$Rb				±0.30[c]	62Ko22			
					(56S59)			
$^{85}_{37}$Rb					62Pe14	$^2S_{1/2}$:3,2	3035.732439 5	
$^{85}_{37}$Rb					64Bo07		^{85}RbF	eqQ=−70.3406[E] 10
$^{85}_{37}$Rb					67Bo40		RbF	Q^{85}/Q^{87}=+2.06694 6
$^{85}_{37}$Rb			±1.3521 10		67Gr08		^{85}RbF	
$^{85}_{37}$Rb			+1.3524[h] 2		68Eh01			g_I/g_J= −1.466478x10^{-4} 22
$^{85}_{37}$Rb			+1.3524[d] 2		69De33			g_I/g_J= −1.466477x10^{-4} 34
$^{86}_{37}$Rb	19d	2	−1.70[a] 1		53B19	$^2S_{1/2}$: $^5/_2$, $^3/_2$	3960 20	
$^{86}_{37}$Rb	19d		−1.6912[d] 5		61Br16	$^2S_{1/2}$: $^5/_2$, $^3/_2$	3946.883 2	g=4.590x10^{-4} 4
$^{87}_{37}$Rb	47Gy	3/2[b]			36M01			
$^{87}_{37}$Rb	47Gy		+2.744 9		39K07		Rb_2	$g/g(^7Li)$=0.8399 28
$^{87}_{37}$Rb	47Gy			±0.13 1	56S59	$^2P_{3/2}$:3,2	265 3	a=85.8 7
								b=11.8 6
						$^2P_{1/2}$		a=409 4
$^{87}_{37}$Rb	47Gy				61Es03	$^2S_{1/2}$:2,1	6834.682614 1	
$^{87}_{37}$Rb	47Gy				62Pe14	$^2S_{1/2}$:2,1	6834.682614 3	
$^{87}_{37}$Rb	47Gy		+2.74996[d] 20		67Fi11			
$^{87}_{37}$Rb	47Gy				68Du05	$5^2P_{1/2}$: 2,1	812 15	
$^{88}_{37}$Rb	18m	2	±0.508[a] 5		68Va03	$^2S_{1/2}$: $^5/_2$, $^3/_2$	1186.084 18	
$^{87}_{38}$Sr			−1.0924 9		59K82		Sr metal	
$^{89}_{39}$Y					59F58	$^2D_{3/2}$:2,1	114.72 20	a=−57.217 15
						$^2D_{5/2}$:3,2	88.63 60	a=−28.749 30
$^{90}_{39}$Y				−0.15[c]	62Ko22			

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{90}_{39}$Y	64h	2	−1.629[a] *8*	−0.155 *3*	62Pe01	$^2D_{5/2}$: $^9/_2,^7/_2$	403.719 *37*	a=−85.258 *6*
						$^7/_2,^5/_2$	293.203 *22*	b—29.716 *38*
						$^5/_2,^3/_2$	198.287 *24*	
						$^3/_2,^1/_2$	114.515 *19*	
						$^2D_{3/2}$: $^7/_2,^5/_2$	613.023 *34*	a=−169.749 *7*
						$^5/_2,^3/_2$	410.871 *24*	b=−21.602 *27*
						$^3/_2,^1/_2$	235.722 *26*	
$^{91}_{39}$Y	58d	1/2	±0.1640[a] *8*		62Pe21	$^2D_{3/2}$:2,1	136.69 *3*	a=68.34 *2*
						$^2D_{5/2}$:3,2	103.05 *4*	a=34.35 *3*
$^{103}_{45}$Rh					68Ch16	$^4F_{9/2}$		a=175.574 *1*
						$^4F_{7/2}$		a=87.416 *1*
						$^4F_{5/2}$		a=107.385 *2*
						$^4F_{3/2}$		a=32.377 *1*
						$^2F_{7/2}$		a=88.198 *1*
						$^2F_{5/2}$		a=210.88 *32*
						$^2D_{5/2}$		a=87.364 *2*
						$^2D_{3/2}$		a=91.718 *1*
$^{105}_{46}$Pd				+0.8 *1*	65Ch19	$^3D_3$		a=−391.178[j] *1*
								b=−652.906[j] *15*
						$^3D_2$		a=+66.359[j] *1*
								b=−398.192[j] *10*
						$^1D_2$		a=621[j] *5*
								b=490[j] *30*
$^{101}_{47}$Ag	9m	9/2			70Wa35			
$^{102}_{47}$Ag	13m	5			70Wa35			
$^{102m}_{47}$Ag	7m	2			68Gr01			
$^{102m}_{47}$Ag	7m		+4.2[ap] *2*		71Gr60	$^2S_{1/2}$: $^5/_2,^3/_2$	39400[p] *1800*	
$^{103}_{47}$Ag	66m	7/2			58E85	$^2S_{1/2}$		
$^{103}_{47}$Ag	66m		+4.45[d] *5*		70Wa35	$^2S_{1/2}$: 4,3	39700 *500*	a=9925 *125*
$^{104}_{47}$Ag	1.2h	5			59E89	$^2S_{1/2}$		
$^{104}_{47}$Ag	1.2h	5	+4.0[a] $^{+2}_{-1}$		61Am02	$^2S_{1/2}$: $^{11}/_2,^9/_2$	33500$^{+2000}_{-1000}$	
$^{104m}_{47}$Ag	27m	2			58R10	$^2S_{1/2}$		
$^{104m}_{47}$Ag	27m	2			59E89	$^2S_{1/2}$		
$^{104m}_{47}$Ag	27m	2	+3.7[a] *2*		61Am02	$^2S_{1/2}$: $^5/_2,^3/_2$	35000 *2000*	
$^{105}_{47}$Ag	40d	1/2			58E84			
$^{105}_{47}$Ag	40d		±0.1014[a] *10*		63Ew02	$^2S_{1/2}$:1,0	1529.057 *20*	
$^{106}_{47}$Ag	24m	1			58R10	$^2S_{1/2}$		
$^{106}_{47}$Ag	24m	1			59E89	$^2S_{1/2}$		
$^{106}_{47}$Ag	24m		positive large		61Am02			
$^{106}_{47}$Ag	24m		+2.88[a] *14*		68Ph02	$^2S_{1/2}$: $^3/_2,^1/_2$	32700 *1600*	
$^{106m}_{47}$Ag	8.3d	6			59E89	$^2S_{1/2}$		
$^{107}_{47}$Ag					53W33	$^2S_{1/2}$:1,0	1712.56 *4*	
$^{107}_{47}$Ag					66Bl11	$^2D_{5/2}$:3,2	378.8453 *3*	a=−126.2818 *1*
						$^4F_{9/2}$:5,4	1596.7506 *6*	a=−319.339 *5*
$^{107}_{47}$Ag					67Da04	$^2S_{1/2}$:1,0	1712.512111 *18*	
$^{107}_{47}$Ag			−0.113431[b] *70*		69De33			g=1.22982x10^{-4} *71*
$^{108}_{47}$Ag	2.4m	1			64Ro04			
$^{108}_{47}$Ag	2.4m		+2.80[a] *1*		69Cu09	$^2S_{1/2}$		a=20800 *150*
$^{109}_{47}$Ag					53W33	$^2S_{1/2}$:1,0	1976.94 *4*	
$^{109}_{47}$Ag					66Bl11	$^2D_{5/2}$:3,2	435.4750 *15*	a=−145.1584 *5*
						$^4F_{9/2}$:5,4	1841.1564 *9*	a=−368.214 *9*
$^{109}_{47}$Ag					67Da04	$^2S_{1/2}$:1,0	1976.932075 *17*	

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{109m}_{47}$Ag	40s	7/2			65St18			
$^{109m}_{47}$Ag	40s		±4.31^a *4*		66St22			
$^{110}_{47}$Ag	24s	1	+2.85^a *5*		69Cu09	$^2S_{1/2}$		a=21200 *300*
$^{110m}_{47}$Ag	253d	6			58E84	$^2S_{1/2}$		
$^{110m}_{47}$Ag	253d		+3.604^d *4*		67Sc04	$^3S_{1/2}$: $^{13}/_2$, $^{11}/_2$	30313.756 *4*	
$^{111}_{47}$Ag	7.5d	1/2	±0.144^a *7*		54L40	$^2S_{1/2}$:1,0	2180 *100*	
$^{111}_{47}$Ag	7.5d	1/2	−0.145^a *2*		56W27	$^2S_{1/2}$:1,0	2204.54 *5*	
$^{112}_{47}$Ag	3.2h	2	±0.0548^a *5*		64Ch06	$^2S_{1/2}$: $^5/_2$, $^3/_2$	518.332 *18*	
$^{113}_{47}$Ag	5.3h	1/2	±0.159^a *2*		64Ch06	$^2S_{1/2}$:1,0	2408.065 *28*	
$^{111}_{48}$Cd					60Fa08	$^3P_2$: $^5/_2$, $^3/_2$	8232.341 *2*	
$^{113}_{48}$Cd					60Fa08	$^3P_2$: $^5/_2$, $^3/_2$	8611.586 *4*	
$^{109}_{49}$In	4.3h	9/2	+5.53^a *6*	+1.20	59M19	$^2P_{3/2}$		a=242.38 *56*
								b=462.1 *64*
$^{110}_{49}$In	66m	2			67Pr13	$^2P_{3/2}$		
$^{110}_{49}$In	66m	2	+4.360 *4*	+0.36 *2*	68Ca10	$^2P_{3/2}$		a=429.20 *36*
					68Ca25			b=192.5 *7*
$^{110m}_{49}$In	4.9h	7	+10.4^a *1*	−0.290	59M19	$^2P_{3/2}$	(for μ>0)	a=291.4 *12*
			or	or				b=−112 *16*
			−10.7^a *1*	+0.311		$^2P_{3/2}$	(for μ<0)	or a=−301.4 *13*
								b=120 *17*
$^{111}_{49}$In	2.8d	9/2	+5.53^a *6*	+1.18	59M19	$^2P_{3/2}$		a=241.78 *30*
								b=455.3 *34*
$^{112}_{49}$In	14m	1	+2.81 *3*	+0.089 *5*	68Ca10	$^2P_{3/2}$		a=554 *4*
					68Ca25			b=48.3 *25*
$^{112m}_{49}$In	21m	4			68Ca14			
$^{113}_{49}$In		9/2			38M05			
$^{113}_{49}$In				±1.144	50M02	$^2P_{3/2}$		(a=241.624^a *24*)
						5,4	1115.807	b=443.102 *44*
$^{113}_{49}$In				±0.820^c	52K10			
$^{113}_{49}$In			Ω=±0.574 *15*	±0.82 *2*	57E07	$^2P_{3/2}$:6,5	1745.4575 *5*	a=241.641293 *58*
						5,4	1115.8253 *5*	b=443.46626 *52*
						4,3	670.9552 *5*	c=0.001728 *45*
$^{113}_{49}$In					57E09	$^2P_{1/2}$:5,4	11385.4300 *20*	
$^{113}_{49}$In				+0.777^c	62Ko22 (50M02)			
$^{113m}_{49}$In	1.7h	1/2	−0.21050^a *6*		60Ch08	$^2P_{1/2}$:1,0	781.084 *10*	
$^{114m}_{49}$In	50d	5	+4.7^a *1*		57G23	$^2P_{1/2}$: $^{11}/_2$, $^9/_2$	9700 *200*	
$^{115}_{49}$In	0.6Jy	9/2			38M05			
$^{115}_{49}$In	0.6Jy	9/2^b		±0.84	39H12	$^2P_{3/2}$:6,3	3552.0 *45*	a=243.0 *30*
								b=458.8 *78*
$^{115}_{49}$In	0.6Jy	9/2	+5.52‡ *4*		42H07	$^2P_{1/2}$:6,5	11387 *3*	$\Delta\nu^{115}/\Delta\nu^{113}$= 1.00224 *10*
							‡Determined from Δm=±1 doublet separation for J=3/2 state. Value subject to error due to perturbation effects of nearby states	
$^{115}_{49}$In	0.6Jy			±1.161	50M02	$^2P_{3/2}$:6,5	1752.702 *35*	a=242.165 *2*
						5,4	1117.153 *24*	b=449.562 *17*
						4,3	668.960 *13*	
$^{115}_{49}$In	0.6Jy			±0.834^c	52K10			

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{115}_{49}$In	0.6Jy		$\Omega=\pm0.565$ *12*		57E07	$^2P_{1/2}$:5,4	11409.7474 *39*	
						$^2P_{3/2}$:6,5	1752.6865 *2*	a=242.165057 *23*
						5,4	1117.1676 *2*	b=449.59656 *21*
						4,3	668.9631 *2*	c=0.001702 *35*
$^{115}_{49}$In	0.6Jy				57E09	$^2P_{1/2}$:5,4	11409.7506 *20*	
$^{115}_{49}$In	0.6Jy		$\Omega=+0.475^c$ *11*		57S28			(c=82^j *32*Hz)
								c=1682 *40*Hz
$^{115m}_{49}$In	4.5h	1/2			61Ki02			
$^{115m}_{49}$In	4.5h		-0.24371^a *7*		62Ca14	$^2P_{1/2}$		a=−903.5 *11*
						$^2P_{3/2}$		a=−95.973 *10*
$^{116m}_{49}$In	54m	5	$+4.21^a$ *8*		56N12	$^2P_{1/2}$:$^{11}/_2$,$^9/_2$	8670 *170*	
$^{116m}_{49}$In	54m	5	$+4.4^a$ *1*		57G23	$^2P_{1/2}$:$^{11}/_2$,$^9/_2$	9000 *200*	
$^{117}_{49}$In	45m	9/2			63Ca05			
$^{117m}_{49}$In	1.9h	1/2	-0.25146 *3*		68Mu04	$^2P_{1/2}$		a=−932.996 *12*
						$^2P_{3/2}$		a=(−)99.005 *5*
$^{113}_{50}$Sn	118d	1/2	$\pm0.879^a$ *9*		69Pr07	$^3P_1$:$^3/_2$,$^1/_2$	728.91 *66*	a=485.911 *25*
$^{115}_{50}$Sn					65Ch06	$^3P_1$		a=+507.445 *4*
						$^3P_2$		a=−1113.770 *4*
$^{117}_{50}$Sn					65Ch06	$^3P_1$		a=+552.608 *4*
						$^3P_2$		a=−1212.956 *3*
$^{119}_{50}$Sn					65Ch06	$^3P_1$		a=+578.296 *4*
						$^3P_2$		a=−1269.419 *3*
$^{121}_{50}$Sn	27h	3/2	$\pm0.699^a$ *7*	±0.08 *4*	69Pr07	$^3P_1$		a=128.726 *8*
			μ/Q negative					b=32.374 *12*
$^{123m}_{50}$Sn	40m	3/2			68Ch38			
$^{115}_{51}$Sb	31m	5/2	$+3.46^a$ *1*	−0.28‡ *7*	68Ja05	$^4S_{3/2}$		a=−307.68 *19*
								b=−3.7 *5*
							‡For Q^{121}=−0.28	
$^{116}_{51}$Sb	15m	3			68Ga08			
$^{117}_{51}$Sb	2.8h	5/2	$+2.67^a$ *1*	−0.42‡ *8*	68Ja05	$^4S_{3/2}$		a=−237.91 *15*
								b=−5.5 *5*
							‡For Q^{121}=−0.28	
$^{118m}_{51}$Sb	3.5m	1	$\pm2.46^a$ *7*		68Ja05	$^4S_{3/2}$		a=547 *13*
$^{119}_{51}$Sb	38h	5/2	$+3.45^a$ *1*	−0.29‡ *7*	68Ja05	$^4S_{3/2}$		a=−307.16 *6*
								b=−3.8 *4*
							‡For Q^{121}=−0.28	
$^{120}_{51}$Sb	16m	1	$\pm2.34^a$ *22*		68Ja05	$^4S_{3/2}$		a=520 *47*
$^{121}_{51}$Sb				−0.20 *3*	60Fe07	$^4S_{3/2}$:4,3	1199.08 *1*	a=−299.034 *4*
						3,2	819.45 *1*	b=−3.68 *2*
						2,1	595.12 *1*	
$^{122}_{51}$Sb	2.8d	2	-1.90^a	+0.66‡ *4*	60Fe08			a=+212.01 *6*
								b=+8.7 *5*
							‡For Q^{121}=−0.28	
$^{123}_{51}$Sb				−0.36‡ *5*	60Fe07	$^4S_{3/2}$:5,4	815.60 *1*	a=−162.451 *3*
						4,3	648.46 *1*	b=−4.67 *3*
						3,2	484.02 *1*	
							‡For Q^{121}=−0.28	
$^{124}_{51}$Sb	60d	3			60Fe08			
$^{116}_{52}$Te	2.5h	0♦			61Ax04			
$^{117}_{52}$Te	61m	1/2			61Ax04			
$^{119}_{52}$Te	16h	1/2			61Ax04			
$^{119}_{52}$Te	16h		±0.25 *5*		65Ad03	J=2		a=425 *20*
$^{119m}_{52}$Te	4.5d	11/2			61Ax04			

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{123}_{53}$I	13h	5/2			58G18			
$^{124}_{53}$I	4.0h	2			58G18			
$^{126}_{53}$I	13d	2			60Ga12			
$^{127}_{53}$I		5/2			53K14			
$^{127}_{53}$I				−0.819‡	53J23	‡Livingston et al. (53L24) quote the unpublished value of Q^{127}=0.819b of Jaccarino, King, and Stroke. The subsequent paper by Jaccarino et al. (54J07) does not give a value of Q but does present the interaction constants and a value of Ω^{127}. In a private communication, Stroke quotes a value of Q^{127}=0.789b. This was obtained from the interaction constants of 54J07, using the measured a^{127} to obtain $<1/r^3>$. It also includes relativistic corrections		
$^{127}_{53}$I			Ω=+0.3		54J07	$^2P_{3/2}$:4,3	4226.172 *15*	a=827.265 *3*
						3,2	1965.884 *10*	b=1146.356 *10*
						2,1	737.492 *8*	c=0.00245 *37*
$^{127}_{53}$I				-0.69^{c} *3*	55M88			
$^{127}_{53}$I			Ω=+0.181^{c} *47*		57S28			(c=0.00287^{j} *37*)
								c=0.00201 *52*
$^{127}_{53}$I				-0.789^{c}‡	59St46	‡Livingston et al. (53L24) quote the unpublished value of Q^{127}=0.819b of Jaccarino, King, and Stroke. The subsequent paper by Jaccarino et al. (54J07) does not give a value of Q but does present the interaction constants and a value of Ω^{127}. In a private communication, Stroke quotes a value of Q^{127}=0.789b. This was obtained from the interaction constants of 54J07, using the measured a^{127} to obtain $<1/r^3>$. It also includes relativistic corrections		
$^{127}_{53}$I				-0.64^{c}	62Ko22 (54J07)			
$^{127}_{53}$I			Ω=+0.265^{c}	-1.097^{c}	71Am02	$^2P_{3/2}$		a=827.26502^{c}
			Ω=+0.167*^{c}	−0.750*^{c}	(54J07)			b=1146.35920^{c}
								c=2602^{c}Hz
$^{128}_{53}$I	25m	1			59S63			
$^{130}_{53}$I	12h	5			58G20			
$^{130}_{53}$I	12h	5			59S63			
$^{131}_{53}$I	8d	7/2			58G18			
$^{131}_{53}$I	8d		+2.738^{a} *1*	−0.40 *1*	60Li13	$^2P_{3/2}$:5,4	3292.99 *9*	a=575.903 *7*
				−0.41* *1*				
						4,3	2138.22 *5*	b=578.866 *75*
						3,2	1314.24 *7*	
$^{132}_{53}$I	2.3h	4			59S64			
$^{132}_{53}$I	2.3h	4			60Ga12			
$^{132}_{53}$I	2.3h		±3.08^{a} *2*	±0.075 *15*	62Wh11	$^2P_{3/2}$		a=567.6 *26*
			μ/Q negative					b=128.2 *206*
$^{133}_{53}$I	21h	7/2			60Ga12			
$^{133}_{53}$I	21h		+2.836^{a} *5*	−0.26 *1*	61Al20	$^2P_{3/2}$:5,4	3260.1 *73*	a=597.0 *10*
				−0.27* *1*		4,3	2277.9 *46*	b=385.2 *74*
						3,2	1515.9 *61*	
$^{135}_{53}$I	6.7h	7/2			60Ga12			
$^{129}_{54}$Xe					61Fa05	$^3P_2$:$^5/_2$,$^3/_2$	5961.2577 *9*	
$^{131}_{54}$Xe			Ω=+0.048 *12*	−0.120 *12*	61Fa05	$^3P_2$:$^7/_2$,$^5/_2$	2693.6234 *7*	a=+706.4714 *7*
						$^5/_2$,$^3/_2$	1608.3475 *8*	b=+252.5145 *64*
						$^3/_2$,$^1/_2$	838.7636 *4*	c=+0.000728 *105*

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{125}_{55}$Cs	45m	1/2	+1.41^a *2*		71Da01	$^2S_{1/2}$:1,0	8754 *40*	
$^{127}_{55}$Cs	6.2h	1/2			56N16			
$^{127}_{55}$Cs	6.2h		+1.43^a *4*		58N27	$^2S_{1/2}$:1,0	8950 *200*	
$^{127}_{55}$Cs	6.2h		+1.43^a *2*		62Kh03	$^2S_{1/2}$:1,0	8900 *150*	
$^{127}_{55}$Cs	6.2h		+1.46^a *2*		71Da01	$^2S_{1/2}$:1,0	9109 *45*	
$^{129}_{55}$Cs	31h	1/2			56N16			
$^{129}_{55}$Cs	31h		+1.47^a *4*		58N27	$^2S_{1/2}$:1,0	9200 *200*	
$^{129}_{55}$Cs	31h		+1.479^a *6*		62Kh03	$^2S_{1/2}$:1,0	9229 *30*	
$^{130}_{55}$Cs	30m	1			56N16			
$^{130}_{55}$Cs	30m		+1.37^a *8* or −1.45^a *8*		58N27	$^2S_{1/2}$:$^3/_2$,$^1/_2$	6400 *350* if $\mu>0$ or 6800 *350* if $\mu<0$	
$^{131}_{55}$Cs	10d	5/2	+3.53^a *4*		53B19	$^2S_{1/2}$:3,2	13200 *110*	
$^{131}_{55}$Cs	10d	5/2			56N14			
$^{131}_{55}$Cs	10d		+3.537^d *2*		65Wo05	$^2S_{1/2}$:3,2	13181.375 *2*	g=7.663x10^{-4} *4*
$^{132}_{55}$Cs	6.2d	2	+2.22^a *2*		58N27	$^2S_{1/2}$:$^5/_2$,$^3/_2$	8648 *35*	
$^{133}_{55}$Cs		7/2			34C04			
$^{133}_{55}$Cs			+2.574 *13*		39K10		Cs_2,CsF,CsCl	$g/g(^7Li)$=0.3369
$^{133}_{55}$Cs				−0.0033 *39*	56Bu19	$^2P_{3/2}$:5,4	252.5 *10*	a=50.67 *11*
						4,3	203.0 *11*	b=−0.46 *53*
						3,2	152.0 *8*	
$^{133}_{55}$Cs					58Ma18	$^2S_{1/2}$:4,3	9192.631770 *20*	
$^{133}_{55}$Cs					66En03		^{133}CsF	eqQ=1.241^E *11*
$^{133}_{55}$Cs					67Ma09	$6^2P_{1/2}$:4,3	1167^E *40*	
$^{134}_{55}$Cs	2.2y	4	+2.98^a *1*		52J18	$^2S_{1/2}$:$^9/_2$,$^7/_2$	10465 *12*	
$^{134}_{55}$Cs	2.2y	4	+2.98^a *1*		53B19	$^2S_{1/2}$:$^9/_2$,$^7/_2$	10440 *30*	
$^{134}_{55}$Cs	2.2y		+2.9889^d‡ *12*		57S111	$^2S_{1/2}$:$^9/_2$,$^7/_2$	10473.626 *15* ‡Using μ^{133}_{unc}=2.563189 *15* (68Ha01)	g/g^{133}=1.01447^d *29*
$^{134m}_{55}$Cs	2.9h	8	+1.10^a *1*		55G04	$^2S_{1/2}$:$^{17}/_2$,$^{15}/_2$	3684.594 *20*	
$^{134m}_{55}$Cs	2.9h	8	+1.10^a *1*		55G31	$^2S_{1/2}$:$^{17}/_2$,$^{15}/_2$	3684.5 *5*	
$^{134m}_{55}$Cs	2.9h		+1.0960^d‡ *3*		62Co14	$^2S_{1/2}$:$^{17}/_2$,$^{15}/_2$	3684.578640 *175* ‡Using μ^{133}_{unc}=2.563189 *15* (68Ha01)	
$^{134m}_{55}$Cs	2.9h				67Ma09	$6^2P_{1/2}$:$^{17}/_2$,$^{15}/_2$	473^E *60*	
$^{135}_{55}$Cs	2My	7/2	+2.728^a *2*		49D01	$^2S_{1/2}$:4,3	9724 *8*	
$^{135}_{55}$Cs	2My		+2.7280^d‡ *8*		57S111	$^2S_{1/2}$:4,3	9724.023 *15* ‡Using μ^{133}_{unc}=2.563189 *15* (68Ha01)	g/g^{133}=1.05820^d *8*
$^{136}_{55}$Cs	13d	5	+3.70^a *4*		71Da01	$^2S_{1/2}$:$^{11}/_2$,$^9/_2$	12702 *28*	
$^{137}_{55}$Cs	30y	7/2	+2.831^a *2*		49D01	$^2S_{1/2}$:4,3	10126.5 *70*	
$^{137}_{55}$Cs	30y		+2.8372^d‡ *9*		57S111	$^2S_{1/2}$:4,3	10115.527 *15* ‡Using μ^{133}_{unc}=2.563189 *15* (68Ha01)	g/g^{135}=1.04005^d *8*; g/g^{133}=1.10058^d *13*
$^{138}_{55}$Cs	32m	3	±0.48^a *10*		67St22	$^2S_{1/2}$		a=500 *100*
$^{135}_{56}$Ba		3/2	+0.836 *2*		41H14			$g/g(^7Li)$=0.2553 *7*; g/g^{137}=0.8949 *8*
$^{135}_{56}$Ba			+0.8370 *8*		59K82			g/g^{137}=0.8939 *2*
$^{137}_{56}$Ba		3/2	+0.935 *3*		41H14			$g/g(^7Li)$=0.2856 *8*
$^{137}_{56}$Ba			+0.9364 *9*		59K82			
$^{131}_{57}$La	59m	3/2			73In04			
$^{132}_{57}$La	4.5h	2			73In04			
$^{132m}_{57}$La	25m	6			73In04			
$^{133}_{57}$La	4.0h	5/2			73In04			
$^{135}_{57}$La	19.4h	5/2			73In04			
$^{136}_{57}$La	9.9m	1			73In04			

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{139}_{57}$La				+0.230 *10*	57T30	$^2D_{5/2}$:6,5	1120.902 *5*	a=182.1706 *6*
						5,4	912.793 *5*	b=54.213 *14*
						4,3	716.288 *3*	c=−0.6 *10*kHz
						3,2	529.090 *10*	
						$^2D_{3/2}$:5,4	737.967 *15*	a=141.1959 *16*
						4,3	551.987 *5*	b=44.781 *14*
						3,2	391.603 *10*	c=0.15 *44*kHz
$^{139}_{57}$La				+0.21[c] *1*	58Mu08 (57T30)			
$^{139}_{57}$La				+0.229[c]	62Ko22 (57T30)			
$^{139}_{57}$La				+0.26,0.23, or 0.28	71Ch02	$^4F_{3/2}$:5,4	2390.631 *11*	a=−480.224 *8*
						4,3	1925.510 *11*	b=14.2 *2*
						$^4F_{5/2}$:6,5	1808.938 *12*	a=300.631 *8*
						5,4	1503.210 *18*	b=14.0 *3*
						4,3	1199.787 *15*	c=0.002 *3*
						$^4F_{7/2}$:7,6	3247.744 *6*	a=462.889 *7*
						6,5	2779.047 *7*	b=19.3 *2*
						5,4	2312.531 *20*	c=−0.002 *2*
						4,3	1847.837 *12*	
						$^4F_{9/2}$:8,7	3928.536 *27*	a=489.533 *2*
						7,6	3430.754 *13*	b=31.9 *2*
						6,5	2935.669 *10*	c=0.003 *4*
						5,4	2442.885 *22*	
						4,3	1952.018 *20*	
				—		$^2F_{5/2}$:6,5	1840.665 *15*	a=304.381 *4*
						5,4	1522.871 *15*	b=27.8 *1*
						4,3	1211.072 *15*	c=−0.002 *3*
						$^2F_{7/2}$:5,4	989.482 *20*	a=−197.068 *7*
						4,3	796.567 *12*	b=41.4 *2*
				—		$^4P_{1/2}$:4,3	9840.632 *15*	a=2460.173 *70*
						$^4P_{3/2}$:4,3	3707.836 *22*	a=929.6 *2*
								b=37.2 *25*
						$^4P_{5/2}$:4,3	3216.524 *20*	a=801.9 *5*
								b=−40 *8*
				+0.30,0.31, or 0.28		$^2D_{3/2}$		a=−424.9 *20*
								b=−13 *4*
						$^2D_{5/2}$		a=881 *6*
								b=22 *36*
				+0.22*‡ *3*				
							‡Average value	
$^{140}_{57}$La	40h	3			60Pe09			
$^{140}_{57}$La	40h		±0.728[P] *15* μ/Q positive	±0.15*[P] *7*	69Hu12 69Pi15	$^2D_{5/2}$		a=55.8[P] *15* b=40[P] *25*
$^{130}_{58}$Ce	25m	0♦			73In04	$^1G_4$;$^3H_4$		
$^{132}_{58}$Ce	4.2h	0♦			73In04	$^1G_4$;$^3H_4$		
$^{133}_{58}$Ce	5.4h	9/2			73In04			
$^{133m}_{58}$Ce	97m	1/2			73In04			
$^{134}_{58}$Ce	72h	0♦			73In04	$^1G_4$,$^3H_4$		
$^{135}_{58}$Ce	17.0h	1/2			73In04			
$^{137}_{58}$Ce	9.0h	3/2			73In04			
$^{137m}_{58}$Ce	34.4h	11/2			73In04			
$^{139}_{58}$Ce	140d	3/2			73In04			
$^{143}_{58}$Ce	33h	3/2			65Ma19			

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{133}_{59}\mathrm{Pr}$	7.5m	5/2			72Ek04			
$^{134}_{59}\mathrm{Pr}$	18.5m	2			72Ek04			
$^{135}_{59}\mathrm{Pr}$	24m	3/2			72Ek04			
$^{136}_{59}\mathrm{Pr}$	13.5m	2			72Ek04			
$^{137}_{59}\mathrm{Pr}$	1.28h	5/2			72Ek04			
$^{138}_{59}\mathrm{Pr}$	2.0h	7			72Ek04			
$^{139}_{59}\mathrm{Pr}$	4.5h	5/2			72Ek04			
$^{140}_{59}\mathrm{Pr}$	3.4m	1			72Ek04			
$^{141}_{59}\mathrm{Pr}$			+3.8 *4*	−0.054	53L22	$^4I_{9/2}$:4,3	3708.05 *5*	a=+926.03 *10*
						3,2	2782.25 *5*	b=−13.9 *10*
$^{141}_{59}\mathrm{Pr}$				−0.02*	58Mu08			
$^{141}_{59}\mathrm{Pr}$			±5.09^{c} *25*	±0.070^{c} *4*	62Ca10			
			μ/Q negative					
$^{141}_{59}\mathrm{Pr}$			+4.98	−0.074	62Wy04			
$^{141}_{59}\mathrm{Pr}$			+4.28^{c} *8*	−0.0589^{c} *42*	63Bl25			
$^{141}_{59}\mathrm{Pr}$			+4.162^{kp} *2*		70Le26	$^4I_{9/2}$		a=926.2087 *1*
								b=−11.878 *2*
								c=220 *80*Hz
			+4.43^{kp} *11*			$^4I_{11/2}$		a=730.3929 *1*
								b=−11.877 *3*
								c=−0.0003 *2*
			+4.42^{kp} *12*			$^4I_{13/2}$		a=613.2399 *1*
								b=−12.850 *2*
								c=−0.0001 *2*
			+4.48^{kp} *5*			$^4I_{15/2}$		a=541.5746 *2*
								b=−14.558 *6*
								c=0.0003 *6*
$^{142}_{59}\mathrm{Pr}$	19h	2	±0.243‡ *15*	±0.035 *15*	62Ca10	$^4I_{9/2}$		a=67.5 *5*
			μ/Q positive					b=7.0 *20*
							‡For μ^{141}=4.16	
$^{142}_{59}\mathrm{Pr}$	19h		±0.250^{c}	±0.0297^{c} *85*	63Bl25			
$^{142m}_{59}\mathrm{Pr}$	?	5^{p}			69Hu12			
$^{143}_{59}\mathrm{Pr}$	14d	7/2			64Bu09	$^4I_{9/2}$		
$^{134}_{60}\mathrm{Nd}$	8m	0♦			72Ek04			
$^{135}_{60}\mathrm{Nd}$	15m	9/2			72Ek04			
$^{136}_{60}\mathrm{Nd}$	55m	0♦			72Ek04	$^5I_4$:5,4	<40kHz, if I=1	
$^{137}_{60}\mathrm{Nd}$	37m	1/2			72Ek04			
$^{138}_{60}\mathrm{Nd}$	5.2h	0♦			72Ek04			
$^{139}_{60}\mathrm{Nd}$	29.7m	3/2			72Ek04			
$^{139m}_{60}\mathrm{Nd}$	5.5h	11/2			72Ek04			
$^{140}_{60}\mathrm{Nd}$	3.4d	0♦			72Ek04			
$^{141}_{60}\mathrm{Nd}$	2.5h	3/2			62Al04	$^5I_4$:$^{11}/_2$,$^9/_2$	≥1630	
$^{143}_{60}\mathrm{Nd}$		7/2			62Sp03			
$^{143}_{60}\mathrm{Nd}$			−1.25 *13*	−0.57 *6*	63Sp08	$^5I_4$:$^{15}/_2$,$^{13}/_2$	1418.25 *14*	a=−195.649 *9*
						$^{13}/_2$,$^{11}/_2$	1257.53 *4*	b=+122.25 *28*
						$^{11}/_2$,$^9/_2$	1084.70 *4*	
						$^9/_2$,$^7/_2$	901.47 *6*	
						$^7/_2$,$^5/_2$	710.0 *1*	Q^{143}/Q^{145}=+1.893 *16*
$^{143}_{60}\mathrm{Nd}$			−1.063^{h} *5*	−0.484^{c} *20*	65Sm04			g=−1.6430x10^{-4} *69*
$^{143}_{60}\mathrm{Nd}$					70Ch41	$^5I_4$		a=−195.652^{p} *2*
								b=122.608^{p} *34*
						$^5I_5$		a=−153.679^{p} *2*
								b=115.741^{p} *36*

$^{143}_{60}$Nd(70Ch41) continued

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{143}_{60}$Nd(70Ch41) continued								
						$^5I_6$		$a=-130.611$[p] *2*
								$b=119.284$[p] *46*
						$^5I_7$		$a=-117.604$[p] *2*
								$b=129.281$[p] *48*
						$^5I_8$		$a=-110.4$[p] *2*
								$b=141.9$[p] *62*
$^{145}_{60}$Nd		7/2			62Sp03			
$^{145}_{60}$Nd			−0.78 *8*	−0.30 *3*	63Sp08	$^5I_4$: $^{15}/_2$, $^{13}/_2$	886.25 *6*	$a=-121.627$ *27*
						$^{13}/_2$, $^{11}/_2$	783.08 *4*	$b=+64.60$ *37*
						$^{11}/_2$, $^{9}/_2$	673.49 *3*	
						$^{9}/_2$, $^{7}/_2$	558.27 *3*	
						$^{7}/_2$, $^{5}/_2$	439.10 *5*	
						$^5I_5$: $^{17}/_2$, $^{15}/_2$	789.83 *20*	$a=-95.531$ *19*
						$^{15}/_2$, $^{13}/_2$	708.38 *20*	$b=+60.65$ *70*
						$^{13}/_2$, $^{11}/_2$	622.80 *15*	
						$^{11}/_2$, $^{9}/_2$	533.36 *20*	
$^{145}_{60}$Nd			−0.654[h] *4*	−0.253[c] *10*	65Sm04			$g=-1.0106\times10^{-4}$ *61*
$^{145}_{60}$Nd					70Ch41	$^5I_4$		$a=-121.628$[p] *2*
								$b=64.637$[p] *28*
						$^5I_5$		$a=-95.535$[p] *2*
								$b=61.044$[p] *42*
						$^5I_6$		$a=-81.195$[p] *2*
								$b=62.926$[p] *58*
						$^5I_7$		$a=-73.108$[p] *2*
								$b=68.165$[p] *74*
$^{147}_{60}$Nd	11d	5/2			60Ca03			
$^{147}_{60}$Nd	11d		±0.553[ap] *10*	±0.7[p] *3*	70Pi11	$J=4$		$a=144$[p] *3*
			μ/Q negative					$b=181$[p] *64*
$^{149}_{60}$Nd	1.9h	5/2			64Bu09	$^5I_4$		
$^{149}_{60}$Nd	1.9h		±0.350[ap] *10*	±1.0[p] *3*	70Pi11	$J=4$		$a=91.0$[p] *19*
			μ/Q negative					$b=260$[p] *43*
$^{140m}_{61}$Pm	5.8m	‡			72Ek05			Nd(45MeVp,)
							‡Could not observe this activity; searched for $I=0$ through 8	
$^{141}_{61}$Pm	20.9m	5/2			72Ek05			
$^{147}_{61}$Pm	2.6y	7/2			60Ca03			
$^{147}_{61}$Pm	2.6y		±2.77[c] *8*		63Bl25			
$^{147}_{61}$Pm	2.6y	7/2	±3.2 *3*	±0.7 *3*	63Bu14	$^6H_{7/2}$		$a=447$ *9*
			μ/Q positive					$b=267$ *71*
$^{148}_{61}$Pm	5.4d	1	+2.07[a] *21*	+0.2 *2*	65Al10	$^6H_{7/2}$		$a=+1038$ *75*
					65Al16			$b=-98$ *10*
$^{149}_{61}$Pm	54h	7/2			61Ca07			
$^{151}_{61}$Pm	28h	5/2			61Ca07			
$^{151}_{61}$Pm	28h	5/2	±1.8 *2*	±1.9 *3*	63Bu14	$^6H_{7/2}$		$a=358$ *22*
			μ/Q positive					$b=778$ *93*
$^{140}_{62}$Sm	15m	0♦			72Ek05			
$^{141}_{62}$Sm	11.3m	1/2			72Ek05			
$^{141m}_{62}$Sm	22.9m	11/2			72Ek05			
$^{142}_{62}$Sm	1.2h	0♦			72Ek05	^7F	$<$40kHz, if $I=1$	
$^{143}_{62}$Sm	8.8m	3/2			72Ek05			
$^{147}_{62}$Sm	0.1Ty	7/2			62Sp03			
$^{147}_{62}$Sm	0.1Ty		−0.796[c] *16*	−0.208[c] *4*	63Bl25			

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{147}_{62}$Sm	0.1Ty		−0.8129 *7*	−0.20 *2*	66Wo05	$^7F_1$		$a=-33.4936$ *1*
								$b=-58.6920$ *8*
						$^7F_2$		$a=-41.1845$ *2*
								$b=-62.2260$ *32*
						$^7F_3$		$a=-50.2401$ *1*
								$b=-33.6812$ *16*
						$^7F_4$		$a=-59.7068$ *20*
								$b=+21.230$ *72*
$^{147}_{62}$Sm	0.1Ty				68Ro16	$J=5$: $^{17}/_2, ^{15}/_2$	551.009^j *42*	$A_1‡=1209.870$ *23*
						$^{15}/_2, ^{13}/_2$	505.364^j *32*	$A_2=25.1448$ *130*
						$^{13}/_2, ^{11}/_2$	452.498^j *17*	$A_3=0$
						$^{11}/_2, ^{9}/_2$	393.414^j *11*	$A_1/A_2<0$
						$^{9}/_2, ^{7}/_2$	329.071^j *15*	
							‡See 68Ro16 for definitions of A's	
$^{147}_{62}$Sm	0.1Ty			−0.18^c *3*	69Ro29	$^7F_{1,2,3,4,5}$		
$^{149}_{62}$Sm		7/2			62Sp03			
$^{149}_{62}$Sm			−0.643^c *15*	+0.060^c *1*	63Bl25			
$^{149}_{62}$Sm			−0.6702 *7*	+0.058 *6*	66Wo05	$^7F_1$		$a=-27.6109$ *1*
								$b=+16.9624$ *4*
						$^7F_2$		$a=-33.9508$ *2*
								$b=+17.9872$ *32*
						$^7F_3$		$a=-41.4176$ *4*
								$b=+9.7488$ *64*
						$^7F_4$		$a=-49.2177$ *29*
								$b=-6.161$ *80*
								$Q^{149}/Q^{147}=0.28901$ *3*
$^{149}_{62}$Sm					68Ro16	$J=5$: $^{17}/_2, ^{15}/_2$	495.031^j *27*	$A_1‡=997.364$ *38*
						$^{15}/_2, ^{13}/_2$	431.239^j *14*	$A_2=7.258$ *23*
						$^{13}/_2, ^{11}/_2$	369.563^j *20*	$A_3=0$
								$A_1/A_2>0$
							‡See 68Ro16 for definitions of A's	
$^{149}_{62}$Sm				+0.052^c‡ *3*	Compilers		‡Using Q of 69Ro29 and Q−ratio of 66Wo05	
$^{153}_{62}$Sm	47h	3/2			60Ca05			
$^{153}_{62}$Sm	47h		−0.021^a *1*	+1.1 *3*	64Su02	$^7F_1$		$a=-2.100$ *5*
								$b=+289.042$ *4*
						$^7F_2$		$a=-2.573$ *6*
								$b=+306.521$ *21*
						$^7F_3$		$a=-3.115$ *4*
								$b=+165.824$ *20*
						$^7F_4$		$a=-3.753$ *9*
								$b=-104.452$ *68*
$^{153}_{62}$Sm	47h		−0.0215 *1*	+1.0 *1*	68Wa10			
$^{155}_{62}$Sm	24m	3/2		large	68Ea02	^7F		
$^{155}_{62}$Sm	24m			±0.9 *1*	68Wa10			$Q^{155}/Q^{153}=\pm0.894$
$^{145}_{63}$Eu	5.9d	5/2			72Ek05			
$^{146}_{63}$Eu	4.65d	4			72Ek05			
$^{147}_{63}$Eu	22d	5/2			72Ek05			
$^{148}_{63}$Eu	54d	5			72Ek05			
$^{149}_{63}$Eu	93d	5/2			72Ek05			
$^{150}_{63}$Eu	12.5h	0♦			72Ek05	$^8S_{7/2}$	<40kHz, if $I=1$	
$^{151}_{63}$Eu					60Sa23	$^8S_{7/2}$:6,5	120.675 1	$a=-20.0523$ *2*
						5,4	100.286 *1*	$b=-0.7012$ *35*
						4,3	80.049 *1*	
$^{151}_{63}$Eu			+3.4631^h *12*		65Ev08	$^8S_{7/2}$		$\mu^{151}/\mu^{153}=2.26505$ *42*
								$a^{151}/a^{153}=2.26498$ *8*

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{152}_{63}$Eu	13y		±1.937 *2*	±3.0 *3*	63Al06	$^8S_{7/2}$: $^{13}/_2$, $^{11}/_2$	59.848 *86*	a=9.345 *6*
						$^{11}/_2$, $^9/_2$	51.246 *35*	b=1.930 *165*
						$^9/_2$, $^7/_2$	42.343 *37*	Q^{152}/Q^{151}=±2.75 *24*
						$^7/_2$, $^5/_2$	33.191 *48*	Q^{152}/Q^{153}=±1.08 *9*
$^{152m}_{63}$Eu	9h	0♦	≤4x10^{-3}, if I=1		59C52		·	a≤60kHz
$^{153}_{63}$Eu				+2.8 *3*	60Sa23	$^8S_{7/2}$:6,5	54.038 *1*	a=−8.8532 *2*
						5,4	44.004 *1*	b=−1.7852 *35*
						4,3	35.004 *1*	
$^{153}_{63}$Eu			+1.5292[h] *9*		65Ev08	$^8S_{7/2}$		
$^{145}_{64}$Gd	22.9m	1/2			72Ek05			
$^{147}_{64}$Gd	38.5h	7/2			72Ek05			
$^{149}_{64}$Gd	9.4d	7/2			72Ek05			
$^{151}_{64}$Gd	120d	7/2			72Ek05			
$^{153}_{64}$Gd	242d	3/2			65Al16			
$^{155}_{64}$Gd			−0.2584[b] *5*	+1.59 *16*	69Un02	$^9D_3$		a=4.9204 *18*
			Ω=−1.6 *6*					b=−406.670 *6*
								c=−0.0015 *5*
						$^9D_2$		a=36.5753[j] *9*
								b=179.407[j] *44*
						$^9D_4$		a=−6.8612[j] *49*
								b=−352.834[j] *38*
						$^9D_5$		a=−11.5125[j] *39*
								b=41.977[j] *40*
						$^9D_6$		a=−12.2424[j] *12*
								b=587.893[j] *12*
$^{157}_{64}$Gd			−0.339*‡ *3*	+1.69‡ *17*	69Un02	$^9D_2$		a=47.9591[j] *76*
								b=191.161[j] *72*
						$^9D_3$		a=6.4456[j] *22*
								b=−433.234[j] *13*
						$^9D_4$		a=−8.9967[j] *49*
								b=−375.884[j] *38*
						$^9D_5$		a=−15.0955[j] *38*
								b=44.744[j] *39*
						$^9D_6$		a=−16.0573[j] *57*
								b=626.275[j] *60*
							‡Using ratios from paramagnetic resonance	
$^{159}_{64}$Gd	18h	3/2			61Ca07			
$^{151}_{65}$Tb	18h	1/2			70Ad09			
$^{152}_{65}$Tb	18h	2			70Ad09			
$^{153}_{65}$Tb	2.3d	5/2			70Ad09			
$^{154}_{65}$Tb	21h	0♦	<10^{-4}, if I=1		70Ad09			
$^{154m}_{65}$Tb	8.5h	3			70Ad09			
$^{155}_{65}$Tb	5.6d	3/2			70Ad09			
$^{156}_{65}$Tb	5.4d	3			70Ad09			
$^{159}_{65}$Tb				+1.45*† *17*	70Ch26	$^6H_{15/2}$		a=673.753 *2*
								b=1449.330 *40*
								c=−0.001 *2*
						$^6H_{13/2}$		a=682.911 *3*
								b=1167.489 *50*
								c=−0.001 *2*
							†For all ($4f^9 6s^2$)−states	

$^{159}_{65}$Tb(70Ch26) continued

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{159}_{65}$Tb(70Ch26) continued				+1.33*‡ *12* or +1.28*‡ *14*	70Ch26	$^8G_{13/2}$		a=532.204 *2* b=928.861 *30* c=0.001 *2*
						Interaction constants and g_J-values for 14 other ($4f^9 6s^2$) or ($4f^8 5d\ 6s^2$) states given		
				+1.34*† *11*			‡For all ($4f^8 5d 6s^2$)–states †Weighted average	
$^{160}_{65}$Tb	73d	3			61Ca07			
$^{161}_{65}$Tb	6.9d	3/2			64Bu09			
$^{149}_{66}$Dy	?	‡			70Ro21		‡Could not observe activity. If I=7/2, then $T_{1/2}$<10m or ≈ $T_{1/2}(^{151}Dy)$	
$^{151}_{66}$Dy	18m	7/2			70Ro21			
$^{152}_{66}$Dy	2.4h	0♦			70Ro21	$^5I_8$	<20kHz, if I=1	
$^{153}_{66}$Dy	6.4h	7/2			70Ro21			
$^{153}_{66}$Dy	6.4h		±0.71*‡ *9* μ/Q positive	±0.14*‡ *8*	72Ro36	$^5I_8$		a=123.5 *8* b=65 *40*
							‡Based on μ^{161} and $Q*^{161}$(72Ro36)	
$^{155}_{66}$Dy	10h	3/2			70Ro21			
$^{155}_{66}$Dy	10h		±0.34*‡ *3* μ/Q negative	±0.91*‡ *10*	72Ro36	$^5I_8$		a=136.5 *5* b=421 *5*
							‡Based on μ^{161} and $Q*^{161}$ (72Ro36)	
$^{157}_{66}$Dy	8.1h	3/2			70Ro21			
$^{157}_{66}$Dy	8.1h		±0.30*‡ *4* μ/Q negative	±1.22*‡ *13*	72Ro36	$^5I_8$		a=121.605 *4* b=564.65 *7*
							‡Based on μ^{161} and $Q*^{161}$ (72Ro36)	
$^{159}_{66}$Dy	144d	3/2			65Al16	$^5I_8$		
$^{161}_{66}$Dy		5/2			62Sp03			
$^{161}_{66}$Dy			−0.47 *9*	+2.36 *4*	67Eb01	$^5I_8$		a=−115.8 *10* b=+1102 *15*
$^{161}_{66}$Dy			−0.46 *5*	+2.37 *28*	70Ch31	$^5I_8$		a=−116.231 *2* b=1091.577 *50* c=−0.002 *5*
						$^5I_7$		a=−126.787 *2* b=1009.742 *60* c=0.000 *5*
$^{161}_{66}$Dy				Q_4~+58^p	72Da38	$^5I_8$ ($4f^{10}6s^2$)		a=−116.23218 *20* b=1091.5740 *75* c=−790 *650*Hz d=−95 *75*Hz
$^{161}_{66}$Dy			−0.4792^{ikp} *50*		72Fe20			
$^{161}_{66}$Dy			−0.48^c *4*	+2.35*^{c} *26*	72Ro36 (70Ch31)	$^5I_8$, $^5I_7$		
$^{163}_{66}$Dy		5/2			62Sp03			
$^{163}_{66}$Dy			+0.66 *13*	+2.46 *4*	67Eb01	$^5I_8$		a=+162.9 *6* b=+1150 *20*
$^{163}_{66}$Dy			+0.65 *6*	+2.51 *30*	70Ch31	$^5I_8$		a=162.754 *2* b=1152.869 *40* c=0.001 *4*
						$^5I_7$		a=177.535 *2* b=1066.430 *60* c=0.002 *6*

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{163}_{66}$Dy				$Q_4\sim+67^{p}$	72Da38	$^5I_8(4f^{10}6s^2)$		a=162.754272 *20* b=1152.8635 *12* c=−20 *130*Hz d=−109 *35*Hz
$^{163}_{66}$Dy			+0.6707^{ikp} *35*		72Fe20			
$^{163}_{66}$Dy			+0.67^{ac}‡ *6*	+2.48*^{c}‡ *27*	72Ro36 (70Ch31)	$^5I_8$	‡Based on μ and $Q*^{161}$ (72Ro36)	
$^{165}_{66}$Dy	2.3h	7/2			61Ca07			
$^{165}_{66}$Dy	2.3h		±0.50 μ/Q negative	±3.2	68Ra03	$^5I_8$		a=89.8 *7* b=1521 *30*
$^{165}_{66}$Dy			±0.52^{ac}‡ *4*	±3.27*^{c}‡ *37*	72Ro36 (68Ra03)	$^5I_8$	‡Based on μ^{161} and $Q*^{161}$ (72Ro36)	
$^{166}_{66}$Dy	82h	0♦	≤10^{-4}, if I=1		61Ca07	$^5I_8$		
$^{153}_{67}$Ho	?	‡			69Ek01		‡Did not observe resonances at frequencies for I=1/2 to 11/2. $T_{1/2}$ possibly less than 9m.	
$^{154}_{67}$Ho	12m	1			69Ek01			
$^{155}_{67}$Ho	50m	5/2			69Ek01			
$^{156}_{67}$Ho	55m	1			69Ek01			
$^{157}_{67}$Ho	14m	7/2			69Ek01			
$^{158}_{67}$Ho	11m	5			69Ek01			
$^{158m}_{67}$Ho	29m	2			69Ek01			
$^{159}_{67}$Ho	33m	7/2			69Ek01			
$^{160}_{67}$Ho	26m	5			69Ek01			
$^{160m}_{67}$Ho	5.0h	2			69Ek01			
$^{161}_{67}$Ho	2.5h	7/2			64Bu09	$J={}^{15}/_2$		
$^{161}_{67}$Ho	2.5h	7/2			69Ek01			
$^{162}_{67}$Ho	15m	1			69Ek01			
$^{162m}_{67}$Ho	68m	6			69Ek01			
$^{164}_{67}$Ho	29m	1			69Ek01			
$^{164m}_{67}$Ho	38m	6			69Ek01			
$^{165}_{67}$Ho					62Go20	$^4I_{15/2}$		a=800.583 *3* b=−1667.950 *50*
$^{165}_{67}$Ho			+4.23	+2.99	62Wy04			
$^{165}_{67}$Ho			+4.01^{c} *8*	+2.82^{c} *5*	63Bl25			
$^{165}_{67}$Ho			+4.1 *4*	+2.4	64Go09	$^4I_{15/2}$:9,8 8,7 7,6 6,5 5,4	7184.829 *10* 6540.836 *10* 5842.368 *10* 5096.265 *10* 4309.281 *10*	a=800.58389 *50* b=−1667.997 *50*
$^{165}_{67}$Ho			+4.12 *2*		68Ha25			
$^{165}_{67}$Ho			+4.08^{ci} *8*		68Su04 (64Go09)			
$^{165}_{67}$Ho				$Q_4\sim+80^{p}$	72Da38	$^4I_{15/2}$		a=800.583169 *36* b=−1668.0789 *33* c=−217 *140*Hz d=−151 *16*Hz
$^{165}_{67}$Ho			+4.125^{k} *44*		72Ha45	$^4I_{15/2}$		g=6.370x10^{-4} *70*
$^{165}_{67}$Ho					72Me16	$^4I_{15/2}$		a=800.5828 *14* b=−1668.100 *91* c=−2224 *7520*Hz d=−398 *790*Hz
$^{166}_{67}$Ho	27h	0♦	≤10^{-4}, if I=1		61Ca07	$^4I_{15/2}$		
$^{166}_{67}$Ho	27h	0♦			61Ch06	$^4I_{15/2}$		a<5kHz, if I=1

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{157}_{68}$Er	20m	3/2			69Ek01			
$^{158}_{68}$Er	2.3h	0♦			69Ek01	$^3H_6$	<20kHz, if I=1	
$^{159}_{68}$Er	36m	3/2			69Ek01			
$^{160}_{68}$Er	29h	0♦			69Ek01	$^3H_6$	<20kHz, if I=1	
$^{161}_{68}$Er	3.2h	3/2			69Ek01			
$^{161}_{68}$Er	3.2h		−0.369[a] *5*	+1.20* *9*	72Ek03	$^3H_6$		a=183.8 *14* b=1738 *10*
$^{163}_{68}$Er	1.2h	5/2			69St05	$^3H_6$		
$^{163}_{68}$Er	1.2h		+0.56[a] *3*	+2.2* *2*	72Ek03	$^3H_6$		a=167 *7* b=3275 *130*
$^{165}_{68}$Er	10h	5/2			64Bu09	J=6		
$^{165}_{68}$Er	10h		±0.65[a] *3* μ/Q positive	±2.2 *1*	65Al10	$^3H_6$		a=195 *6* b=3502 *115*
$^{167}_{68}$Er		7/2			62Sp02			
$^{167}_{68}$Er			−0.564[ch] *7*	+2.82[c]	63Bl25			
$^{167}_{68}$Er			−0.5647[h] *24*	+2.827 *12*	65Sm04	$^3H_6$		a=−120.4864 *5* b=−4552.959 *23* g=−0.8720x10^{-4} *37*
$^{169}_{68}$Er	9.4d	1/2			61Ca07	$^3H_6$		
$^{169}_{68}$Er	9.4d		±0.513 *25*		63Do09	$^3H_6$		g=5.55x10^{-4} *27* a=725.46 *31*
$^{171}_{68}$Er	7.5h	5/2			61Ca07	$^3H_6$		
$^{171}_{68}$Er	7.5h		±0.70[a] *5* μ/Q negative	±2.4 *2*	64Bu09	$^3H_6$		a=197.0 *29* b=3646 *106*
$^{159}_{69}$Tm	9m	5/2			71Ek01			
$^{160}_{69}$Tm	9m	1			71Ek01			
$^{161}_{69}$Tm	37m	7/2			71Ek01			
$^{161m}_{69}$Tm	7m	‡			71Ek01		‡Could not observe this activity; searched for I=$^1/_2$ through $^9/_2$	
$^{162}_{69}$Tm	21m	1			71Ek01			
$^{162m}_{69}$Tm	77m	‡			71Ek01		‡Could not observe this activity; searched for I=0 through 7	Er(80MeV p,)
$^{163}_{69}$Tm	1.8h	1/2	±0.082 *2*		67Sc33	$^2F_{7/2}$		a=133.4 *15*
$^{163m}_{69}$Tm	11m	‡			71Ek01		‡Could not observe this activity; searched for I=$^1/_2$ through $^9/_2$	
$^{164}_{69}$Tm	2m	1			71Ek01			
$^{164m}_{69}$Tm	5m	6			71Ek01			
$^{165}_{69}$Tm	29h	1/2			68Ek01			
$^{165}_{69}$Tm	29h	1/2	±0.138[a] *2*		68Sc26	$^2F_{7/2}$		a=224.4 *30*
$^{165m}_{69}$Tm	12m	‡			71Ek01		‡Could not observe this activity; searched for I=$^1/_2$ through $^9/_2$	
$^{166}_{69}$Tm	7.7h	2			61Wa04			
$^{166}_{69}$Tm	7.7h		±0.05[a] *3* μ/Q positive	±4.6 *7*	62Wa27	$^2F_{7/2}$: $^{11}/_2$,$^9/_2$ $^9/_2$,$^7/_2$ $^7/_2$,$^5/_2$ $^5/_2$,$^3/_2$	4640 *20* −330 *30* −2800 *100* −3390 *130*	a=19 *6* b=7700 *300*
$^{166}_{69}$Tm	7.7h		±0.0465[c] *15*	±4.36[c] *17*	63Bl25			
$^{166}_{69}$Tm	7.7h		±0.047[ac] *15*		67Gi04			(a=19 6)
$^{166}_{69}$Tm	7.7h		±0.092[a] *2* μ/Q positive	±1.85* *15*	72Ad14	$^2F_{7/2}$		a=37.1 *5* b=2935 *40*
$^{167}_{69}$Tm	9.6d	1/2			61Wa04			
$^{167}_{69}$Tm	9.6d		−0.197[ap] *2*		73An12	$^2F_{7/2}$		a=318.5 *5*
$^{168}_{69}$Tm	85d	3			71Ek01			

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{169}_{69}$Tm			±0.24[c]		62Li06			
$^{169}_{69}$Tm			−0.229 *3*		62Ri11	$^2F_{7/2}$:4,3	1496.555 *10*	a=−374.1374 *16*
								g=2.478x10^{-4} *32*
$^{169}_{69}$Tm			−0.2310[h] *15*		67Gi04	$^2F_{7/2}$:4,3	1496.550667[j] *12*	a=−374.137661 *3*
						4,3	1496.550642 *12*	g=+2.498x10^{-4} *15*
$^{170}_{69}$Tm	127d	1	±0.26 *2*	±0.61 *5*	60Ca15	$^2F_{7/2}$: $^9/_2$, $^7/_2$	74 *20*	a=200 *3*
			μ/Q positive			$^7/_2$, $^5/_2$	1960 *22*	b=1010 *15*
$^{170}_{69}$Tm	127d		±0.245[c] *4*	±0.574[c] *9*	63Bl25			
$^{170}_{69}$Tm	127d		±0.247[ac] *4*		67Gi04			(a=200 *3*)
$^{171}_{69}$Tm	1.9y	1/2			61Ca07			
$^{171}_{69}$Tm	1.9y		±0.227[a] *5*		64Bu09	$^2F_{7/2}$		a=372.1 *59*
$^{171}_{69}$Tm	1.9y		±0.230[ac] *4*		67Gi04			(a=372.1 *59*)
$^{167}_{71}$Lu	54m	7/2			72Ek01			
$^{169}_{71}$Lu	1.5d	7/2			68Ek01			
$^{170}_{71}$Lu	2.0d	0♦			68Ek01	$^2D_{3/2}$		a<0.020, if $I\neq0$
$^{171}_{71}$Lu	8.3d	7/2			68Ek01			
$^{175}_{71}$Lu			+2.17 *19*	+5.68 *6*	62Ri04	$^2D_{3/2}$:5,4	2051.2305 *40*	a=194.3316 *4*
						4,3	345.4974 *24*	b=1511.4015 *30*
						3,2	−496.5777 *8*	g=3.50x10^{-4} *10*
						$^2D_{5/2}$:6,5	1837.579 *10*	a=146.7790 *8*
						5,4	800.3467 *43*	b=1860.6480 *80*
						4,3	161.8248 *56*	g=3.13x10^{-4} *24*
						3,2	−157.7283 *51*	
						2,1	−238.0556 *40*	
$^{175}_{71}$Lu					71Fi03	$^2D_{3/2}$:5,4	2051.220129 *90*	a=194.33292 *30*
					73Fi08	4,3	345.49662 *30*	b=1511.39627 *32*
						3,2	496.57800 *10*	c=−70 *19*Hz
						$^2D_{5/2}$:6,5	1837.57010 *40*	a=146.77647 *14*
						5,4	800.34261 *33*	b=1860.65613 *84*
						4,3	161.81548 *50*	c=913 *162*Hz
						2,1	238.05836 *10*	d=−16 *24*Hz
$^{176}_{71}$Lu	20Gy	7	±3.184[a]‡ *15*	±8.0 *7*	62Sp03	$^2D_{3/2}$: $^{17}/_2$, $^{15}/_2$	2486 *10*	a=138.80 *46*
						$^{15}/_2$, $^{13}/_2$	775 *5*	b=2151 *10*
						$^{13}/_2$, $^{11}/_2$	−404 *9*	
							‡Using μ^{175}_{unc}=2.211 *10*, 62Re02	
$^{176m}_{71}$Lu	3.7h	1	+0.318[a] *3*	−2.39 *4*	65Wh03	$^2D_{3/2}$		a=+97.19644 *30*
								b=−635.19314 *70*
						$^2D_{5/2}$		a=+73.17285 *30*
								b=−781.97469 *70*
$^{177}_{71}$Lu	6.8d	7/2	+2.235[a] *10*	+5.51 *6*	62Pe07	$^2D_{3/2}$:5,4	2021.850 *130*	a=194.84 *2*
						4,3	360.300 *85*	b=1466.71 *12*
						3,2	−463.130 *105*	
						$^2D_{5/2}$:6,5	1811.784 *95*	a=147.17 *1*
						5,4	800.348 *50*	b=1805.93 *14*
						4,3	175.896 *50*	
						3,2	−138.968 *55*	
						2,1	−221.640 *45*	
$^{177}_{72}$Hf			+0.7902[h] *7*	+4.5* *5*	73Bu25	$^3F_2$: $^{11}/_2$, $^9/_2$	991.79202 *24*	a=113.43314 *7*
						$^9/_2$, $^7/_2$	477.00847 *21*	b=624.3293 *13*
						$^7/_2$, $^5/_2$	162.88685 *15*	c=270 *180*Hz
						$^5/_2$, $^3/_2$	4.86356 *32*	d=45 *40*Hz
								g_I=−1.2194x10^{-4} 9

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{179}_{72}$Hf			−0.6382[h] *13*	+5.1* *5*	73Bu25	$^3F_2$: $^{13}/_2$, $^{11}/_2$	82.13214 *60*	a=−71.42891 *9*
						$^{11}/_2$, $^{9}/_2$	392.84775 *37*	b=705.5181 *24*
						$^{9}/_2$, $^{7}/_2$	541.91044 *7*	c=−430 *200*Hz
						$^{7}/_2$, $^{5}/_2$	558.67174 *24*	d=70 *60*Hz
								g_I=0.7660x10^{-4} *15*
$^{181}_{73}$Ta					71Bu10	$^4F_{3/2}$:5,4	1822.389 *6*	a=509.0801 *8*
						4,3	2325.537 *2*	b=−1012.251 *8*
						$^4F_{5/2}$:6,5	1451.476 *7*	a=313.4681 *8*
						5,4	1537.530 *8*	b=834.820 *12*
						4,3	1444.685 *2*	
						$^4F_{7/2}$:4,3	1218.372 *2*	
$^{183}_{73}$Ta	5.0d	7/2			63Do13			
$^{185}_{74}$W	74d	3/2			63Do13			
$^{187}_{74}$W	24h	3/2			63Do13			
$^{186}_{75}$Re	90h	1			63Do13			
$^{186}_{75}$Re	90h		+1.730[h] *3*		65Ar01	$^6S_{5/2}$		a=−78.3060 *10*
								b=+8.3595 *16*
								g=+9.34x10^{-4} *2*
$^{186}_{75}$Re	90h		positive		65Sc13	$^6S_{5/2}$: $^{7}/_2$, $^{5}/_2$	265.292 *14*	a=78.3058 *24*
						$^{5}/_2$, $^{3}/_2$	208.305 *14*	b=8.3601 *50*, b/a<0
$^{186}_{75}$Re	90h			~0.4[c]	66Ku07 (65Ar01)			
$^{188}_{75}$Re	17h	1			63Do13			
$^{188}_{75}$Re	17h		+1.780[h] *5*		65Ar01	$^6S_{5/2}$		a=80.4326 *8*
								b=7.7463 *11*, b/a<0
								g=+9.61x10^{-4} *3*
$^{188}_{75}$Re	17h		positive		65Sc13	$^6S_{5/2}$: $^{7}/_2$, $^{5}/_2$	273.379 *13*	a=80.4320 *32*
						$^{5}/_2$, $^{3}/_2$	212.698 *17*	b=7.7455 *60*, b/a<0
$^{188}_{75}$Re	17h			~0.4[c]	66Ku07 (65Ar01)			
$^{191}_{77}$Ir				±0.78 *20*	73Bu15	$^4F_{9/2}$:6,5	659.26496 *12*	a=57.52148 *4*
						5,4	189.44002 *9*	b=471.20425 *57*
						4,3	84.05040 *80*	c=−20 *30*Hz
$^{192}_{77}$Ir	74d	4			63Do13			
$^{193}_{77}$Ir				±0.70 *18*	73Bu15	$^4F_{9/2}$:6,5	660.09043 *12*	a=62.65556 *5*
						5,4	224.47848 *13*	b=426.23546 *64*
						4,3	33.53453 *89*	c=20 *30*Hz
$^{194}_{77}$Ir	19h	1			63Do13			
$^{195}_{78}$Pt					67Ch26	$^3D_3$		a=5717 *21*
						$^3D_2$		a=2608 *3*
$^{195}_{78}$Pt					71Gr61	$^3F_4$: $^{9}/_2$, $^{7}/_2$	3820.564 *7*	a=849.014 *2*
$^{197}_{78}$Pt	20h	1/2	±0.50[a] *2*		68Ch18			
$^{190}_{79}$Au	40m	1	±0.063		64Li06	$^2S_{1/2}$: $^{3}/_2$, $^{1}/_2$	3004 *7*	
$^{190}_{79}$Au	40m	1	±0.065[a] *9*		66Ch05	$^2S_{1/2}$: $^{3}/_2$, $^{1}/_2$	3105 *425*	
$^{191}_{79}$Au	3.0h	3/2			60Ew06			
$^{191}_{79}$Au	3.0h		±0.137[a] *7*		64Ew02	$^2S_{1/2}$:2,1	5770 *6*	
$^{192}_{79}$Au	4.1h	1	±0.0079[a] *1*		60Ew06 (59E88)	$^2S_{1/2}$: $^{3}/_2$, $^{1}/_2$	372.1 *1*	
$^{193}_{79}$Au	18h	3/2			60Ew06			
$^{193}_{79}$Au	18h		±0.139[a] *7*		64Ew02	$^2S_{1/2}$:2,1	5882 *10*	

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{194}_{79}$Au	39h		±0.076[a] *3*		57H69	$^2S_{1/2}$: $^3/_2$, $^1/_2$	3600 *120*	
$^{194}_{79}$Au	39h	1			60Ew06			
$^{194}_{79}$Au	39h		±0.074[a] *4*		65Ch08	$^2S_{1/2}$: $^3/_2$, $^1/_2$	3489.865 *32*	
$^{195}_{79}$Au	192d	3/2			60Ew06			
$^{195}_{79}$Au	192d		±0.147[a] *7*		65Ch08	$^2S_{1/2}$:2,1	6220 *38*	
$^{196}_{79}$Au	6.2d	2			60Ew06			
$^{196}_{79}$Au	6.2d		+0.5879[k] *14*		70Sc07	$^2S_{1/2}$: $^5/_2$, $^3/_2$	21347.2522 *15*	
$^{196m}_{79}$Au	9.7h	12			62Ch13	$^2S_{1/2}$		
$^{197}_{79}$Au			±0.13 *1*		53W33	$^2S_{1/2}$:2,1	6107.1 *10*	
$^{197}_{79}$Au				+0.585	66Ch03	$^2D_{5/2}$:4,3	518.880 *17*	a=80.236 *3*
						3,2	713.101 *8*	b=1049.781 *11*, $b/a<0$
						2,1	1000.304 *10*	c=0.0004 *4*, $c/a>0$
				+0.598[c]		$^2D_{3/2}$		
				+0.592‡ *12*			‡Average value	
$^{197}_{79}$Au			Ω=+0.0098 *7*	+0.604	67Bl16	$^2D_{3/2}$:3,2	311.5473 *2*	a=199.8425 *2*
			to +0.014 *1*			2,1	1310.7555 *12*	b=−911.0766 *5*
						1,0	1110.9315 *5*	c=0.000212 *14*
			Ω=+0.15			$^4F_{9/2}$:6,5	2233.7160 *14*	a=432.276 *1*
						5,4	2273.8874 *6*	b=−540.026 *1*
						4,3	2089.1430 *4*	c=0.00326 *10*
			Ω=+0.06 *6*	(+0.585)	(66Ch03)	$^2D_{5/2}$		
				+0.594‡			‡Average value	
$^{197}_{79}$Au			+0.144865[b] *70*		67Da04	$^2S_{1/2}$:2,1	6099.320184 *13*	
$^{198}_{79}$Au	2.7d	2	+0.552[a] *4* if $\mu>0$		56C08	$^2S_{1/2}$: $^5/_2$, $^3/_2$	21800 *150* if $\mu>0$	
			−0.570[a] *4* if $\mu<0$				22500 *150* if $\mu<0$	
$^{198}_{79}$Au	2.7d		+0.5898[d] *5*		67Va16	$^2S_{1/2}$: $^5/_2$, $^3/_2$	21450.7167 *4*	g=1.5908x10^{-4} *6*
$^{199}_{79}$Au	3.2d	3/2	±0.264[a] *5*		56C08	$^2S_{1/2}$:2,1	11110 *130* if $\mu>0$	
							11180 *130* if $\mu<0$	
$^{199}_{79}$Au	3.2d		+0.2699[d] *7*		67Va16	$^2S_{1/2}$:2,1	10962.7227 *3*	g=0.9706x10^{-4} *12*
$^{199}_{80}$Hg					60Mc11	$^3P_2$: $^5/_2$, $^3/_2$	22666.559 *5*	a=9066.449 *3*
$^{201}_{80}$Hg			Ω=−0.13 *1*	+0.50 *4*	60Mc11	$^3P_2$: $^7/_2$, $^5/_2$	11382.6288 *8*	a=−3352.0292 *8*
						$^5/_2$, $^3/_2$	8629.5218 *5*	b=399.150 *2*
						$^3/_2$, $^1/_2$	5377.4918 *20*	c=−0.00184 *9*
$^{201}_{80}$Hg				+0.36[c]	62Ko22			
					(60Mc11)			
$^{201}_{80}$Hg				+0.39[c]	65Mu15	$^3P_2$		
					(60Mc11)			
$^{193}_{81}$Tl	23m	1/2			73Ek03			
$^{194}_{81}$Tl	33m	2	±0.135 *3*		73Ek03	$^2P_{1/2}$		a=443 *9*
$^{195}_{81}$Tl	1.2h	1/2			62Ax02			
$^{195}_{81}$Tl	1.2h		+1.66 *13*		73Ek03			g=+1.79x10^{-3} *14*
$^{196}_{81}$Tl	1.8h	2	±0.0699 *2*		73Ek03	$^2P_{1/2}$		a=228.8 *6*
$^{197}_{81}$Tl	2.8h	1/2			57B132			
$^{197}_{81}$Tl	2.7h		+1.66 *13*		73Ek03			g=+1.79x10^{-3} *14*
$^{198}_{81}$Tl	5.3h	2	±<2x10^{-3}		58L45			
$^{198}_{81}$Tl	5.3h		±0.0012063 *9*		73Ek03	$^2P_{1/2}$		a=3.9499 *6*
$^{198m}_{81}$Tl	1.8h	7			57B132			
$^{198m}_{81}$Tl	1.8h		±0.640 *74*		74EkZX	$^2P_{1/2}$		a=599 *69*
$^{199}_{81}$Tl	7.4h	1/2			57B132			
$^{199}_{81}$Tl	7.4h		+1.65 *10*		73Ek03			g=+1.78x10^{-3} *11*
$^{200}_{81}$Tl	26.1h	2			58M21			
$^{200}_{81}$Tl	26.1h		±0.035675 *28*		73Ek03	$^2P_{1/2}$		a=116.814 *8*

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{201}_{81}$Tl	73.5h	1/2			58L45			
$^{201}_{81}$Tl	73.5h	1/2			58M21			
$^{201}_{81}$Tl	73.5h		+1.71 *11*		73Ek03			$g=+1.84\times10^{-3}$ *12*
$^{202}_{81}$Tl	12.2d	2			58M35			
$^{202}_{81}$Tl	12.2d		±0.565		73Ek03	$^2P_{1/2}$		$a=185.1$ *7*
$^{203}_{81}$Tl					56L53	$^2P_{1/2}$:1,0	21105.447 *5*	
$^{203}_{81}$Tl			+1.6109^{bp} *14*		68Fo10	$^2P_{3/2}$:2,1	524.05994 *10*	$g=17.375\times10^{-4}$ *14*
$^{203}_{81}$Tl					68Pa07	$^2P_{1/2}$:1,0	21105.4497638 *5*	
$^{203}_{81}$Tl					68Pe18	$6^2P_{3/2}$:2,1	524.059953 *3*	
$^{204}_{81}$Tl	3.9y	2	±0.062^a *6*		56B124			$a=200$ *20*
$^{204}_{81}$Tl	3.9y	2	±0.0894^a *20*		57B132	$^2P_{1/2}$:$^5/_2$,$^3/_2$	732 *5*	
$^{204}_{81}$Tl	3.9y		±0.0893^a *1*		58W44	$^2P_{1/2}$:$^5/_2$,$^3/_2$	730.837 *5*	
$^{205}_{81}$Tl					56L53	$^2P_{1/2}$:1,0	21310.835 *5*	
$^{205}_{81}$Tl			±1.6265 *9*		64Bo37		TlF	
$^{205}_{81}$Tl					67La23	$^2P_{1/2}$:1,0	21310.8339466 *2*	
$^{205}_{81}$Tl			+1.6271^{bp} *15*		68Fo10	$^2P_{3/2}$:2,1	530.07655 *10*	$g=17.549\times10^{-4}$ *14*
$^{205}_{81}$Tl					68Pe18	$6^2P_{3/2}$:2,1	530.076546 *3*	
$^{206}_{81}$Tl	4.2m	0♦	$<10^{-5}$, if $I=1$		69Cu09	$J=^1/_2$		$a<163$kHz
$^{207}_{82}$Pb					70Lu09	$^1D_2$:$^5/_2$,$^3/_2$	1524.545 *20*	$a=609.820$ *8*
$^{199}_{83}$Bi	25m	9/2			59A198			
$^{200}_{83}$Bi	35m	7			59A198			
$^{201}_{83}$Bi	1.8h	9/2			59A198			
$^{201m}_{83}$Bi	62m	$I>21/2$ or $\mu<0.1$‡			59A198		‡If this activity were produced with about the same probability as the ground state, a resonance should have been observed unless I were very large or μ very small	
$^{202}_{83}$Bi	1.6h	5			59A198			
$^{203}_{83}$Bi	12h	9/2	+4.59^a *5*	−0.64 *5*	59L50	$J=^3/_2$:6,5	3386 *30*	$a=-502.4$ *30*
						5,4	2396 *15*	$b=-558$ *25*
$^{204}_{83}$Bi	12h	6	+4.25^a *5*	−0.41 *5*	59L50	$J=^3/_2$:$^{15}/_2$,$^{13}/_2$	2841 *25*	$a=-349.0$ *20*
						$^{13}/_2$,$^{11}/_2$	2216 *15*	$b=-358$ *20*
$^{205}_{83}$Bi	15d	9/2	≈+5.5^a‡		59L50	$J=^3/_2$:6,5	≈4000	$a\approx-600$
							‡Value very uncertain due to large configuration interaction corrections which are not included	
$^{206}_{83}$Bi	6.3d	6			57M24			
$^{206}_{83}$Bi	6.3d	6	+4.56^a *5*	−0.19 *5*	59L50	$J=^3/_2$:$^{15}/_2$,$^{13}/_2$	2914 *25*	$a=-374.7$ *30*
						$^{13}/_2$,$^{11}/_2$	2411 *20*	$b=-166$ *30*
$^{209}_{83}$Bi	>2Ay			−0.34	60Ti01	$J=^3/_2$:6,5	2884.7 *2*	$a=-446.97$ *4*
						5,4	2171.5 *1*	$b=-304.25$ *83*
$^{209}_{83}$Bi	>2Ay			−0.29^c	62Ko22			
$^{209}_{83}$Bi	>2Ay			−0.35	68Lu08	$^2P_{3/2}$:6,5	3598.647 *6*	
						5,4	2251.038 *10*	
						4,3	1311.930 *10*	
$^{209}_{83}$Bi	>2Ay		$\Omega=+0.43$		70Hu05	$^4S_{3/2}$:6,5	2884.666 *2*	$a=-446.937$ *1*
						5,4	2171.419 *2*	$b=-305.067$ *2*
						4,3	1584.502 *2*	$c=0.0183$ *1*
$^{209}_{83}$Bi	>2Ay		+4.25 *14*	−0.383 *40*	70La07	$^2P_{3/2}$		$a=491.028$ *1*
			$\Omega=+0.55$‡ *3*					$b=978.639$ *9*
								$c=0.0193$ *5*
							‡Used $\mu=4.08$	
$^{209}_{83}$Bi	>2Ay			−0.46^c	72Ro37	$^4S_{3/2}$,$^2D_{3/2}$,$^2P_{3/2}$		
			$\Omega=0.62^c$ *8*			$^4S_{3/2}$,$^2P_{3/2}$		

Table F: Nuclear Moments by Atomic and Molecular Beams – Continued

Nucleus	$T_{1/2}$	I	μ	Q	Refer.	Atomic State: (F,F')	$\Delta\nu(F,F')$ or Molecule Used	Interaction Constants or Moment Ratios
$^{210}_{83}$Bi	5d	1			54S96			
$^{210}_{83}$Bi	5d		±0.0442[a] *1* μ/Q negative	±0.13 *1*	62Al02	$J={}^3/_2$: $^5/_2$,$^3/_2$ $^3/_2$,$^1/_2$	194.93 *9* 220.19 *8*	a=21.78 *3* b=112.38 *3*
$^{210}_{83}$Bi	5d		negative‡	positive‡	64Po04		‡From fitting experimental values of μ and Q and β–decay data to deduce reasonable Ψ's	
$^{201}_{84}$Po	18m	3/2			61Ax02			
$^{202}_{84}$Po	51m	0♦			61Ax02			a<0.02, if I=1
$^{203}_{84}$Po	42m	5/2			61Ax02			
$^{204}_{85}$Po	3.5h	0♦			61Ax02			a<0.02, if I=1
$^{205}_{84}$Po	1.8h	5/2			61Ax02			
$^{205}_{84}$Po	1.8h		≈±0.26[a]‡	+0.17	68Jo19			a=134.14 *2* b=232.3 *2*
							‡Value very uncertain due to large configuration interaction corrections which are not included	
$^{206}_{84}$Po	8.8d	0♦			61Ax02			a<0.02, if I=1
$^{207}_{84}$Po	6.0h	5/2			61Ax02			
$^{207}_{84}$Po	6.0h		≈+0.27[a]‡ Ω=+0.11 *1*	+0.28	61Ol01	J=2: $^9/_2$,$^7/_2$ $^7/_2$,$^5/_2$ $^5/_2$,$^3/_2$	884.785 *13* 421.950 *8* 158.567 *12*	a=139.551 *2* b=380.548 *16* c=−0.0120 *10*
							‡Value very uncertain due to large configuration interaction corrections which are not included	
$^{210}_{84}$Po	138d	0♦			61Al20			
$^{211}_{85}$At	7.2h	9/2			58G16			
$^{233}_{91}$Pa	27d	3/2			58H115			
$^{233}_{91}$Pa	27d	3/2	+3.4 *8*	−3.0	61Ma42			g=12.5x10^{-4} *30* a=+595 *30* b=−2400 *300*
$^{238}_{93}$Np	2.1d	2			58A92			
$^{239}_{93}$Np	2.3d	5/2			58H111			
$^{239}_{94}$Pu	24ky	1/2	±0.02		58H70	^{7}F$_1$: $^3/_2$,$^1/_2$	7.683 *60*	a=5.14
$^{239}_{94}$Pu	24ky		+0.200[b] *4*		65Fa02			
$^{241}_{95}$Am	460y	5/2			60Ma30	^{8}S$_{7/2}$		a=17.144 *8* b=123.82 *10* b/a<0
$^{241}_{95}$Am	460y		+1.59[b] *3*		66Ar04	^{8}S$_{7/2}$		a=17.1437 *28* b=123.848 *32*, b/a<0 g=3.42x10^{-4} *6*
$^{242}_{95}$Am	16h	1	±0.33 μ/Q negative	±2.76	61Ma27			a=10.124 *10* b=69.639 *40*
$^{242}_{95}$Am	16h		+0.3826[b] *15*		66Ar04	^{8}S$_{7/2}$		a=10.1282 *14* b=69.6339 *13* g=2.059x10^{-4} *8*
$^{242}_{96}$Cm	160d	0♦	<2x10^{-4}, if I=1		59H115			
$^{253}_{99}$Es	20.5d		±4.06[ik] *20*	±6.1	72Go42			a=816.57 *60* b=−4335 *16*

Table F: Nuclear Moments by Atomic and Molecular Beams — Continued

* Polarization or Sternheimer correction included
♦ No hyperfine structure observed
[a] Calculated from the $\Delta\nu-$ or $a-$ratio for two isotopes
[b] Non–resonance or zero–moment experiment
[c] Recalculation of earlier data
[d] Determined from $\Delta m = \pm 1$ doublet separation
[E] Electric resonance experiment
[f] Inferred from intensity or polarization distribution across the beam
[g] Calculated from the $b-$ratio for two isotopes
[h] Direct measurement by triple resonance
[i] No diamagnetic correction added. Unsure if authors already corrected for it.
[j] Not corrected for mixing of other states or higher order perturbation effects
[k] Direct measurement
[l] MASER experiment
[m] Metastable or excited state
[p] Preliminary value from meeting abstract, thesis, private communication, etc.

Table G: Nuclear Moments by Optical Spectroscopy

Introduction

A nuclear angular momentum, designated by I, and an associated magnetic moment, μ_I, were first postulated by Pauli [24Pa01] and by Goudsmit and Back [27Go01] to explain an observed hyperfine structure (hfs) in spectral lines of the order of magnitude of $1 cm^{-1}$ or roughly 1/2000 of the fine structure which is due to different orientations of the electron's spin with respect to its orbital angular momentum.

This hyperfine structure is attributed to the splitting of the energy levels of the atom as a result of the interaction between the nuclear magnetic moment and the magnetic field due to the electrons. Deviations from the expected magnitude of this splitting can be ascribed to the interaction of the nuclear electric quadrupole moment with the electric field.

The individual electronic states are split by the magnetic interaction into $2I + 1$ or $2J + 1$ substates depending upon whether I is less than or greater than J, the electronic spin. An observed spectral line, arising from a transition between two such electronic states, will have a multiplicity greater than $2I + 1$ or $2J + 1$ unless J is zero for one of the states. Two typical transitions are illustrated in figure 1. If J is known for each of the states involved in the transition, I can be determined by the multiplicity and the relative spacings of the components. The statistical weights of the hyperfine substates are also functions of I so that the relative intensities of the hfs components may also indicate the nuclear spin.

A few nuclei have also been studied by molecular band spectroscopy. This technique has been used to make unequivocal assignments of zero spin by the observation of the absence of alternating intensities in the band spectra of diatomic homonuclear molecules. The method of atomic spectroscopy cannot establish a zero spin since only an upper limit can be placed on the hfs splitting by a study of the spectral lines.

Values of the nuclear magnetic dipole and electric quadrupole moments are calculated from the hyperfine interaction constants which are in turn computed from the wavelengths of the observed lines. Since the values of μ determined in this way

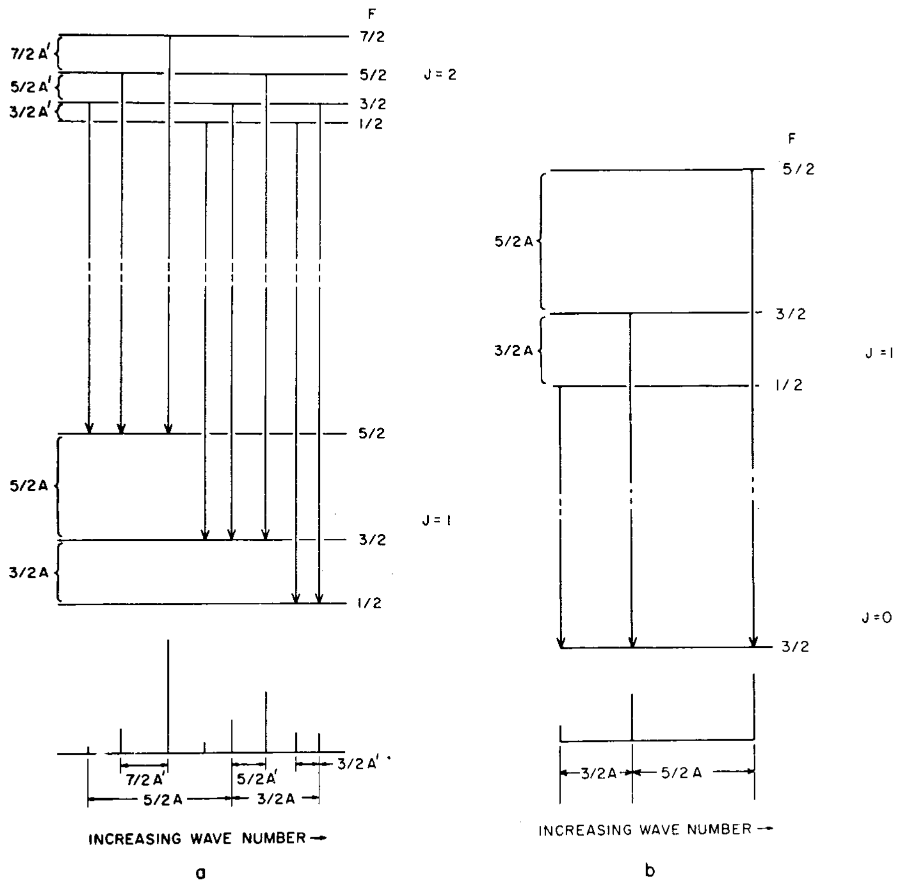

FIGURE 1. Schematic level diagram showing transitions between an upper and lower state in an atom where the nucleus has $I = 3/2$ and $Q = 0$ (a) for $J_{upper} = 2$ and $J_{lower} = 1$, (b) for $J_{upper} = 1$, and $J_{lower} = 0$. The lower part of each diagram graphically depicts the relative wave numbers and intensities of the corresponding multiplets. The magnetic dipole interaction constants for the $J = 1$ and $J = 2$ states are denoted by A and A', respectively.

are accurate only to a few percent, this table does not list all values measured by the optical method but only those not measured by more accurate techniques and those for which the sign of the moment was determined.

The calculation of the quadrupole moment Q from the interaction constant depends upon the determination of the electric field gradient at the nucleus. In some of the earlier calculations the wavefunctions used were very crude. No attempt has been made by the compilers to reevaluate the Q's with newer wavefunctions. In addition, the nuclear quadrupole moment causes a polarization of the atomic core electrons (Sternheimer effect). The correction for this effect can be of the order of tens of percent.

There have been a few errors or ambiguities in assignment of spin by optical spectroscopy. These can be caused by such factors as

(1) Errors in assignment of J to the states involved.

(2) Isotopic impurities which may produce lines masking those under study.

(3) Distortion of intensity ratios resulting from self-absorption, diffuse radiation background, or in the case of photographic recording, a nonlinearity of density response of the photographic material.

The precision with which hyperfine interactions can be determined by optical spectroscopy is limited by

(1) Lifetimes of the excited energy levels, which are of the order of 10^{-8} seconds and produce a line broadening of about $3\times10^{-3}\mathrm{cm}^{-1}$.

(2) Doppler effect due to atomic motion. This can be reduced by cooling the source or using an atomic beam in which the motion of the atoms is perpendicular to the optical path.

(3) The finite resolving power of the optical equipment. This involves both the inherent limitations of the system and the imperfections of preparation of optical surfaces.

A general review of the optical method can be found in F.M. Kelly, *Determination of Nuclear Spins and Magnetic Moments by Atomic Spectroscopy* [58Ke25]. Details of the techniques and apparatus are discussed in S. Tolansky, *High Resolution Spectroscopy* [47To19].

A few measurements of nuclear moments from the analysis of meson–atomic X–rays have also been included in this table. These values have been marked by a 'l'.

The last systematic literature search for information included in the table was in early 1971.

Explanation of Table G

Nucleus	Chemical symbol with Z– and A–number States, other than ground states, are designated by "m" following the A–number.
$T_{1/2}$	Half–life of radioactive nucleus
I	Nuclear spin, in units of $h/2\pi$
μ or μ^1/μ^2	Nuclear magnetic dipole moment, in nuclear magnetons, given with diamagnetic correction, or magnetic moment ratio. See Policies, Diamagnetic corrections, for factors used A 5% uncertainty in the diamagnetic correction is assumed.
Q or Q^1/Q^2	Nuclear electric quadrupole moment, in barns, as given by the experimenter, or quadrupole moment ratio. Values marked by an asterisk, *, indicate that the experimenter has made some polarization or Sternheimer corrections in computing the moment.
Refer.	Reference key

Table G: Nuclear Moments by Optical Spectroscopy

Nucleus	$T_{1/2}$	I	μ or μ^1/μ^2	Q or Q^1/Q^2	Refer.
${}^{1}_{1}H$		1/2[b]			29M01
${}^{1}_{1}H$		1/2[b]			30C01
${}^{1}_{1}H$		1/2[b]			30H02
${}^{2}_{1}H$		1[b]			33L02
${}^{2}_{1}H$		1[b]			34M03
${}^{3}_{1}H$	12y	1/2[b]			49D31
${}^{3}_{2}He$		1/2[b]			49D24
${}^{3}_{2}He$			negative		50F51
${}^{4}_{2}He$		0[b]			29M01
${}^{7}_{3}Li$		3/2[b]			30H01
${}^{7}_{3}Li$		3/2			32G03
${}^{12}_{6}C$		0[b]			29M01
${}^{13}_{6}C$		1/2[bE]			48J21
${}^{14}_{6}C$	5.6ky	0[bE]			48J21
${}^{14}_{7}N$		1[b]			28O01
${}^{15}_{7}N$		1/2[bE]			39K11
${}^{15}_{7}N$		1/2[b]			40W10
${}^{16}_{8}O$		0[b]			29M01
${}^{19}_{9}F$		1/2[b]			29G01
${}^{19}_{9}F$		1/2			33C04
${}^{20}_{10}Ne$		0♦			27H01
${}^{21}_{10}Ne$		≥3/2[E]	negative[E]		49K21
${}^{21}_{10}Ne$				±0.0926[q] *16*	71Du05
${}^{22}_{10}Ne$		0♦			27H01
${}^{23}_{11}Na$		3/2			33G03
${}^{23}_{11}Na$		3/2[b]			33J04
${}^{23}_{11}Na$		3/2	±1.99[a]		34E02
${}^{23}_{11}Na$			+2.14		34S05
${}^{23}_{11}Na$			±2.218 *13*		67Dr09
${}^{24}_{12}Mg$		0♦			31M02
${}^{25}_{12}Mg$		5/2	−0.96 *7*		49C18
${}^{26}_{12}Mg$		0♦			31M02
${}^{27}_{13}Al$		5/2	+3.7		38H06
${}^{31}_{15}P$		1/2[b]			33A01
${}^{31}_{15}P$		1/2	+1.15 *5*		49C31
${}^{32}_{16}S$		0[b]			31N01
${}^{32}_{16}S$		0[b]			36O01
${}^{36}_{18}Ar$		0♦			37K03
${}^{36}_{18}Ar$		0♦[E]			53M73
${}^{37}_{18}Ar$	34d	3/2	+0.95 *20*		65Ro13
${}^{38}_{18}Ar$		0♦[E]			53M73
${}^{39}_{18}Ar$	265y	7/2	−1.3 *3*		67Tr12
${}^{40}_{18}Ar$		0♦			37K03
${}^{40}_{18}Ar$		0♦[E]			53M73
${}^{39}_{19}K$		3/2	positive		37J02

Table G: Nuclear Moments by Optical Spectroscopy — Continued

Nucleus	$T_{1/2}$	I	μ or μ^1/μ^2	Q or Q^1/Q^2	Refer.
$^{40}_{20}$Ca		0♦			31F01
$^{43}_{20}$Ca		7/2	−1.2		54K14
$^{45}_{21}$Sc		7/2			34K01
$^{45}_{21}$Sc		7/2			34S01
$^{45}_{21}$Sc			+4.8		37K02
$^{51}_{23}$V		7/2			36K04
$^{51}_{23}$V				+0.28 *15*	56M36
$^{51}_{23}$V				$+0.26^{c}$	62Ko22
$^{55}_{25}$Mn		5/2			30W01
$^{55}_{25}$Mn			+3.0		39F03
$^{55}_{25}$Mn				+0.4* *2*	55M56
$^{55}_{25}$Mn				+0.3 *1*	58R54
$^{55}_{25}$Mn				+0.35 *5*	62Wa30
$^{59}_{27}$Co		7/2			35K05
$^{59}_{27}$Co		7/2	+2.7		35M07
$^{59}_{27}$Co				+0.5 *2*	53M65
$^{59}_{27}$Co				±0.49 *3*	69Mu11
				±0.42* *3*	
$^{61}_{28}$Ni			$\pm\leq 0.25^{E}$		50K55
$^{63}_{29}$Cu		3/2			32R02
$^{63}_{29}$Cu		3/2	+2.5	−0.1 *1*	36S07
$^{63}_{29}$Cu				−0.13 *6*	53K39
$^{63}_{29}$Cu				−0.28 *7*	56K64
$^{63}_{29}$Cu				-0.20^{E} *4*	61Fi01
$^{63}_{29}$Cu				-0.181^{c}	62Ko22
					(61Fi01)
$^{63}_{29}$Cu				−0.212* *4*	69St24
$^{63}_{29}$Cu				−0.212* *4*	70Fi17
$^{65}_{29}$Cu		3/2			32R02
$^{65}_{29}$Cu			+2.6	−0.1 *1*	36S07
$^{65}_{29}$Cu				−0.15 *10*	49B61
$^{65}_{29}$Cu				−0.22 *6*	56K64
$^{65}_{29}$Cu				-0.19^{E} *4*	61Fi01
$^{65}_{29}$Cu				−0.196* *4*	69St24
					(67Fi02)
$^{65}_{29}$Cu				-0.161^{E} *3*	70Fi17
				−0.196* *4*	(67Fi02)
$^{64}_{30}$Zn		0♦			29S01
$^{64}_{30}$Zn		0♦			31M02
$^{66}_{30}$Zn		0♦			29S01
$^{66}_{30}$Zn		0♦			31M02
$^{67}_{30}$Zn		5/2	+0.9		37L07
$^{67}_{30}$Zn		$5/2^{E}$			48A06
$^{68}_{30}$Zn		0♦			29S01
$^{68}_{30}$Zn		0♦			31M02
$^{69}_{31}$Ga		3/2			32J04
$^{69}_{31}$Ga		3/2			33C02
$^{69}_{31}$Ga			+2.0	+1	36S10
$^{69}_{31}$Ga			$^{71}/_{69}$=1.2700 *8*		56J29

Table G: Nuclear Moments by Optical Spectroscopy — Continued

Nucleus	$T_{1/2}$	I	μ or μ^1/μ^2	Q or Q^1/Q^2	Refer.
$^{71}_{31}$Ga		3/2			32J04
$^{71}_{31}$Ga		3/2			33C02
$^{71}_{31}$Ga			+2.5	±≤0.5	36S10
$^{75}_{33}$As		3/2			32T01
$^{75}_{33}$As			+1.5 *3*	+0.3 *2*	36S05
$^{75}_{33}$As				+0.27* *4*	58Mu08
$^{75}_{33}$As				+0.29^{c}	62Ko22
$^{76}_{34}$Se		0♦			33R02
$^{77}_{34}$Se		1/2^{bE}			54D05
$^{78}_{34}$Se		0♦			33R02
$^{78}_{34}$Se		0^{bE}			54D05
$^{80}_{34}$Se		0^{b}			34O01
$^{80}_{34}$Se		0^{bE}			54D05
$^{82}_{34}$Se		0♦			33R02
$^{79}_{35}$Br		3/2			30B01
$^{79}_{35}$Br		3/2			32T02
$^{81}_{35}$Br		3/2			30B01
$^{81}_{35}$Br		3/2			32T02
$^{82}_{36}$Kr		0♦			33K02
$^{83}_{36}$Kr		9/2			32M06
$^{83}_{36}$Kr			negative		33K02
$^{83}_{36}$Kr		9/2		+0.15	38K02
$^{83}_{36}$Kr		9/2^{E}		+0.22^{E} *2*	55R46
$^{83}_{36}$Kr			−0.982^{E}	+0.17^{E} *5*	59B08
$^{84}_{36}$Kr		0♦			33K02
$^{85}_{36}$Kr	11y	9/2	±1.005 *2* $^{85}/_{83}$=1.035 *2*	+0.43 *3* $^{85}/_{83}$=+1.66 *10*	55R13
$^{86}_{36}$Kr		0♦			33K02
$^{85}_{37}$Rb		5/2	±1.4		33K01
$^{87}_{37}$Rb	47Gy	3/2	±2.8		33K01
$^{87}_{37}$Rb	47Gy			+0.14 *6*	56K12
$^{86}_{38}$Sr		0♦			31F01
$^{87}_{38}$Sr		9/2	−1.1		38H05
$^{88}_{38}$Sr		0♦			31F01
$^{88}_{38}$Sr		0♦			38H05
$^{89}_{39}$Y		1/2	≤0.1		40W08
$^{89}_{39}$Y		1/2	−0.14		49C17
$^{89}_{39}$Y		1/2	negative		50K69
$^{91}_{40}$Zr		5/2^{E}			49A06
$^{91}_{40}$Zr			−1.9 *2*		55M88
$^{93}_{41}$Nb		9/2	≈3.7		34B01
$^{93}_{41}$Nb		9/2	+5.3	≈0	47M27
$^{93}_{41}$Nb				−0.25 *15*	58Mu04
$^{93}_{41}$Nb				−0.20^{c}	62Ko22
$^{92}_{42}$Mo		0♦			51A29
$^{94}_{42}$Mo		0♦			51A29
$^{95}_{42}$Mo		5/2			51A29
$^{95}_{42}$Mo		5/2	negative		54W07
$^{96}_{42}$Mo		0♦			51A29

Table G: Nuclear Moments by Optical Spectroscopy — Continued

Nucleus	$T_{1/2}$	I	μ or μ^1/μ^2	Q or Q^1/Q^2	Refer.
$^{97}_{42}$Mo		5/2			51A29
$^{97}_{42}$Mo		5/2	negative		54W07
$^{98}_{42}$Mo		0♦			51A29
$^{100}_{42}$Mo		0♦			51A29
$^{99}_{43}$Tc	210ky	9/2	+5.5 *3*	+0.34 *17*	53K49
$^{99}_{44}$Ru		5/2	−0.63 *15*		55M78
			μ_{ave}(Ru)=−0.66 *2*		
			(μ^{101}/μ^{99}=±1.09 *3*		52G19)
$^{101}_{44}$Ru		5/2	−0.69 *15*		55M78
$^{103}_{45}$Rh		1/2	−0.10 *3*		51K41
$^{105}_{46}$Pd		5/2	−0.57 *5*		52S56
$^{105}_{46}$Pd		5/2	−0.57		53B28
$^{107}_{47}$Ag		1/2	−0.10		37J01
$^{107}_{47}$Ag		1/2	−0.086		50C26
$^{107}_{47}$Ag			−0.111[E] *8*		51B32
$^{109}_{47}$Ag		1/2	−0.19		37J01
$^{109}_{47}$Ag		1/2	−0.159		50C26
$^{109}_{47}$Ag			−0.129[E] *8*		51B32
$^{110}_{48}$Cd		0♦			29S01
$^{111}_{48}$Cd		1/2			31S01
$^{111}_{48}$Cd		1/2	−0.62		33J02
$^{112}_{48}$Cd		0♦			29S01
$^{113}_{48}$Cd	>3Jy	1/2			31S01
$^{113}_{48}$Cd	>3Jy	1/2	−0.62		33J02
$^{114}_{48}$Cd		0♦			29S01
$^{116}_{48}$Cd		0♦			29S01
$^{113}_{49}$In		9/2[f]	$^{113}/_{115}$=1.0[f]		37B08
$^{115}_{49}$In	600Ty	9/2			33J03
$^{115}_{49}$In	600Ty	9/2			34P01
$^{115}_{49}$In	600Ty			+0.82	37B08
$^{115}_{49}$In	600Ty		+5.3	+0.8	37S11
$^{115}_{50}$Sn		1/2	−0.86		49G02
$^{116}_{50}$Sn		0♦			31M02
$^{117}_{50}$Sn		1/2			33S03
$^{117}_{50}$Sn		1/2	−0.89		34T01
$^{118}_{50}$Sn		0♦			31M02
$^{119}_{50}$Sn		1/2			33S03
$^{119}_{50}$Sn		1/2	−0.89		34T01
$^{120}_{50}$Sn		0♦			31M02
$^{121}_{51}$Sb		5/2			32B01
$^{121}_{51}$Sb		5/2	+4.0		34C03
$^{121}_{51}$Sb				−1.3*	53S17
$^{121}_{51}$Sb				−0.53*[c] *10*	55M88
$^{121}_{51}$Sb				−0.50[c]	62Ko22
					(55M88)
$^{121}_{51}$Sb				−0.54 *8*	61Le13

Table G: Nuclear Moments by Optical Spectroscopy — Continued

Nucleus	$T_{1/2}$	I	μ or μ^1/μ^2	Q or Q^1/Q^2	Refer.
$^{123}_{51}$Sb		7/2			32B01
$^{123}_{51}$Sb		7/2	+3.2		34C03
$^{123}_{51}$Sb				-1.2^{c} *2*	49M48
					(40T03)
$^{123}_{51}$Sb				−1.7*	53S17
$^{123}_{51}$Sb				-0.68^{*c} *10*	55M88
$^{123}_{51}$Sb				−0.69 *10*	61Le13
$^{123}_{52}$Te	>50Ty	1/2	$^{125}/_{123}$=1.208 *60*		49M47
$^{123}_{52}$Te	>50Ty	$1/2^{E}$			50F08
$^{123}_{52}$Te	>50Ty		-0.6^{E} *2*		52R05
$^{125}_{52}$Te		1/2			49M47
$^{125}_{52}$Te		$1/2^{E}$			50F08
$^{125}_{52}$Te			-0.7^{E} *2*		52R05
$^{126}_{52}$Te		0♦			33R02
$^{128}_{52}$Te		0♦			33R02
$^{130}_{52}$Te		0♦			33R02
$^{127}_{53}$I		5/2			38M06
$^{127}_{53}$I			+2.8	−0.5	39S15
$^{127}_{53}$I				-0.67^{g}	58Mu10
				−0.62* *4*	
$^{127}_{53}$I				-0.49^{h} *8*	64Mu11
$^{129}_{54}$Xe		1/2			34J01
$^{129}_{54}$Xe		1/2	negative		34K02
$^{129}_{54}$Xe		$1/2^{E}$			50K09
$^{131}_{54}$Xe		3/2	positive		34K02
$^{131}_{54}$Xe		$3/2^{E}$		$\approx -0.15^{E}$	50K09
				$^{131}/^{83}$Kr≈−1	
$^{131}_{54}$Xe			$+0.687^{E}$ *3*	-0.12^{E} *2*	52B57
			$^{129}/_{131}$=−1.131 *5*		
$^{132}_{54}$Xe		0♦			34J01
$^{134}_{54}$Xe		0♦			34J01
$^{136}_{54}$Xe		0♦			34J01
$^{133}_{55}$Cs		7/2			31K01
$^{133}_{55}$Cs			$\pm 2.40^{a}$		34H03
$^{133}_{55}$Cs		7/2			34J02
$^{133}_{55}$Cs			±2.52		35S06
$^{133}_{55}$Cs				±≤0.3	40S09
$^{134}_{56}$Ba		$0♦^{E}$			50A51
$^{135}_{56}$Ba		3/2			32M06
$^{135}_{56}$Ba		3/2			37B09
$^{135}_{56}$Ba		$3/2^{E}$			50A51
$^{135}_{56}$Ba			$^{137}/_{135}=1.11^{E}$	$+0.25^{E}$ *12*	60Ka24
$^{135}_{56}$Ba				$+0.23^{c}$	62Ko22
$^{135}_{56}$Ba			$^{137}/_{135}=+1.10^{E}$ *3*	$^{137}/_{135}=+1.6^{E}$ *1*	63Ja15
$^{135}_{56}$Ba				+0.13 *5*	64Ja11
$^{135}_{56}$Ba				$\pm 0.41^{i}$ *4*	66Co26
$^{135}_{56}$Ba			±0.843 *7*		66Co32
$^{135}_{56}$Ba				±0.17 *2*	68Be60
$^{136}_{56}$Ba		0♦			50A51

Table G: Nuclear Moments by Optical Spectroscopy — Continued

Nucleus	$T_{1/2}$	I	μ or μ^1/μ^2	Q or Q^1/Q^2	Refer.
$^{137}_{56}$Ba		3/2			32M06
$^{137}_{56}$Ba		3/2			37B09
$^{137}_{56}$Ba		3/2^E			50A51
$^{137}_{56}$Ba				+0.2^E *1*	60Ka24
$^{137}_{56}$Ba				+0.21 *5*	64Ja11
$^{137}_{56}$Ba				±0.11 *5*	66Co26
$^{137}_{56}$Ba			±0.930 *7*		66Co32
$^{137}_{56}$Ba			$^{137}/_{135}$=1.120 *10*	($^2S_{1/2}$)	67Ke16
			$^{137}/_{135}$=1.144 *54*	($^2P_{1/2}$)	
$^{137}_{56}$Ba				±0.26 *3*	68Be60
				(Using $^{137}/_{135}$=1.54)	
$^{138}_{56}$Ba		0♦			50A51
$^{137}_{57}$La	60ky	7/2	+2.690 *6*	+0.26 *8*	72Fi19
$^{138}_{57}$La	112Gy		+3.702^E *4*	+0.51^E *9*	72Fi14
			$^{138}/_{139}$=0.9328 *8*	$^{138}/_{139}$=2.3 *4*	
$^{139}_{57}$La		7/2			34A02
$^{139}_{57}$La			+2.76		40W08
$^{139}_{57}$La				+0.3 *1*	55L59
$^{139}_{57}$La				+0.21*^{E} *4*	58Mu08
$^{141}_{59}$Pr		5/2			29W01
$^{141}_{59}$Pr			+3.9^c *3*		53B26
					(29W01)
$^{141}_{59}$Pr			+4.0^c *2*		60Mu11
$^{141}_{59}$Pr			+4.09 *6*		65Re03
$^{143}_{60}$Nd		7/2^E	−1.1^E *1*		54M91
$^{145}_{60}$Nd		7/2^E	−0.69^E *10*		54M91
$^{147}_{61}$Pm	2.6y	7/2			60Kl2
$^{147}_{61}$Pm	2.6y	7/2	+2.58 *7*	+0.74 *20*	66Re04
$^{147}_{62}$Sm	0.1Ty	7/2^E	−0.76^E *8*	±≤1	54M15
$^{149}_{62}$Sm		7/2^E	−0.64^E *6*	±≤1	54M15
$^{151}_{63}$Eu		5/2			35S01
$^{151}_{63}$Eu			+3.4	≈+1.2	38S10
$^{151}_{63}$Eu			$^{151}/_{153}$=2.245 *5*		57K51
$^{151}_{63}$Eu			+3.39 *3*		60Kr07
$^{151}_{63}$Eu				+0.95^h *10*	60Kr08
$^{151}_{63}$Eu				±1.16^{gk} *8*	65Mu07
$^{151}_{63}$Eu				+1.15^g *9*	65Wi09
				($^{151}/_{153}$=0.393	60Sa23)
$^{151}_{63}$Eu				±1.12^{Eh} *7*	68Gu02
$^{152}_{63}$Eu	13y			±2.4^i *3*	64Ga12
$^{152}_{63}$Eu	13y		negative	positive	70He09
$^{153}_{63}$Eu		5/2			35S01
$^{153}_{63}$Eu			+1.5	≈+2.5	38S10
$^{153}_{63}$Eu			+1.51 *2*		60Kr07
$^{153}_{63}$Eu				+2.42^h *20*	60Kr08
$^{153}_{63}$Eu				±2.92^{gk} *20*	65Mu07
$^{153}_{63}$Eu				+2.94^g *23*	65Wi09
$^{153}_{63}$Eu				±2.85^{Eh} *18*	68Gu02
$^{154}_{63}$Eu				positive	70He09

Table G: Nuclear Moments by Optical Spectroscopy — Continued

Nucleus	$T_{1/2}$	I	μ or μ^1/μ^2	Q or Q^1/Q^2	Refer.
$^{155}_{64}$Gd		$3/2^{E}$	-0.30^{E} *4*	$+1.1^{E}$ *3*	56S21
$^{155}_{64}$Gd			-0.32^{E} *4*	$+1.6^{E}$	59K10
$^{157}_{64}$Gd		$3/2^{E}$	-0.37^{E} *4*	$+1.0^{E}$ *3*	56S21
$^{157}_{64}$Gd			-0.40^{E} *4*	$+2^{E}$	59K10
$^{159}_{65}$Tb		3/2			34S02
$^{159}_{65}$Tb			positive	+1.26 *12*	65Ar05
$^{159}_{65}$Tb				+1.32 *13*	66Ar18
$^{159}_{65}$Tb				±1.18 *12*	70De05
$^{165}_{67}$Ho		7/2			35S02
$^{165}_{67}$Ho		7/2			57B39
$^{165}_{67}$Ho			+3.7 *7*		58B85
$^{165}_{67}$Ho			$+3.97^{h}$ *5*		68Su04
$^{169}_{69}$Tm		1/2			34S03
$^{169}_{69}$Tm		1/2	−0.205 *20*		55L49
$^{169}_{69}$Tm			-0.25^{c}		60Ca15
$^{171}_{70}$Yb		1/2			38S10
$^{171}_{70}$Yb			+0.45		38S11
$^{171}_{70}$Yb			+0.49 *6*		55K33
			$^{171}/_{173}$=−0.724 *1*		
$^{173}_{70}$Yb		5/2		+3.9 *4*	38S10
$^{173}_{70}$Yb			−0.65		38S11
$^{173}_{70}$Yb		5/2			54K52
$^{173}_{70}$Yb			−0.67 *1*		55K33
$^{173}_{70}$Yb				+2.4	56K42
$^{173}_{70}$Yb				$+2.8*^{E}$ *2*	62Ro26
$^{175}_{71}$Lu		7/2	+1.7	+6.1	35S04
$^{175}_{71}$Lu			+2.6 *5*	+5.9	36G03
$^{175}_{71}$Lu				$+5.7*^{c}$ *3*	55K23
$^{175}_{71}$Lu				$+3.6*^{c}$ *2*	57M96
$^{175}_{71}$Lu			+2.0 *2*	+5.6 *6*	58S134
$^{175}_{71}$Lu			$^{175}/_{176}$=0.711 *5*	$^{175}/_{176}$=0.71 *1*	61Bl07
$^{175}_{71}$Lu				$+5.0^{c}$	62Ko22
					(55K23)
$^{175}_{71}$Lu			±2.24 *11*		67He17
$^{176}_{71}$Lu	20Gy	≥7	+3.8 *7*	+7 *1*	39S14
$^{176}_{71}$Lu	20Gy	6 *1*	+2.8 *3*	+8 *1*	58S134
$^{176}_{71}$Lu	20Gy	7^{E}			59K97
$^{176}_{71}$Lu	20Gy	7^{E}	$+2.8^{E}$ *3*		61Bl07
$^{177}_{72}$Hf		$7/2^{E}$	$^{177}/_{179}$=−1.276 *8*	$^{177}/_{179}$=0.99 *2*	56S22
$^{177}_{72}$Hf			$+0.61^{E}$ *3*	$+3^{E}$ *1*	56S53
$^{178}_{72}$Hf		0♦			35R01
$^{179}_{72}$Hf		$9/2^{E}$			56S22
$^{179}_{72}$Hf			-0.47^{E} *3*	$+3^{E}$ *1*	56S53
$^{180}_{72}$Hf		0♦			35R01
$^{181}_{73}$Ta		7/2			33G02
$^{181}_{73}$Ta		7/2			33M01
$^{181}_{73}$Ta			+2.1		35G01
$^{181}_{73}$Ta				≈+6	43S15

Table G: Nuclear Moments by Optical Spectroscopy — Continued

Nucleus	$T_{1/2}$	I	μ or μ^1/μ^2	Q or Q^1/Q^2	Refer.
$^{181}_{73}Ta$			+1.9	+5.9	52B71
$^{181}_{73}Ta$				+4.3* *4*	55K23
$^{181}_{73}Ta$				+2.7*^{c} *3*	57M96
$^{181}_{73}Ta$			+2.4^c *2*		58Mu08
$^{181}_{73}Ta$				+3.9^c	62Ko22 (55K23)
$^{182}_{74}W$		0♦			34G04
$^{183}_{74}W$		1/2			48K30
$^{183}_{74}W$		1/2^E			50F08
$^{183}_{74}W$			+0.08 *2*		51V06
$^{183}_{74}W$			+0.115		65Gl08
$^{184}_{74}W$		0♦			34G04
$^{186}_{74}W$		0♦			34G04
$^{185}_{75}Re$		5/2			31M01
$^{185}_{75}Re$		5/2			31Z01
$^{185}_{75}Re$			$^{187}/_{185}$=1.0108 *4*	+2.6	37S12
$^{185}_{75}Re$			+3.3		38S09
$^{185}_{75}Re$				≈+2.9	65Ho06
$^{185}_{75}Re$				±2.3^E *9* $^{187}/_{185}$=0.95 *4*	66Ku07
$^{185}_{75}Re$				±2.36 *50*	69Kr07
$^{186}_{75}Re$	90h		±1.38 *45*		64Wi09, 65Sc13
$^{187}_{75}Re$	60Gy	5/2			31M01
$^{187}_{75}Re$	60Gy	5/2			31Z01
$^{187}_{75}Re$	60Gy			+2.6	37S12
$^{187}_{75}Re$	60Gy		+3.3		38S09
$^{187}_{75}Re$	60Gy			≈+2.9	65Ho06
$^{187}_{75}Re$	60Gy			±2.2^E *9*	66Ku07
$^{187}_{75}Re$	60Gy			±2.24 *50*	69Kr07
$^{188}_{75}Re$	17h		±1.41 *45*		64Wi09, 65Sc13
$^{187}_{76}Os$		1/2	positive		55M45
$^{187}_{76}Os$		1/2	+0.0658 *11*		61Gu08
$^{187}_{76}Os$			+0.0662 *6*		62Mu04
$^{189}_{76}Os$		3/2	+0.70 *9*	+2.0 *8*	52M40
$^{189}_{76}Os$		3/2			58B159
$^{189}_{76}Os$				+0.8^c	62Ko22 (57M96)
$^{189}_{76}Os$				+0.8* *2*	62Mu04
$^{189}_{76}Os$			+0.792		65Gl08
$^{189}_{76}Os$				±0.91^E *10*	68Hi04
$^{191}_{77}Ir$		3/2	positive		50B75
$^{191}_{77}Ir$		3/2	+0.16 *3*	+1.2 *6*	52M40
$^{191}_{77}Ir$		3/2	+0.2 *1*	+1.5 *1*	53S61
$^{193}_{77}Ir$		3/2			35V01
$^{193}_{77}Ir$		3/2	positive		50B75
$^{193}_{77}Ir$		3/2	+0.17 *3*	+1.0 *5*	52M40
$^{193}_{77}Ir$		3/2	+0.2 *1*	+1.5 *1*	53S61
$^{194}_{78}Pt$		0♦			35F06
$^{195}_{78}Pt$		1/2			36J01
$^{195}_{78}Pt$			+0.6		36S08
$^{195}_{78}Pt$		1/2			37T03
$^{196}_{78}Pt$		0♦			35F06

Table G: Nuclear Moments by Optical Spectroscopy — Continued

Nucleus	$T_{1/2}$	I	μ or μ^1/μ^2	Q or Q^1/Q^2	Refer.
$^{197}_{79}$Au		3/2	+0.195 *4*		39E03
$^{197}_{79}$Au			+0.136 *8*		52K07
$^{197}_{79}$Au			+0.14 *2*	+0.56 *10*	53S60
$^{197}_{79}$Au				±0.58^1 *1*	66Ac02
$^{197}_{79}$Au				±0.54^1 *2*	66Ha43
$^{193}_{80}$Hg	6h	3/2	−0.613 *20*		64Kl01
$^{193}_{80}$Hg	6h	3/2		−1.8 *10*	66Da07
$^{193m}_{80}$Hg	11h	13/2	−1.06	+1.2 *3*	64To05
				$^{193m}/_{201}$=2.74 *54*	
$^{193m}_{80}$Hg	11h	13/2			66Da07
$^{195}_{80}$Hg	9.5h		+0.526 *5*		63Kl03
$^{195}_{80}$Hg	9.5h	1/2	+0.54		64To05
$^{195m}_{80}$Hg	40h		−1.060 *10*	+1.5 *10*	63Kl03
$^{195m}_{80}$Hg	40h	13/2	−1.05	+1.3 *6*	64To05
				$^{195m}/_{201}$=2.81 *4*	
$^{197}_{80}$Hg	65h	1/2	+0.52 *1*		54B92
$^{197m}_{80}$Hg	24h	13/2	−1.04 *1*	+1.5 *3*	59M82
$^{198}_{80}$Hg		0♦			31S03
$^{198}_{80}$Hg		0♦			31T01
$^{199}_{80}$Hg		1/2			31S03
$^{199}_{80}$Hg			±0.547 *2*		40M10
$^{199}_{80}$Hg			+0.532		57Bl10
$^{199}_{80}$Hg			+0.51		61Ag3
$^{199}_{80}$Hg			+0.454		63Sc34
$^{199}_{80}$Hg			±0.506 *3*		67Dr09
$^{200}_{80}$Hg		0♦			31S03
$^{200}_{80}$Hg		0♦			31T01
$^{201}_{80}$Hg		3/2			31S03
$^{201}_{80}$Hg		3/2	−0.6	+0.5	35S04
$^{201}_{80}$Hg			±0.607		40M10
$^{201}_{80}$Hg				+0.47 *3*	59C34
$^{201}_{80}$Hg			−0.5582 *8*		60Ra27
			$^{201}/_{199}$=1.1090 *7*		
$^{201}_{80}$Hg			−0.504	+0.49	63Sc34
$^{201}_{80}$Hg				+0.45	65Mu15
				+0.41*	
$^{202}_{80}$Hg		0♦			31S03
$^{202}_{80}$Hg		0♦			31T01
$^{203}_{80}$Hg	47d	5/2	+0.830 *20*	±0.5 *8*	64Re03
$^{204}_{80}$Hg		0♦			31S03
$^{204}_{80}$Hg		0♦			31T01
$^{195}_{81}$Tl	1.2h		+1.56 *4*		69Go21
$^{197}_{81}$Tl	2.8h		+1.55 *2*		66Da15
$^{199}_{81}$Tl	7.4h		+1.57		61Hu04
$^{200}_{81}$Tl	26h		±≤0.15		61Hu04
$^{201}_{81}$Tl	72h		+1.58		61Hu04
$^{202}_{81}$Tl	12d		±≤0.15		61Hu04
$^{203}_{81}$Tl		1/2			31S02
$^{203}_{81}$Tl		1/2			32J02
$^{205}_{81}$Tl		1/2			31S02
$^{205}_{81}$Tl		1/2			32J02
$^{205}_{81}$Tl			$^{205}/_{203}$=1.00966 *46*		37S12
$^{203}_{81}$Tl			$^{205}/_{203}$=1.0089 *10*		60Od02

Table G: Nuclear Moments by Optical Spectroscopy — Continued

Nucleus	$T_{1/2}$	I	μ or μ^1/μ^2	Q or Q^1/Q^2	Refer.
$^{206}_{82}$Pb		0♦			31M02
$^{206}_{82}$Pb		0♦			32K01
$^{207}_{82}$Pb		1/2			31M02
$^{207}_{82}$Pb		1/2			32K01
$^{208}_{82}$Pb		0♦			31M02
$^{208}_{82}$Pb		0♦			32K01
$^{206}_{83}$Bi	6.3d		+4.50		69Ma43
			$^{206}/_{209}$=+1.104		
$^{209}_{83}$Bi	>2Ay	9/2			28B01
$^{209}_{83}$Bi	>2Ay	9/2	+3.6	−0.4	35S04
$^{209}_{83}$Bi	>2Ay		+4.10 *8*		50K59
$^{209}_{83}$Bi	>2Ay			−0.37 *4*	67Di04
$^{209}_{83}$Bi	>2Ay			−0.379[b] *15*	68Ei04
$^{209}_{83}$Bi	>2Ay		+4.23[n] *10*	−0.4[h] *1*	70Cr01
			+3.7[hp] *5*	−0.79[p] to −20[p]	
$^{209}_{83}$Bi	>2Ay			−0.41 *4*	70Ge10
$^{209}_{84}$Po	103y	1/2			55V16
$^{209}_{84}$Po	103y		+0.77[d]		66Ch27
$^{227}_{89}$Ac	22y	3/2			51T19
$^{227}_{89}$Ac	22y		+1.1 *1*	+1.7 *2*	55F26
$^{229}_{90}$Th	7.3ky	5/2	+0.41 *10*	≈4.6	64Eg01
$^{229}_{90}$Th	7.3ky	5/2	+0.34 *7*		64To02
$^{231}_{91}$Pa	34ky	3/2			34S04
$^{231}_{91}$Pa	34ky	3/2			61Ri06
$^{233}_{92}$U	162ky	5/2	positive	large	54V01
$^{233}_{92}$U	162ky	5/2	$^{233}/_{235}$≈−1.5		55K36
$^{233}_{92}$U	162ky	5/2	$^{233}/_{235}$=−1.6 *1*	$^{233}/_{235}$=+0.8 *3*	56K53
$^{233}_{92}$U	162ky		positive	positive	56V27
			$^{233}/_{235}$=−1.6	$^{233}/_{235}$=+0.80	
$^{233}_{92}$U	162ky	5/2		+13 *5*	56Z05
$^{233}_{92}$U	162ky		±0.74	±7.9	69Ba52,
					69Be29
$^{233}_{92}$U	162ky		(±0.74)	±4.9	compilers
			(using		
			μ/Q=0.152 *15*		57D40)
$^{235}_{92}$U	710My	7/2			55V07
$^{235}_{92}$U	710My	7/2			56K53
$^{235}_{92}$U	710My	7/2	$^{233}/_{235}$=−1.5	$^{233}/_{235}$=+0.7	57B66
$^{237}_{93}$Np	2.1My	5/2			48T08
$^{239}_{94}$Pu	24ky	1/2			54V06
$^{239}_{94}$Pu	24ky	1/2			55K36
$^{239}_{94}$Pu	24ky	1/2			55K40
$^{239}_{94}$Pu	24ky		+0.27 *6*		60Ch09
$^{239}_{94}$Pu	24ky		+0.21 *6*		62Ge11
$^{239}_{94}$Pu	24ky				63Be16
			±0.207[j] *33* or		(62Ge11)
			±0.175[j] *40*		(62Ko08)
$^{239}_{94}$Pu	24ky		+0.17 *4*		64Ba10
$^{239}_{94}$Pu	24ky		+0.19 *5*		66Ko24

Table G: Nuclear Moments by Optical Spectroscopy — Continued

Nucleus	$T_{1/2}$	I	μ or μ^1/μ^2	Q or Q^1/Q^2	Refer.
$^{241}_{94}$Pu	13y		±0.73 *12* or ±0.62 *15* ($^{241}/_{239}$=3.53 *2*		63Be16 54B72)
$^{241}_{94}$Pu	13y			+5.6 *2*	64Ch10
$^{241}_{94}$Pu	13y		−0.673^E *15* $^{241}/_{239}$=−3.365 *20*		69Ge04
$^{241}_{95}$Am	460y	5/2			53F01
$^{241}_{95}$Am	460y	5/2		large	56T18
$^{241}_{95}$Am	460y		+1.4 *3*	+4.9	56M31
$^{241}_{95}$Am	460y		$^{241}/_{243}$=1.008		57F53
$^{243}_{95}$Am	8ky	5/2	$^{241}/_{243}$=1.00 *2*		54C19
$^{243}_{95}$Am	8ky		+1.4 *3*	+4.9	56M31
$^{249}_{97}$Bk	314d	7/2			67Wo01
$^{249}_{97}$Bk	314d		±5.1 *7*	±4.7 *10*	69Wo07, 70Co34
$^{253}_{99}$Es	20d	≥7/2			68Wo07
$^{253}_{99}$Es	20d	7/2	+5.1 *13*	±5.1 *10*	70Wo14, 70Co34

* Polarization or Sternheimer correction included
♦ No hyperfine structure observed
[a] Polarization of resonance radiation
[b] Band spectra studied
[c] Recalculation of earlier data
[d] Reexamined spectra of 55V16
[E] Enriched sample
[f] ^{113}In−lines apparently coincident with ^{115}In−lines. Therefore, moments are believed to be the same. Lines 2% as intense as ^{115}In−lines should have been observed
[g] From I−spectra
[h] From II−spectra
[i] Q obtained from deformation which was estimated from isotope shifts
[j] Calculated from data on ionization potentials
[k] Average value of Q's determined for several states
[l] From μ−atom hyperfine structure
[m] Excited state
[n] From III−spectra
[p] From IV−spectra
[q] LASER
[r] From μ−atom nuclear transition

Table H: Nuclear Moments by Optical Double Resonance and Pumping Techniques

Introduction

In this table, data obtained by several methods involving combinations of optical spectroscopy and magnetic resonance have been collected. Some values obtained from measurements combining optical pumping and nuclear magnetic resonance are tabulated here as well as in Table E.

The possibility of using optical radiation to alter the populations of atomic states in order to study hyperfine structure by magnetic resonance techniques was first discussed in a paper by Brossel and Kastler [49Br65] and later treated more fully in a paper by Kastler [50Ka16].

Most of the optical resonance methods involve three basic features: (1) excitation of an atom from the ground state to a metastable state by resonance radiation to increase the population of certain magnetic substates by choice of appropriate frequency and polarization; (2) observation of radiation either transmitted or scattered at right angles; and (3) application of an oscillating rf or microwave magnetic field to induce a transition between substates, altering their relative populations with a subsequent change in the polarization, frequency, or intensity of the observed radiation.

A schematic diagram of a typical experimental arrangement is shown in figure 1. Light originates in a resonance lamp S. It is focused by lens L and polarized by screen P. The gas in the vessel absorbs and re–emits the resonance radiation. Photocells at the positions PC_1 and PC_2 serve to measure the transmitted or scattered light, respectively. A uniform magnetic field can be applied by a pair of Helmholtz coils and an oscillating magnetic field by coils rf.

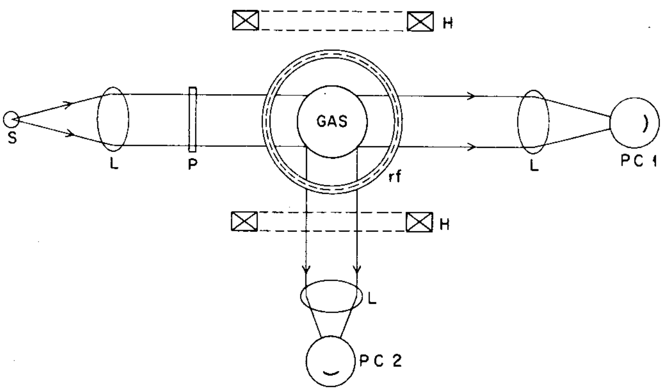

FIGURE 1. One possible arrangement of components of an optical double resonance experiment. Screen P can be used to polarize the resonance radiation from the source S. Photocells PC_1 and PC_2 respond to the transmitted and scattered light, respectively. The Helmholtz coils H produce a magnetic field along the axis of the scattered light, and the rf coils, an oscillating magnetic field perpendicular to the incident and scattered radiation.

One of the first such double resonance experiments was performed by Brossel and Bitter with Hg. The energy levels of the $^1S_0$ and $^3P_1$ states of the even isotopes are shown in figure 2. Absorption of incident plane–polarized, $\pi(\Delta m_J=0)$, resonance radiation of 2537 Å populates the $^3P_1$, $m_J=0$ substate. Application of an oscillating field at resonance frequency, inducing the $\Delta m_J=\pm1$ transitions, will make the circularly polarized, $\sigma(\Delta m_J=\pm1)$, lines appear in the scattered radiation.

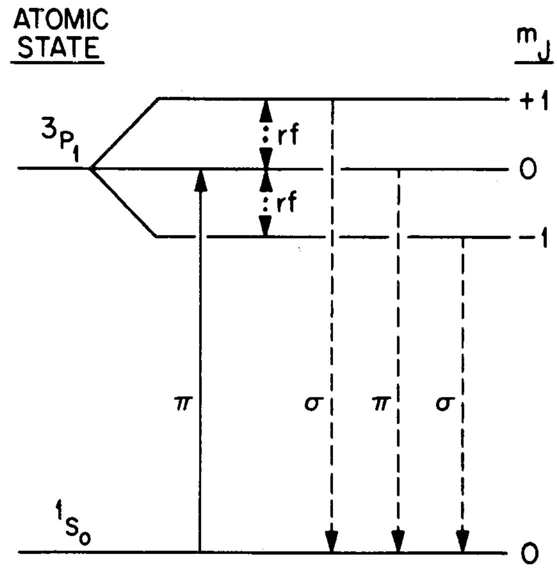

FIGURE 2. An energy level diagram for an even isotope of Hg showing transitions involved in a typical optical double resonance experiment. The levels shown are the $^1S_0$ and $^3P_1$ states as split by a magnetic field. The solid arrow indicates the optical absorption process while the broken arrows represent possible emission processes. Dotted arrows represent the induced rf transitions.

The optical pumping type of experiment is illustrated by the diagram for ^{199}Hg in figure 3. Absorption of incident, circularly polarized, $\sigma^+(\Delta m_F=+1)$, radiation of the appropriate energy selectively populates the $^3P_1$, $F=^1/_2$, $m_F=+^1/_2$ level which decays by π and σ emission to the $+^1/_2$ and $-^1/_2$ ground substates, respectively. Since the $m_F=+^1/_2$ state cannot absorb the σ^+ radiation, the $-^1/_2$ state is gradually depleted and the atoms are "pumped" into the upper state. When the atoms have been oriented in this manner, the application of an rf field to induce the $+^1/_2\rightarrow-^1/_2$ transition in the ground state will produce an increase in the absorption and scattering of the σ^+ light.

In a variation of the optical pumping method, a mixture of two gases or vapors is used. If one of these is optically oriented, it is found that the second gas will become oriented by collisions with the atoms of the first gas by means of a spin–exchange process. A magnetic resonance experiment per-

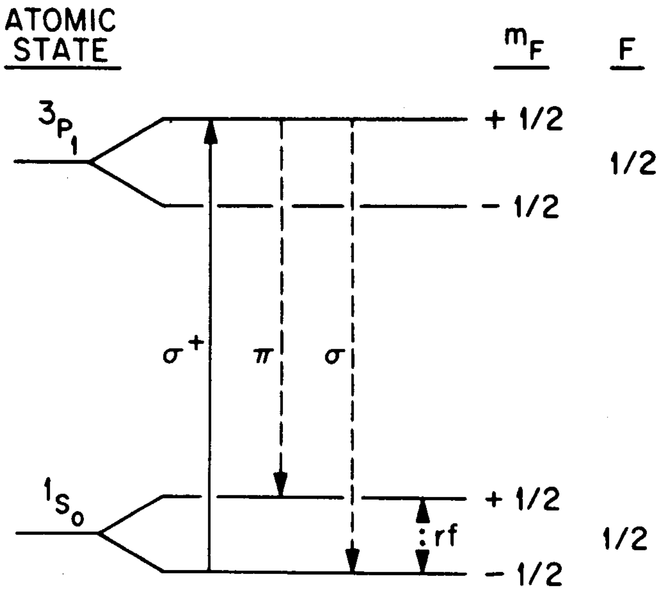

FIGURE 3. An energy level diagram showing the transitions involved in a typical optical pumping experiment. The levels shown are the $^1S_0$ and $^3P_1$, $F=1/2$, states of $^{199}Hg(I=1/2)$. The solid arrow represents the absorption process while the broken arrows represent the two possible emission processes. The dotted arrow represents the induced rf transition. Transitions to the $F=3/2$ state are not shown.

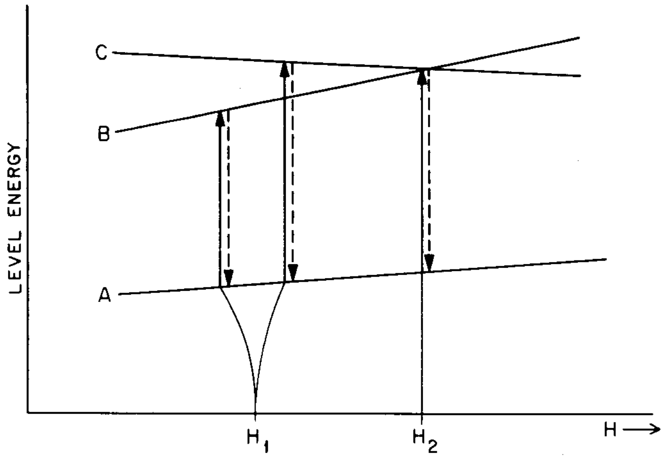

FIGURE 4. Diagram of the transitions in a level crossing experiment. Curves A, B, and C show the field dependence of the energies for the ground-state level A and two excited states B and C. Solid arrows indicate induced transitions; dashed arrows, the emitted radiation.

formed on the second gas results in a disorientation of the first gas. The existence of the resonance for the second gas is then observed as a change in the transmission of the resonant radiation for the first gas.

In level crossing experiments, the vapor or gas is illuminated while in a homgeneous but variable magnetic field. When the magnetic field is adjusted to a value for which two levels cross, a change in the angular distribution of the resonant radiation can be observed depending on the nature of the radiation used and the m_F-values of the levels. At a field such as H_1, figure 4, the resonant radiation will be made up of the transitions CA or BA. when the levels cross or approach degeneracy (a level separation less than the natural line–width) such as at field H_2, figure 4, the scattering is from a single state, made up of a combination of the two interfering levels, and there is a change in the scattering amplitudes. Since in this type of experiment no rf or microwave radiation is needed to induce transitions between the sublevels because the energy difference of the levels is zero, it has been called a double resonance experiment at zero frequency. This technique was first used by Colegrove *et al.* [59Co92] to measure the fine–structure separation of the $^3P_1$ and $^3P_2$ levels in helium. Additional information on the interference or coherence effects in resonance fluorescence can be found in papers by Franken [61Fr11] and by Rose and Carovillano [61Ro32].

In these experiments the interaction constants and hyperfine–structure splittings for the atomic states can be found from the energy differences (determined by the frequencies of the applied rf fields) of the hyperfine levels if transitions can be induced between them at known fields. A simple discussion of the energies of the atomic levels and the calculation of the nuclear moments from the hyperfine constants can be found in the Introduction to Table F: Nuclear Moments by Atomic and Molecular Beams.

There are many variations of double resonance techniques. In some experiments, electron bombardment is used to excite the atoms; in others, variable Zeeman scanning is used to alter the energy of the radiation emitted by the source. General discussions of optical orientation and its applications can be found in papers by Bell and Bloom [57Be36], Kopfermann [60Ko20], Dodd and Series [61Do10], Skrotskii and Izyumova [61Sk3], Bitter [62Bi21], Cohen–Tannoudji and Kastler [66Co42], and Budick [67Bu26]; as well as in the papers already referred to.

The last systematic literature search for the information included in the table was in early 1971.

Explanation of Table H

Nucleus	Chemical symbol with Z– and A–numbers States, other than ground states, are designated by "m" following the A–number.
$T_{1/2}$	Half–life of radioactive nucleus
I	Nuclear spin, in units of $h/2\pi$
μ	Nuclear magnetic dipole moment, in nuclear magnetons, given with diamagnetic correction. See Policies, Diamagnetic corrections, for factors used A 5% uncertainty in the diamagnetic correction is assumed. Values of μ, which are calculated from $\Delta\nu$– or a–ratios, do not include a hyperfine–structure anomaly correction. This correction can be of the order of 0.001% to 1%. See [70FuCo].
Q	Nuclear electric quadrupole moment, in barns, as given by the experimenter Values marked by an asterisk, *, indicate that the experimenter has made some polarization or Sternheimer corrections in computing the moment.
Method	Symbols used to designate the various techniques are as follows: DR Optical double resonance EI Electron impact LX Level crossing OP Optical pumping SE Spin exchange
Refer.	Reference key
Atomic State:	Atomic state for which the hyperfine–structure splitting and interaction constants are listed
F,F'	Total angular momentum quantum numbers which characterize hyperfine levels of the atomic state at zero magnetic field
$\Delta\nu(F,F')$	Zero–field hyperfine–structure splitting between levels of total spin F and F', given without sign Values are given in MHz unless otherwise noted
Interaction Constants	Values of the interaction constants as given by the experimenter Values are given in MHz unless otherwise noted. See Introduction to Table F for discussion of interaction constants.

Table H: Nuclear Moments by Optical Double Resonance and Pumping Techniques

Nucleus	$T_{1/2}$	I	μ	Q	Method Refer.	Atomic State F,F'	$\Delta\nu(F,F')$	Interaction Constants
$^{1}_{1}H$					SE 62Pi04	$^2S_{1/2}$:1,0	1420.405738 *6*	
$^{2}_{1}H$					SE 60An13	$^2S_{1/2}$:$^3/_2$,$^1/_2$	327.384347 *5*	
$^{2}_{1}H$					OP 68Ha24	$^2S_{1/2}$:$^3/_2$,$^1/_2$	327.3843526 *12*	
$^{2}_{1}H$					SE 69La29	$^2S_{1/2}$:$^3/_2$,$^1/_2$	327.38435251 *5*	
$^{3}_{1}H$	12y				SE 62Pi04	$^2S_{1/2}$:1,0	1516.701464 *6*	
$^{3}_{2}He$					LX 66Ge06	2^3P		a=−4283.5
$^{3}_{2}He$					EI 69Jo27	3^3P:J=1,F=$^3/_2$↔ J=2,F=$^3/_2$	6058	
$^{3}_{2}He$					OP 70Ro16	2^3S_1:$^3/_2$,$^1/_2$	6739.701177 *16*	
$^{3}_{2}He^{+}$					SE 69Sc26	$^2S_{1/2}$:1,0	8665.649867 *10*	
$^{6}_{3}Li$					DR 65Ri03	$2^2P_{1/2}$:$^3/_2$,$^1/_2$	26.0 *3*	a=17.3 *2*
$^{6}_{3}Li$					SE 69Wr01	$^2S_{1/2}$:$^3/_2$,$^1/_2$	228.205261[i] *12*	in He,Ne,Ar
$^{6}_{3}Li^{+}$					EI 69Ad11	2^3P_1:2,1	2880 *5*	
$^{7}_{3}Li$					DR 65Ri03	$2^2P_{1/2}$:2,1	93.3 *10*	a=46.65 *50*
$^{7}_{3}Li$				−0.03 *2*	LX 67Br05	$2^2P_{3/2}$		a=−3.40 *23* b=−0.18 *12*
$^{7}_{3}Li$				−0.039*[c] *26*	LX 69Ly05	$2^2P_{3/2}$		
$^{7}_{3}Li$				−0.0117**123*	LX 69Is05	$3^2P_{3/2}$		a=−0.965 *20* b=−0.019 *22*
$^{7}_{3}Li$					SE 69Wr01	$^2S_{1/2}$:1,0	803.504094[i] *25*	in He, Ne, Ar
$^{7}_{3}Li$				+0.00073[c] −0.0013*[c]	LX 71Am02	$3^2P_{3/2}$		
$^{7}_{3}Li$					LX 71Ha70	$2^2P_{3/2}$ $3^2P_{3/2}$		a=−3.01 *5* a=−0.98 *4* b=−0.09 *1*
$^{8}_{3}Li$	0.85s	2	±1.653[j]		SE 71Ot04	$^2S_{1/2}$:$^5/_2$,$^3/_2$	382.542[j] *15*	
$^{14}_{7}N$					SE 59An34	$^4S_{3/2}$:$^5/_2$,$^3/_2$ $^3/_2$,$^1/_2$	26.12721 *18* 15.67646 *12*	a=+10.45091 *7* b=−0.00005 *8*
$^{14}_{7}N$					SE 62Ho17	$^4S_{3/2}$:$^5/_2$,$^3/_2$ $^3/_2$,$^1/_2$	26.127288[i] *40* 15.676390[i] *40*	a=10.450925[f] *20* b=7[f] *20*Hz
$^{14}_{7}N$					SE 70We11	^4S		a=10.4509294[i] *18* b=1.3‡5Hz
							‡b is independent of T and P	
$^{15}_{7}N$					SE 59An34	$^4S_{3/2}$:2,1	29.29136 *16*	a=−14.64568 *8*
$^{15}_{7}N$					SE 62Ho17	$^4S_{3/2}$:2,1	29.290902[i] *40*	a=14.645441[f] *20*
$^{15}_{7}N$					SE 62La1	$^4S_{3/2}$:2,1	29.290913 *15*	
$^{20}_{11}Na$	408ms	2	±0.3694[j] *10*		SE 70Bo47 71Ot04	$^2S_{1/2}$:$^5/_2$,$^3/_2$	276.6[j] *3*	^{20}Ne(d,)
$^{21}_{11}Na$	23s	3/2	±2.46[j] *8*		SE 69Ko10 71Ot04			^{20}Ne(d,)
$^{23}_{11}Na$				+0.10 *6*	DR 54S34	$^2P_{3/2}$:3,2 2,1	61 *2* 36.6 *20*	a=19.5 *6* b=2.4 *14*
$^{23}_{11}Na$					OP 58A06	$^2S_{1/2}$:2,1	1771.6262 *1*	
$^{23}_{11}Na$				+0.13 *4*	DR 58K69			
$^{23}_{11}Na$					DR 60Ar9	$^2D_{5/2}$		a<0.33
$^{23}_{11}Na$				+0.097 *13*	DR 60Do1	$3^2P_{3/2}$		a=18.5 *6* b=2.25 *40*, $b/a>0$
$^{23}_{11}Na$				±0.146[b] *20* ±0.145 *17*	DR 66Ac01	$3^2P_{3/2}$ (using $a(P_{1/2})$ and b)		a=18.7 *4* b=3.4 *4*
$^{23}_{11}Na$				±0.138[b] *25*	DR 66Ba20	$3^2P_{3/2}$		$a=18.5^{+6}_{-2}$ b=3.2 *5*
$^{23}_{11}Na$					LX 68Co21	$3^2P_{3/2}$		a=18.5 *4* b=3.0 *6*

Table H: Nuclear Moments by Optical Double Resonance and Pumping Techniques – Con.

Nucleus	$T_{1/2}$	I	μ	Q	Method Refer.	Atomic State F,F'	$\Delta\nu(F,F')$	Interaction Constants
$^{23}_{11}$Na					OP 68Ma57	$^2S_{1/2}$:2,1	1771.626150[p] *50*	
$^{23}_{11}$Na				±0.121[b] *14*	LX 68Sc12	$3^2P_{3/2}$		a=18.65 *10*
				±0.097*				b=2.82 *30*
				±0.114[b] *12*	LX	$4^2P_{3/2}$		a=6.006‡ *30*
				±0.095*				b=0.86‡ *9*
							‡Assumed g_J=1.334	
$^{23}_{11}$Na				+0.124[b] *15*	LX 69Ba27	$3^2P_{3/2}$		a=18.80‡ *15*
								b=2.9‡ *3*
							‡Assumed g_J=1.3344 *4*	
$^{23}_{11}$Na					DR 70Ha59	$3^2P_{1/2}$		a=94.3 *2*
$^{23}_{11}$Na				±0.109*[b] *3*	LX 70Ma32	$3^2P_{3/2}$		a=19.74 *5*
								b=3.34 *4*
$^{23}_{11}$Na				±0.095[b] *20*	LX 70Sc33	$3^2P_{3/2}$		a=18.9 *3*
								b=2.4 *3*
						$4^2P_{3/2}$		a=6.2 *2*
								b=1.0 *1*
$^{23}_{11}$Na				±0.102*[c] *12*	LX 71St12	$3^2P_{3/2}$		
				±0.100*[c] *11*	(68Sc12)	$4^2P_{3/2}$		
$^{27}_{13}$Al					LX 66Bu15	$^2D_{5/2}$		a=182.1 *15*
								b=13.1 *30*, $b/a<0$
$^{27}_{13}$Al					LX 70St26	$^2D_{5/2}$		a=204‡ *3*
							‡For g_J=1.2	$\|b/a\|\leq0.2$
						$^2D_{3/2}$		a=72‡ *8*
							‡For g_J=0.8	$\|b/a\|\leq0.3$
$^{31}_{15}$P					SE 62La26	$^4S_{3/2}$		a=+55.055691[i] *8*
$^{31}_{15}$P					64Be42	$^4S_{3/2}$	expect $a<0$, unless exchange polarization model breaks down	
$^{36}_{19}$K	245ms	2	±0.548[j] *3*		SE 73Sc36			^{36}Ar(p,)
$^{37}_{19}$K	1.2s	3/2	+0.20320 *6*		SE 71Vo03	$^2S_{1/2}$:2,1	240.2672 *7*	^{36}Ar(d,)
$^{39}_{19}$K			+0.40 *2*	+0.11 *2*	DR 57R37	$5^2P_{3/2}$		a=1.97 *1*
								b=1.7 *3*, $b/a>0$
$^{39}_{19}$K					OP 60Bl15	$^2S_{1/2}$:2,1	461.719690 *30*	
$^{39}_{19}$K					DR 61Fo11	$5^2P_{1/2}$		a=8.99 *15*
$^{39}_{19}$K				±0.056[p] *22*	LX 67Ba64			
$^{39}_{19}$K					LX 68Sc09	$4^2P_{3/2}$		a=6.0 *1*
								b=2.9 *2*
				±0.053* *8*		$5^2P_{3/2}$		a=1.95 *5*
				±0.057 *4*				b=0.92 *10*
$^{39}_{19}$K				±0.0625[b] *24*	LX 69Ne03	$4^2P_{3/2}$		a=6.13 *5*
								b=2.72 *12*
				±0.061[b] *14*		$5^2P_{3/2}$		a=1.97 *2*
								b=0.85 *3*
$^{39}_{19}$K				+0.053*[c]	LX 70Fi17	$4^2P_{3/2}$		
				+0.053*[c]	(69Ne03)	$5^2P_{3/2}$		
$^{39}_{19}$K					DR 71Ch61	$6^2S_{1/2}$:2,1	45.8 *2*	
$^{39}_{19}$K				+0.049*[c] *4*	LX 71St12 (68Sc09)			
$^{40}_{19}$K	1.3Gy			−0.093[E] *25*	DR 62Bu10	$5^2P_{3/2}$: $^{11}/_2$, $^9/_2$	7.68 *30*	a=−2.45 *5*
				−0.078[El] *25*		$^7/_2$, $^5/_2$	14.38 *12*	b=−1.31 *33*
$^{40}_{19}$K	1.3Gy			−0.07*[bE]	LX 68Ne05	$4^2P_{3/2}$		a=−7.59 *6*
								b=−3.5 *5*
						$5^2P_{3/2}$		a=−2.45 *2*
								b=−1.1 *2*

Table H: Nuclear Moments by Optical Double Resonance and Pumping Techniques— Con.

Nucleus	$T_{1/2}$	I	μ	Q	Method Refer.	Atomic State F,F'	$\Delta\nu(F,F')$	Interaction Constants
$^{40}_{19}$K	1.3Gy			$-0.068*^{c}$	LX 70Fi17	$4^2P_{3/2}$		
				$-0.069*^{c}$	(68Ne05)	$5^2P_{3/2}$		
$^{40}_{19}$K	1.3Gy			$-0.067*^{c}$ *10*	LX 71St12	$4^2P_{3/2}$		
				$-0.067*^{c}$ *12*	(68Ne05)	$5^2P_{3/2}$		
$^{41}_{19}$K					OP 60Bl15	$^2S_{1/2}$:2,1	254.013870 *35*	
$^{41}_{19}$K				$\pm0.0761^{b}$ *36*	LX 69Ne03	$4^2P_{3/2}$		a=3.40 *8*
								b=3.34 *24*
				$\pm0.0760^{b}$ *15*		$5^2P_{3/2}$		a=1.08 *2*
								b=1.06 *4*
$^{41}_{19}$K				$+0.065*^{c}$‡	LX 70Fi17		‡Using Q^{41}/Q^{39}=1.2173	
$^{41}_{19}$K				$+0.060*^{c}$‡ *5*	LX 71St12		‡Using Q^{41}/Q^{39}=1.2173	
$^{43}_{20}$Ca				<±0.23	LX 69Kl03	$^1P_1$		a=−15.3 *4*
								b<±12
$^{53}_{24}$Cr					DR 66Bu01	$^7P_4(3d^54p)$		a=11.60 *15*
						$^7P_3(3d^54p)$		a≤1.5 *20*
						$^7P_2(3d^54p)$		a=26.16 *10*
						$^7P_3(3d^44s4p)$		a=70.4 *26*
$^{55}_{25}$Mn				±0.40 *2*	LX 69Ha22	$z^6P_{7/2}$		a=429.059^{f} *43*
								b=63.86^{f} *90*
								c=0.030^{f} *59*
						$z^6P_{5/2}$		a=467.410^{f} *13*
								b=−73.46^{f} *19*
								c=−0.029^{f} *26*
						$z^6P_{3/2}$		a=571.85 *80*
								b=11.5 *56*
$^{55}_{25}$Mn					SE 71Da36	$^6S_{5/2}$		a=−72.420836^{p} *15*
								b=−19031^{p} *17*Hz
								c=−0.7^{p} *10*Hz
								d<0.25; e<0.02Hz
$^{63}_{29}$Cu				negative	LX 66Bu14	$^2P_{3/2}$		a=195 *2*
								b=41 *8*, b/a<0
$^{63}_{29}$Cu					LX 66Ne05	$^2P_{3/2}$		a=+194.72 *15*
				−0.25		(using a($^2P_{1/2}$) and b)		b=−28.8 *6*
$^{63}_{29}$Cu					LX 67Bu10	$^4P_{3/2}$		a=+2140.0 *23*
								b=−37.9 *2*
$^{63}_{29}$Cu				−0.315‡ *12*	LX 68Bu16	$^2P_{3/2}$		a=195.23 *25*
				−0.235† *10*				b=28.75 *70*
								b/a<0
							‡Used $<r^{-3}>=1.29a_o^{-3}$	
							†From D-levels, with corrections	
$^{63}_{29}$Cu				$-0.211*^{cl}$ *4*	69St24			
$^{63}_{29}$Cu				−0.210*‡ *4*	LX 70Fi17		‡Using Q^{63}/Q^{65}=1.0805	
$^{65}_{29}$Cu					LX 66Bu14	$^2P_{3/2}$		a=210 *2*
								b=35 *8*, b/a<0
$^{65}_{29}$Cu					LX 66Ne05	$^2P_{3/2}$		a=+208.57 *15*
				−0.22		(using a($^2P_{1/2}$) and b)		b=−25.9 *6*
$^{65}_{29}$Cu					LX 67Bu10	$^4P_{3/2}$		a=+2292.3 *25*
								b=−35.0 *2*
$^{65}_{29}$Cu				-0.161^{c} *3*	67St29	$^2D_{5/2}$		
				or $-0.196*^{c}$ *4*	(67Fi02)	(atomic spectra)		
				-0.228^{c} *5*	(LX 67Bu10)	$^2P_{3/2}$		
				or $-0.194*^{c}$ *4*				
				ave −0.195* *4*				
$^{65}_{29}$Cu				$-0.194*^{c}$ *4*	LX 70Fi17	$4^2P_{3/2}$		
					(66Ne05)			

Table H: Nuclear Moments by Optical Double Resonance and Pumping Techniques – Con.

Nucleus	$T_{1/2}$	I	μ	Q	Method Refer.	Atomic State F,F'	$\Delta\nu(F,F')$	Interaction Constants
$^{63}_{30}$Zn	38m	3/2	−0.28156* *5*	+0.29[l] *3*	DR 69La05	$^3P_1$		a=−326.57[f] *4* b=−34.46[f] *3* Q^{63}/Q^{67}=1.8347 *13*
$^{65}_{30}$Zn	245d	5/2	+0.7692 *2*	−0.024 *2*	DR 64By01	$^3P_1$:$^7/_2$,$^5/_2$ $^5/_2$,$^3/_2$	1875.475 *6* 1334.123 *6*	a=+535.163[f] *2* b=+2.870[f] *5* Q^{65}/Q^{67}=−0.1528 *3*
$^{65}_{30}$Zn	245d				LX 64La08	$^3P_1$		b=+2.867[f]‡ *12* Q^{65}/Q^{67}=−0.1527 *8*
							‡Used a–value of 64By01	
$^{67}_{30}$Zn				+0.18 *2*	DR 57Bl10	$^3P_1$:$^7/_2$,$^5/_2$ $^5/_2$,$^3/_2$	2111.13 *12* 1551.54 *10*	a=608.99 *5* b=−19.37 *9*
$^{67}_{30}$Zn					DR 62Lu04	$^3P_1$		a=609.15[cf] b=−18.8[cf]
$^{67}_{30}$Zn					DR 64By01	$^3P_1$:$^7/_2$,$^5/_2$ $^5/_2$,$^3/_2$	2111.300 *3* 1551.565 *4*	a=609.086[f] *2* b=−18.782[f] *8*
$^{67}_{30}$Zn					LX 64La08	$^3P_1$		b=−18.770[f]‡ *12*
							‡Used a–value of 64By01	
$^{67}_{30}$Zn			±0.87524 *11*		OP 67Sp04	(^{67}Zn vapor; mineral oil)		$\nu^{67}/\nu(^1H)$= 0.0625241 *6*
$^{67}_{30}$Zn			±0.87524 *11*		OP 67Sp11	(^{67}Zn+^{111}Cd cell)		$\nu^{67}/\nu(^{111}Cd)$= 0.295228 *2*
$^{67}_{30}$Zn				+0.150[c] *15*	DR 69La05	$^3P_{2,1}$		
$^{85}_{37}$Rb				+0.295 *20*	DR 55Me07	$6^2P_{3/2}$:4,3 3,2 2,1	39.35 *15* 20.67 *20* 9.79 *20*	a=8.16 *6* b=8.40 *40*
$^{85}_{37}$Rb					DR 61Bu02	$6^2P_{3/2}$:4,3 3,2 2,1	39.275 *48* 20.812 *61* 9.824	a=8.178 *9* b=8.199 *40*
$^{85}_{37}$Rb				±0.298[bE] *1* or ±0.247*[bE]	DR 65Sc08	$5^2P_{3/2}$		a=25.029 *16* b=26.032 *70*
				±0.283[bE] *8* or ±0.254*[E]		$6^2P_{3/2}$ (from b and fine structure separation)		a=8.25 *10* b=8.16 *20*
$^{85}_{37}$Rb					LX 66Bu17	$6^2P_{3/2}$		a=8.163‡ *4* b=8.19‡ *3*
							‡Assumed g_F=1.334	
$^{85}_{37}$Rb			+1.3524 *2*		OP 67Ba47	$^2S_{1/2}$		g_I/g_J= -1.46648×10^{-4} *8*
$^{85}_{37}$Rb				+0.316 *7* or +0.267* *6*	DR 68Bu06	$7^2P_{3/2}$:4,3	17.78 *4*	a=3.71 *1* b=3.68 *8*
$^{85}_{37}$Rb					DR 68Fe01	$7^2P_{1/2}$:3,2	52.95 *6*	a=17.65 *2*
$^{85}_{37}$Rb			±1.3524 *2*		OP 68Wh01			g_I/g_J= 1.4664908×10^{-4s} *30* g^{85}/g^{87}= 0.2950736 *7*
$^{85}_{37}$Rb				+0.316 *20* or +0.270* *17*	DR 68Zu01	$8^2P_{3/2}$:4,3	9.55 *6*	a=1.99‡ *2* b=1.98‡ *12*
							‡Used known μ– and Q–ratios to determine a and b from $\Delta\nu$	
$^{85}_{37}$Rb				±0.330[cp] ±0.317[cp]	DR 68Zu03 (65Sc08)	$5^2P_{3/2}$ $6^2P_{3/2}$		
$^{85}_{37}$Rb				+0.260*‡ *2*	70Fi17		‡Using Q^{85}/Q^{87}=2.0669	
$^{85}_{37}$Rb					DR 71Ch61	$7^2S_{1/2}$:3,2	271 *15*	
$^{85}_{37}$Rb				+0.263*‡ *2*	71St12		‡Using Q^{85}/Q^{87}=2.0669	
$^{85}_{37}$Rb					DR 72Ch57	$5^2D_{3/2}$		a=8[p] *3*
$^{85}_{37}$Rb					DR 72Gu26	$7^2S_{1/2}$:3,2	278[p] *5*	

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Nucleus	$T_{1/2}$	I	μ	Q	Method Refer.	Atomic State F,F'	$\Delta\nu(F,F')$	Interaction Constants
$^{87}_{37}$Rb	47Gy			+0.143 *10*	DR 55Me07	$6^2P_{3/2}$:3,2	86.95	a=27.63‡ *10*
								b=4.06‡ *20*
							‡Used known ratios g^{87}/g^{85}=3.388 and b^{85}/b^{87}=2.0669	
$^{87}_{37}$Rb	47Gy				OP 58B99	$^2S_{1/2}$:2,1	6834.682608 *7*	
$^{87}_{37}$Rb	47Gy				DR 61Bu02	$6^2P_{3/2}$:3,2	87.122 *43*	a=27.707 *15*
						2,1	51.418 *31*	b=4.000 *39*
						1,0	23.696 *97*	
$^{87}_{37}$Rb	47Gy				OP 61Ca22	$^2S_{1/2}$:2,1	6834.682590 *70*	
$^{87}_{37}$Rb	47Gy				DR 63Bu13	$5^2P_{3/2}$:3,2	267.17 *15*	a=84.853 *30*
						2,1	157.09 *10*	b=12.611 *70*
						1,0	72.25 *20*	
$^{87}_{37}$Rb	47Gy			±0.144^{bE} *1*	DR 65Sc08	$5^2P_{3/2}$		a=84.852 *30*
				or 0.120*^{bE}				b=12.611 *70*
				±0.137^{bE} *4*		$6^2P_{3/2}$		(a=27.96 *35*)
								b=3.95 *10*
				±0.123*^{E}		(from b and fine structure separation)		
$^{87}_{37}$Rb	47Gy			+0.138^{E} *1*	DR 65Zu01	$6^2P_{3/2}$:3,2	87.04 *3*	a=27.70 *2*
				+0.114*^{E} *1*		2,1	51.46 *2*	b=3.94 *4*
						1,0	23.75 *6*	
$^{87}_{37}$Rb	47Gy				LX 66Bu17	$6^2P_{3/2}$		a=27.61‡ *4*
								b=3.91‡ *7*
							‡Assumed g_F=1.334	
$^{87}_{37}$Rb	47Gy		+2.7500 *5*		OP 67Ba47	$^2S_{1/2}$		g_I/g_J= −4.96997x10^{-4} *9*
$^{87}_{37}$Rb	47Gy			+0.147 *2*	DR 68Bu06	$7^2P_{3/2}$:3,2	39.43 *2*	a=12.57 *1*
				or +0.124* *2*		2,1	23.43 *3*	b=1.71 *3*
						1,0	10.87 *4*	
$^{87}_{37}$Rb	47Gy		±2.7499 *5*		OP 68Wh01			g_I/g_J= 4.9699147x10^{-4s} *50*
$^{87}_{37}$Rb	47Gy			+0.153 *9*	DR 68Zu01	$8^2P_{3/2}$:3,2	21.20 *4*	a=6.75‡ *3*
				or +0.131* *8*				b=0.96‡ *6*
							‡Used known μ– and Q–ratios to determine a and b from $\Delta\nu$	
$^{87}_{37}$Rb	47Gy			±0.160^{cp}	DR 68Zu03	$5^2P_{3/2}$		
				±0.153^{cp}	(65Sc08)	$6^2P_{3/2}$		
$^{87}_{37}$Rb	47Gy				70Fi17			
				+0.126*^{c} *1*	DR (65Sc08)	$5^2P_{3/2}$		
				+0.126*^{c} *1*	DR (65Zu01)	$6^2P_{3/2}$		
				+0.124*^{c} *2*	DR (68Bu06)	$7^2P_{3/2}$		
$^{87}_{37}$Rb	47Gy				DR 71Ch61	$7^2S_{1/2}$:2,1	565 *40*	
$^{87}_{37}$Rb	47Gy			+0.127*‡ *1*	71St12		‡Average value	
				±0.127*^{c} *1*	DR (65Sc08)	$5^2P_{3/2}$		
				±0.127*^{c} *1*	DR (65Zu01)	$6^2P_{3/2}$		
				±0.123*^{c} *2*	DR (68Bu06)	$7^2P_{3/2}$		
				±0.129*^{c} *8*	DR (68Zu01)	$8^2P_{3/2}$		
$^{87}_{37}$Rb	47Gy				DR 72Ch57	$5^2D_{3/2}$		a=23^{P} *5*
$^{87}_{37}$Rb	47Gy				DR 72Gu26	$7^2S_{1/2}$:2,1	623^{P} *7*	
$^{87}_{38}$Sr				+‡0.36 *3*	DR 63Zu04	5^3P_1: $^{11}/_2$,$^9/_2$	1463.149 *6*	a=−‡260.084 *2*
						$^9/_2$,$^7/_2$	130.264 *6*	b=−‡35.658 *6*
							‡Sign from optical spectroscopy data	
$^{89}_{39}$Y					LX 70Be59	$z^2F_{5/2}$	For g_F=0.854	a=23.8 *4*
						$z^2F_{7/2}$	For g_F=1.148	a=84.08 *1*

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Nucleus	$T_{1/2}$	I	μ	Q	Method Refer.	Atomic State F,F'	$\Delta\nu(F,F')$	Interaction Constants
$^{105}_{46}$Pd					LX 68Bu04	$^3P_1$		a=132 *6* b/a=−1.1 *5*
$^{107}_{47}$Ag					LX 66Bu18	$^2P_{3/2}$		a=28 *4*
$^{109}_{47}$Ag					LX 72Mo48	$5^2P_{3/2}$		a=36 *4*
$^{105}_{48}$Cd	5.5m	5/2	-0.7385^a *2*	$+0.43^l$ *4*	DR 69La06	$^3P_1$		$a=-1025.9^f$ *2* $b=-103.9^f$ *3*
$^{107}_{48}$Cd	6.7h	5/2	-0.6155^a *8*	$+0.77^{cl}$ *10*	DR 63By02	$^3P_1$		a=−854.2 *10* b=−166 *3*
$^{107}_{48}$Cd	6.7h		-0.61447^a *15*	$+0.68^{cl}$ *7*	LX 63Th06 69La06	$^3P_1$		$a=-853.543^f$ *6* $b=-163.279^f$ *5*
$^{107}_{48}$Cd	6.7h		±0.61444 *15*		OP 66Mc17 68Mc20	(Cd vapor; mineral oil) (^{107}Cd+^{111}Cd cell)		$\nu/\nu(^1H)$= 0.0437924 *20* $\nu/\nu(^{111}Cd)$= 0.20678100 *22*
$^{109}_{48}$Cd	470d	5/2	-0.8276^a *15*	+0.78 *10*	DR 63Mc11	$^3P_1$		a=−1148.6 *20* b=−167.3 *20*
$^{109}_{48}$Cd	470d				LX 63Th06	$^3P_1$		$a=-1148.784^f$ *7* $b=-165.143^f$ *5*
$^{109}_{48}$Cd	470d		±0.82701 *20*		OP 66Mc17 68Mc20	(Cd vapor; mineral oil) (^{109}Cd+^{111}Cd cell)		$\nu/\nu(^1H)$= 0.0589435 *20* $\nu/\nu(^{111}Cd)$= 0.27832106 *28*
$^{109}_{48}$Cd	470d		±0.82701 *20*		OP 68Le08	(^{111}Cd+^{109}Cd cell)		ν^{111}/ν^{109}= 3.5929795 *20*
$^{109}_{48}$Cd	470d			$+0.69^c$ *7*	69La06	$^3P_1$		
$^{111}_{48}$Cd					DR 62La24	$^3P_1$:$^3/_2$,$^1/_2$	6185.72 *2*	
$^{111}_{48}$Cd					DR 63La12	$^3P_1$		a=−4123.81 *1*
$^{111}_{48}$Cd					LX 64Lu04	$^1P_1$		a=±186 *4*
$^{111}_{48}$Cd			±0.59429 *14*		OP 66Le21	(^{111}Cd+^{199}Hg cell)		$\nu/\nu(^{199}Hg)$= 1.1879850 *5*
$^{111}_{48}$Cd			±0.59429 *14*		OP 66Mc16 68Mc20	(Cd vapor; mineral oil)		$\nu/\nu(^1H)$= 0.2117831 *6*
$^{111}_{48}$Cd					OP 69Le10	5^1P_1		a positive
$^{111m}_{48}$Cd	49m	11/2	-1.1040^a *4*	-0.85^l *9*	DR 69La06	$^3P_1$		$a=-697.1^f$ *2* $b=+202.3^f$ *5*
$^{113}_{48}$Cd	>3Jy				DR 62La24	$^3P_1$:$^3/_2$,$^1/_2$	6470.79 *2*	
$^{113}_{48}$Cd	>3Jy		±0.62167 *15*		OP 67Le22	(^{111}Cd+^{113}Cd cell)		ν^{113}/ν^{111}= 1.0460840 *2*
$^{113}_{48}$Cd	>3Jy		±0.62167 *15*		OP 66Mc16 68Mc20	(Cd vapor;mineral oil)		$\nu/\nu(^1H)$= 0.221543 *2* ν^{113}/ν^{111}= 1.04608417 *24*
$^{113}_{48}$Cd	14y	11/2	-1.0875^a *3*	-0.71^l *7*	DR 64By03 69La06	$^3P_1$:$^{13}/_2$,$^{11}/_2$ $^{11}/_2$,$^9/_2$	4310.572 *5* 3949.625 *7*	$a=-686.0425^f$ *8* $b=+169.047^f$ *9*
$^{113m}_{48}$Cd	14y		−1.0867 *3*		OP 69Ch07	(^{113}Cd+^{111}Cd cell)		ν^{113m}/ν^{111}= 0.16623263 *10*
$^{115}_{48}$Cd	2.3d	1/2	−0.6462 *3*		DR 64Mc06	$^3P_1$		a=−4484 *2*
$^{115}_{48}$Cd	2.3d		−0.64777 *15*		OP 69Ch07	(^{115}Cd+^{111}Cd cell)		ν^{115}/ν^{111}= 1.0900002 *12*
$^{115m}_{48}$Cd	43d	11/2	-1.0424^a *10*	-0.55^l *6*	DR 64Mc06 69La06	$^3P_1$		a=−657.6 *6* b=+131 *6*
$^{115m}_{48}$Cd	43d		−1.0400 *25*		OP 69Ch07	(^{115}Cd+^{111}Cd cell)		ν^{115m}/ν^{111}= 0.15908842 *6*

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Nucleus	$T_{1/2}$	I	μ	Q	Method Refer.	Atomic State F,F'	$\Delta\nu(F,F')$	Interaction Constants
$^{113}_{49}$In and					LX 69Br09	$5^2D_{3/2}$		a=±64.5‡ *10*
$^{115}_{49}$In								b/a=−0.59 *17*
						$6^2D_{3/2}$		a=±72.1‡ *3*
								b/a=−0.47 *5*
							‡Assumed g_J=0.8	
$^{113}_{49}$In and					LX 70Zi06	$5^2D_{5/2}$	For g_J=1.2	a=148 *8*
$^{115}_{49}$In								b/a≤0.3
								β‡=1.9 *4*
							‡Stark coefficient in MHz/(kV/cm)^2	
$^{117}_{50}$Sn					LX 67Br24	$^3P^\circ_1$		a^{117}/a^{119}=0.9555 *3*
$^{129}_{54}$Xe					EI 69Jo26	5d[7/2]$_4$		a=−583.571[p] *2*
$^{129}_{54}$Xe					LX 69Le02	5d[5/2]$^\circ_2$		a=829.5 *8*
$^{131}_{54}$Xe			±0.6913 *23*		‡ 67Ha33		‡"Electron−pumping." NMR observed by change in radiation when aligned nuclei bombarded by electrons	
$^{131}_{55}$Cs	10d			−0.572* *10*	LX 68Ac01	$6^2P_{3/2}$		a=+96.54 *30*
								b=−91.6 *16*
$^{131}_{55}$Cs	10d			−0.691 *9*	DR 69Sc15	$7^2P_{3/2}$:4,3	104.0 *2*	a=+31.73 *6*
				−0.57* *1*		3,2	108	b=−28.63 *35*
						2,1	86.4 *3*	
$^{131}_{55}$Cs	10d			−0.575*‡ *6*	71St12		‡Weighted average	
				−0.583*[c] *10*	LX (68Ac01)	$6^2P_{3/2}$		
				−0.570*[c] *8*	LX (68Ac01)	$7^2P_{3/2}$		
$^{132}_{55}$Cs	6.2d			+0.459* *10*	LX 68Ac01	$6^2P_{3/2}$		a=+75.75 *60*
								b=+73.35 *160*
$^{132}_{55}$Cs	6.2d		+2.22[a] *1*	+0.570 *15*	DR 69Sc15	$7^2P_{3/2}$:$^7/_2$,$^5/_2$	108.30 *30*	a=+25.03 *12*
				+0.47* *1*		$^5/_2$,$^3/_2$	47.75 *40*	b=+23.60 *60*
						$^3/_2$,$^1/_2$	17.00 *50*	
$^{132}_{55}$Cs	6.2d			+0.469*‡ *10*	71St12		‡Weighted average	
				+0.468*[c] *10*	LX (68Ac01)	$6^2P_{3/2}$		
				+0.474*[c] *30*	LX (68Ac01)	$7^2P_{3/2}$		
$^{133}_{55}$Cs				−0.003 *2*	DR 55A56	$7^2P_{3/2}$:5,4	82.85 *5*	a=16.60 *1*
						4,3	66.45 *5*	b=−0.11 *8*
						3,2	49.90 *5*	
$^{133}_{55}$Cs					DR 58Bu05	$7^2P_{1/2}$:4,3	400.8 *1*	
$^{133}_{55}$Cs				−0.0036 *13*	DR 59Bu93	$7^2P_{3/2}$:5,4	82.93 *3*	
						4,3	66.42 *5*	
						3,2	49.94 *3*	
$^{133}_{55}$Cs				−0.0024[b] *20*	DR 62Bu30	$8^2P_{3/2}$:5,4	38.093 *30*	a=7.626 *5*
						4,3	30.502 *130*	b=−0.049 *42*
						3,2	22.912 *30*	
$^{133}_{55}$Cs					DR 64Fa11	$7^2P_{3/2}$:3,2	49.81[h] *3*	
						$8^2P_{3/2}$:5,4	37.82 *5*	a=+7.58 *1*
						4,3	30.32	b=−0.14 *5*
						3,2	22.85 *3*	
$^{133}_{55}$Cs			±2.5780 *7*		OP 68Ha01			g_I/g_J= 1.9917398x10^{-4}[g] *26*
$^{133}_{55}$Cs				−0.0028*	LX 69Sv01	$6^2P_{3/2}$	For g_J=1.345	a=50.72 *3*
								b=−0.38 *18*
				−0.0032*		$7^2P_{3/2}$	For g_J=1.3349	a=16.610 *6*
								b=−0.15 *3*
				−0.0030*‡ *6*			‡Average	

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$^{133}_{55}$Cs					LX 69Vi03	$6^2P_{3/2}$	For g_J=1.3341 *3*	a=50.45 *8*
								b=−0.66 *72*
$^{133}_{55}$Cs					DR 71Ch61	$8^2S_{1/2}$:4,3	684 *50*	
$^{133}_{55}$Cs				−0.0030*^{c} *11*	DR 71St12	$7^2P_{3/2}$		
					(59Bu93)			
$^{134}_{55}$Cs	2.1y			+0.436 *3*	DR 68He07	$7^2P_{3/2}$:$^{11}/_2$,$^9/_2$	105.10 *6*	a=+16.851 *16*
				+0.356* *2*		$^9/_2$,$^7/_2$	72.0 *15*	b=+18.07 *12*
						$^7/_2$,$^5/_2$	46.56 *13*	
$^{134}_{55}$Cs	2.1y			+0.427 *11*	DR 68Kn01	$8^2P_{3/2}$:$^{11}/_2$,$^9/_2$	47.84 *12*	(a=7.69)
				+0.355* *11*				b=8.06 *20*
$^{134}_{55}$Cs	2.1y			+0.455 *3*	DR 69Zu04	$6^2P_{3/2}$		
$^{134}_{55}$Cs	2.1y				70Fi17			
				+0.360*^{c} *3*	DR (69Zu04)	$6^2P_{3/2}$		
				+0.356*^{c} *2*	DR (68He07)	$7^2P_{3/2}$		
				+0.355*^{c} *7*	DR (68Kn01)	$8^2P_{3/2}$		
$^{134}_{55}$Cs	2.1y			+0.364*‡ *2*	71St12		‡Weighted average	
				+0.367*^{c} *3*	(70Fi17)	$6^2P_{3/2}$		
				+0.361*^{c} *3*	DR (68He07)	$7^2P_{3/2}$		
				+0.359*^{c} *7*	DR (68Kn01)	$8^2P_{3/2}$		
$^{135}_{55}$Cs	2My			+0.049 *2*	DR 59Bu93	$^2P_{3/2}$:5,4	89.42 *5*	(a=17.57‡ *1*)
								b=+2.19 *9*
							‡Calculated using a^{133}(55A56) and g−ratios from atomic beam measurements (57St11)	
$^{135}_{55}$Cs	2My			+0.0536*	LX 69Sv01	$6^2P_{3/2}$	For g_J=1.345	a=53.64 *4*
								b=7.41 *32*
				+0.0495*		$7^2P_{3/2}$	For g_J=1.3349	a=17.570 *6*
								b=2.35 *7*
				+0.052*‡ *5*			‡Average	
$^{135}_{55}$Cs	2My			+0.044*^{1}‡ *2*	DR 71St12	$7^2P_{3/2}$	‡Based on Q^{*134}, weighted average, and b−values of 59Bu93, 68He07	
$^{137}_{55}$Cs	30y			+0.050 *2*	DR 59Bu93	$^2P_{3/2}$:5,4	92.99 *5*	(a=18.28‡ *1*)
								b=+2.23 *9*
							‡Calculated using a^{133}(55A56) and g−ratios from atomic beam measurements (57St11)	
$^{137}_{55}$Cs	30y			+0.0545*	LX 69Sv01	$6^2P_{3/2}$	For g_J=1.345	a=55.80 *4*
								b=7.54 *20*
				+0.0499*		$7^2P_{3/2}$	For g_J=1.3349	a=18.274 *6*
								b=2.37 *4*
				+0.052*‡ *5*			‡Average	
$^{137}_{55}$Cs	30y			+0.045*^{1}‡ *2*	DR 71St12		‡Based on Q^{*134}, weighted average, and b−values of 59Bu93, 68He07	
$^{135}_{56}$Ba				+0.18 *2*	DR 63Zu05	$^3P_1$:$^5/_2$,$^3/_2$	2536.94 *6*	a=1028.31 *2*
						$^3/_2$,$^1/_2$	1603.39 *2*	b=−27.08 *2*
$^{135}_{56}$Ba			±0.83651 *26*		OP 66Ol02	$^1S_0$		
$^{135}_{56}$Ba					LX 68Op01	$^3P_1$		b/a=−0.02636 *13*
$^{135}_{56}$Ba$^+$					OP 70Vo08	$6^2S_{1/2}$		a=3591.6706 *3*
$^{137}_{56}$Ba				+0.28 *3*	DR 63Zu05	$^3P_1$:$^5/_2$,$^3/_2$	2824.46 *6*	a=1150.59 *2*
						$^3/_2$,$^1/_2$	1819.50 *2*	b=−41.61 *2*
$^{137}_{56}$Ba				±0.20	LX 64Lu09	$^1P_1$		a=−113.2 *10*
								(b=58.2‡)
							‡From atomic spectroscopy data	

Table H: Nuclear Moments by Optical Double Resonance and Pumping Techniques—Con.

Nucleus	$T_{1/2}$	I	μ	Q	Method Refer.	Atomic State F,F'	$\Delta\nu(F,F')$	Interaction Constants
$^{137}_{56}$Ba			±0.93573 *28*		OP 66O102	$^1S_0$		ν^{137}/ν^{135}= 1.11862 *3*
$^{137}_{56}$Ba					LX 68Op01	$^3P_1$		b/a=−0.03621 *13*
$^{137}_{56}$Ba$^+$					OP 70Vo08	$6^2S_{1/2}$		a=4018.8711 *4*
$^{139}_{57}$La					LX 70He26	$y^2D_{3/2}$	For g_J=0.802	a=143.18 *11* b=1.27 *37*
						$y^2D_{5/2}$	For g_J=1.186	a=63.41 *21* b=−13.3 *14*
$^{139}_{57}$La					LX 70He20	$z^2F_{5/2}$	For g_J=0.9054	a=410.8 *10* b=52.87 *39* b/a=+0.1287 *2*
						$z^2F_{7/2}$	For g_J=1.195	a=146.11 *25* b=50.7 *19* b/a=+0.347 *8*
$^{147}_{62}$Sm					LX 69Ha60	$^5F_1(4f^55d6s^2)$ $^7D_1(4f^66s6p)$		a∼−297^p a∼+267^p
$^{169}_{69}$Tm					LX 69Ha60	$J={}^9/_2$ $J={}^7/_2$		a=−333.9^p *31* a=−360.7^p *31*
$^{171}_{70}$Yb					LX 67Bu06	$^3P_1$		a^{171}/a^{173}= −3.6174 *2*
$^{171}_{70}$Yb			±0.49188 *20*		OP 67O101	$^1S_0$		
$^{171}_{70}$Yb					LX 69Ba48 DR	$^3P_1(6s6p)$		a=3959.1 *14* a^{171}/a^{173}=3.6166 *3*
$^{171}_{70}$Yb					LX 69Bu06	$^1P_1$		a/g_J=206.0 *16*
$^{171}_{70}$Yb					LX 70Bu11	$^3P_1(4f^{14}6s6p)$		a^{171}/a^{173}= 3.61650 *5*
						$^3P_1(4f^{13}5d6s^2)$		a^{171}/a^{173}=3.6329 *5*
$^{171}_{70}$Yb					DR 70Wa07	$^3P_1$:${}^3/_2$,${}^1/_2$	5936.739 *30*	a=3958.228 *60*
$^{173}_{70}$Yb			±0.67755 *27*		OP 67O101	$^1S_0$		μ^{173}/μ^{171}= 1.37748 *6*
$^{173}_{70}$Yb					LX 69Ba48 DR	$^3P_1(6s6p)$		a=−1094.7 *6* b=−826.9 *9*
$^{173}_{70}$Yb					LX 69Bu06	$^1P_1(6s6p)$		a/g_J=56.9 *5* b/g_J=575 *7*
$^{173}_{70}$Yb					LX 70Bu11	$^3P_1(6s6p)$		a=−1094.35 *3* b=−826.59 *20*
$^{173}_{70}$Yb					DR 70Wa07	$^3P_1$:${}^7/_2$,${}^5/_2$ ${}^5/_2$,${}^3/_2$	4697.916 *30* 1496.414 *75*	a=−1094.318 *35* b=−825.904 *85*
$^{175}_{71}$Lu					LX 70Go15	$^2D_{3/2}$	For g_J=0.80	a=−1313.34 *50* b=−455.8 *12*
						$^2F_{5/2}$		a/g_J=+351.864 *56* b/g_J=+3444.2 *19*
$^{181m}_{73}$Ta	11ns		±3.30‡ *12*		LX 70Li16		Hf crystal	ω=152 5MHz for H=24.2kG
							‡Observed by time differential perturbed angular correlations	
$^{197}_{79}$Au				±1.04^b ±0.57‡	LX 69Go10	$6^2P_{3/2}$		a=14.0 *5* b=327.6 *6* b/a=+23.4 *8*
							‡From b and fine structure	

Table H: Nuclear Moments by Optical Double Resonance and Pumping Techniques—Con.

Nucleus	$T_{1/2}$	I	μ	Q	Method Refer.	Atomic State F,F'	$\Delta\nu(F,F')$	Interaction Constants
$^{183}_{80}$Hg	8.8s	1/2	$+0.518^{j}$‡ 9		OP 72Bo09 72Ot03	$^3P_1$		a=15300 700
							‡Also measured by NMR/βAO on ground state	
$^{185}_{80}$Hg	50s	1/2	$+0.504^{j}$‡ 4		OP 72Bo09 72Ot03	$^3P_1$		a=14900 400
							‡Also measured by NMR/βAO on ground state	
$^{187}_{80}$Hg	2.4m	3/2	-0.586^{jp} 6	-0.3^{lp} 11	OP 72Ot03 71Bo31			
$^{193}_{80}$Hg	6h	3/2	-0.627^{k} 2		LX 65Re18	$^3P_1$		a=−6133 15
$^{193}_{80}$Hg	6h		$\pm0.62364^{p}$ 34		OP 70Mo40	$6\,^1S_0$		
$^{193}_{80}$Hg	6h			-0.77^{lp}	OP 71Fu18	$^3P_1$		(a=−6133 15) b=+477 182
$^{193m}_{80}$Hg	11h		$\pm1.063^{k}$ 1		LX 65Sm01	$^3P_1$		a=−2399.69 6 b=−725 90
$^{193m}_{80}$Hg	11h		$\pm1.0517^{p}$ 6		OP 70Mo40	$6\,^1S_0$		
$^{193m}_{80}$Hg	11h		-1.0518^{p} 5		OP 71Re23			ν/ν^{199}= 0.1609411^{p} 5
$^{195}_{80}$Hg	9.5h		±0.5381 3		OP 64Wa01			μ^{195}/μ^{199}= 1.070356 66
$^{195}_{80}$Hg	9.5h		$\pm0.5389^{k}$ 3		LX 65Sm01	$^3P_1$		a=15813.46 23 a^{195}/a^{199}= 1.071927 15
$^{195m}_{80}$Hg	40h	13/2	$\pm1.049^{k}$ 1		LX 65Sm01	$^3P_1$		a=−2368.04 8 b=−782.45 86
$^{195m}_{80}$Hg	40h		$\pm1.0380^{p}$ 5		OP 70Mo40	$6\,^1S_0$		
$^{195m}_{80}$Hg	40h		-1.0381^{p} 5		OP 71Re23			ν/ν^{199}= 0.1588454 4
$^{197}_{80}$Hg	65h	1/2	$\pm0.525^{k}$ 1		DR 59M81	$^3P_1$		a=15405 30
$^{197}_{80}$Hg	65h		$\pm0.5243^{k}$ 3		LX 61Hi16	$^3P_1$		a=15387.1 53
$^{197}_{80}$Hg	65h		±0.5241 2		OP 62Wa07			μ^{197}/μ^{199}= 1.042479 15
$^{197}_{80}$Hg	65h		$\pm0.5245^{k}$ 3		DR 63St15	$^3P_1$: $^3/_2$, $^1/_2$	23086.37 10	a=15392.66^{f} 15
$^{197m}_{80}$Hg	24h		-1.032^{k} 8		DR 61Br17	$^3P_1$: $^{15}/_2$, $^{13}/_2$ $^{13}/_2$, $^{11}/_2$	(18248‡ 11) 14234.86 9	a=−2328.89 84 b=−902.9 54
							‡Calculated from data of Hirsch	
$^{197m}_{80}$Hg	24h		-1.0316^{k} 10	±1.61 13	DR 61Hi16	$^3P_1$: $^{15}/_2$, $^{13}/_2$ $^{13}/_2$, $^{11}/_2$	18246 14 14236 20	a=−2328.8 17 b=−901 13
$^{197m}_{80}$Hg	24h		$\pm1.0211^{p}$ 6		OP 70Mo40			
$^{197m}_{80}$Hg	24h		-1.0212^{p} 5		OP 71Re23			ν/ν^{199}= 0.1562657 3
$^{199}_{80}$Hg					DR 59P33	$6\,^3F_4$: $^9/_2$, $^7/_2$	5800 100	
$^{199}_{80}$Hg			+0.50270 24		OP 61Ca21	$^1S_0$		$\mu^{199}/\mu(^1H)$= +0.1782706 3
$^{199}_{80}$Hg					LX 61Hi16	$^3P_1$		a=14750.7 50
$^{199}_{80}$Hg					DR 63St15	$^3P_1$: $^3/_2$, $^1/_2$	22128.56 10	a=14754.04^{f} 14
$^{199m}_{80}$Hg	43m	13/2	-1.00832^{p} 5		OP 71Re23			ν/ν^{199}= 0.1542921 5
$^{199m}_{80}$Hg	43m				LX 71Re24	$6\,^3P_1$		a=-2298.7^{p}‡ 4
							‡Assumed b=−900 300	
$^{199m}_{80}$Hg	43m			$+2.0^{jp}$ 13	OP 72Ot03			
$^{201}_{80}$Hg				±0.58 18	DR 58S40	$^3P_1$		a=5441 15 b=−35 2
$^{201}_{80}$Hg					DR 59P33	$6\,^3F_4$: $^{11}/_2$, $^9/_2$ $^9/_2$, $^7/_2$ $^7/_2$, $^5/_2$	2860 50 2340 50 1820 50	

Table H: Nuclear Moments by Optical Double Resonance and Pumping Techniques—Con.

Nucleus	$T_{1/2}$	I	μ	Q	Method Refer.	Atomic State F,F'	$\Delta\nu(F,F')$	Interaction Constants
$^{201}_{80}$Hg			−0.55671 *27*		OP 61Ca21	$^1S_0$		$\mu^{201}/\mu(^1H)=$ −0.1974198 *9*
$^{201}_{80}$Hg					DR 61Ko5	$^3P_1$:$^5/_2$,$^3/_2$ $^3/_2$,$^1/_2$	13986.557 *8* 7551.613 *13*	$a=-5454.569$ *3* $b=-280.107$ *5*
$^{201}_{80}$Hg			−0.55670 *27*		DR 63Le18			$\mu^{201}/\mu^{199}=$ −1.1074164 *5*
$^{203}_{80}$Hg	47d		±0.8436 *4*		OP 70Ki05	$6\,^1S_0$		$\nu^{201}/\nu=$ 1.09984 *18*
$^{203}_{80}$Hg	47d		+0.850ᵃ *9*	+0.40ˡ *4*	LX 70Re14	$^3P_1$		$a=4991.35$ *3* $b=-249.2$ *3*
$^{205}_{80}$Hg	5.5m	1/2	+0.5968ʲᵖ *5*		OP 72Ot03			
$^{203}_{81}$Tl and $^{205}_{81}$Tl					LX 69Zi02	$6\,^2D_{3/2}$	For $g_J=0.8$	$a=42$ *2* β‡$=0.12$ *1* $a/\beta>0$
							‡Stark coefficient in MHz/(kV/cm)^2	
$^{203}_{81}$Tl and $^{205}_{81}$Tl					LX 70Zi07	$7\,^2D_{3/2}$	For $g_J=0.8$	$a=55$ *1* β‡$=0.20$ *4* $a/\beta>0$
							‡Stark coefficient in MHz/(kV/cm)^2	
$^{207}_{82}$Pb					LX 66Sa09	$^3P_1$		$a=8811$ *17*
$^{207}_{82}$Pb			±0.5783 *7*		OP 69Gi03	$^3P_0$		$\nu/\nu_p=0.20502$ *22*
$^{207}_{82}$Pb			±0.57810‡ *29*		OP 69Gi04	$^3P_0$		$\nu/\nu(^{199}Hg)=$ 1.14960 *4*
							‡Using $\mu^{199}_{unc.}=+0.497856$ *5*, 61Ca21	
					72Gi20		Large discrepancy with NMR-value may be due to large interaction of $^3P_1$-state with $^3P_0$-state	

* Polarization or Sternheimer correction included
ᵃ Calculated from the $\Delta\nu$– or a–ratio for two isotopes
ᵇ Calculated from b/a
ᶜ Recalculation of earlier data
ᵈ No diamagnetic correction added. Unsure if authors already corrected for it
ᴱ Enriched sample used
ᶠ Corrected for second order perturbations of neighboring levels
ᵍ Extrapolated to zero intensity
ʰ Extrapolated to zero power
ⁱ Extrapolated to zero pressure
ʲ Resonance observed by depolarization of polarized nuclei
ᵏ Calculated using $a^{199}=14754.0$ *1* [63St15] and the uncorrected $\mu(^{199}Hg)=+0.497856$ *5* from Cagnac [61Ca21]
ˡ Calculated from the b–ratio for two isotopes
ᵐ Metastable or excited state
ᵖ Preliminary value from meeting abstract, thesis, private communication, etc.

Table J: Nuclear Moments by Nuclear Orientation, Perturbed Angular Correlation and Nuclear Specific Heat Measurements

Introduction

Nuclear moment values obtained by nuclear orientation, perturbed angluar correlation and nuclear specific heat measurements are collected in this table. The last systematic literature search for the data included was done in early 1972. A brief review of the techniques follows.

Nuclear Orientation:

If a sample of nuclei is unoriented, the spatial distribution of radiation emitted by the sample is isotropic. If the nuclei can be oriented in some manner, the radiation is frequently no longer isotropic. The actual distribution depends on the type of radiation (α, β, or γ's), the degree of orientation of the nuclei, the spins of the initial and final states as well as the angular momentum, L, carried off by the radiation. The term "oriented" is used to indicate that the $2I+1$ nuclear magnetic substates, m_Z, are unequally populated. If the pairs of substates with the same m_Z but opposite signs, $+m_Z$ and $-m_Z$, have equal populations, the nuclei are said to be aligned. If they have unequal populations, the nuclei are said to be polarized.

The angular distribution of the radiation emitted by an ensemble of nuclei, with spin I_o, can be written in terms of Legendre polynomials as:

$$W(\theta) = \sum_{k=0}^{k_{max}} B_k F_k P_k(\cos\theta) \tag{1}$$

where k_{max} is the smaller of $2I_o$ and $2L$. θ is the angle between some fixed axis, z, and the direction of propagation of the radiation. The B_k are orientation parameters which depend on the relative populations of the substates of I_o. The F_k are angular correlation functions which depend on the spins I_o, I_f and on L of the transition. For radiation other than γ's, "particle parameters", b_k, must be included in the expansion. For α's and unpolarized γ's, in general, only even k occur. Odd k can be present for β-decay and polarized γ's.

To be oriented at low temperature, the nuclei must have a lifetime long enough so that they can be incorporated in a suitable material. Most γ-emitting states, with the exception of a few isomers, have very short lifetimes. However, many radioactive nuclei which decay by α- or β-emission or K-capture have long lifetimes and the angular distribution of the γ or γ's following the decay can be measured. The degree of orientation of the γ-emitting state can be calculated from that of the oriented nucleus if the spins of the preceding states and the angular momenta carried off by and mixtures of all preceding radiations are known. Such calculations assume that the intermediate state half-lives are short so that there are no perturbations acting to change the populations of the states. If this is true, the angular distribution in (1) can be replaced by:

$$W(\theta) = \sum_{k=0}^{k_{max}} B_k(I_o,T)[\prod_a U_k^{(a)}(I_a,L_a,I_{a+1})] \times F_k(I_n,L_n,I_f)\, P_k(\cos\theta) \tag{2}$$

where each $U_k^{(a)}$ is a function of the nuclear spins and angular momentum for the ath unobserved transition preceding the observed one. k_{max} is the smaller of $2I_o$, $2I_a$, $2I_n$, $2L_a$, $2L_n$. If any of the spins I_o through I_n is 0 or 1/2, the angular distribution becomes isotropic.

For an assembly of atoms at thermal equilibrium, the population of any level, m, is proportional to the $\exp[-E_m/kT]$. If the differences in the energies of the levels are small with respect to kT, the populations will be approximately equal. However, if the separation between levels can be made the order of kT, either by increasing the interaction energy and/or decreasing T, the nuclei can be oriented. For a discussion of several methods for producing oriented nuclei at low temperatures, see [65Da10] or [65De31].

Originally paramagnetic salts, incorporating the nucleus under investigation, were cooled to very low temperatures by adiabatic demagnetization. The nuclei were oriented by the hyperfine interaction of external or internal fields with the nuclear or electronic moments. The "brute force" method of orientation making use of the direct interaction of the nuclear magnetic moment was originally suggested by Gorter [34Go01] as a means of possibly further lowering temperatures. More recently, orientation experiments have been done on nuclei imbedded as dilute impurities in ferromagnetic metals and antiferromagnetic crystals, taking advantage of the very large fields present at the impurity sites. These materials are usually cooled by thermal contact with paramagnetic salts at very low temperatures.

The material chosen for cooling must fit certain requirements. It must have a large specific heat so that it will not warm up rapidly after being cooled. It must be able to be cooled to a very low temperature and it must be possible to determine its temperature. A large number of the earlier orientation experiments were done on nuclei in the following classes of salts since many had been thoroughly investigated and their properties well known; see [61Hu20]:

Tutton salts: $M''M'_2(XO_4)_2{\cdot}6H_2O$

Rare-earth ethyl sulphates: $M'''(C_2H_5SO_4)_3{\cdot}9H_2O$

Double nitrates: $M_2'''M_3''(NO_3)_{12}\cdot 24H_2O$

Fluosilicates: $M''SiF_6\cdot 6H_2O$

Two of these, cerium magnesium nitrate, CMN, and neodymium ethyl sulphate, NES, have been used for very many moment determinations. Around 1965, it was observed by the Berkeley group [65Fr19], [66Bl17] that the temperature dependence of γ-anisotropies of CMN and NES showed sharp discontinuities below ~0.003°K. They felt these could only be satisfactorily explained by assuming that the earlier temperature scales for these materials were based on properties that were not sensitive enough to the temperature below ~0.003°K. It appeared that the temperatures actually reached were much lower than those given by the magnetic temperature relationship. For this reason, very low temperature measurements done with these salts prior to 1965 are suspect.

In order to determine nuclear moments, a material, whose low temperature properties are known, is chosen for the nuclear environment. It is cooled, the nuclei oriented, and the γ-intensity or the γ-anisotropy, ϵ,

$$\epsilon = [W(90°) - W(0°)]/W(90°) \tag{3}$$

is measured as a function of the temperature. The resulting curve is then fit by adjusting the values of the interaction constants on which the orientation parameters, B_k, depend. The anisotropy or intensity also depends upon the values chosen for the spins of all nuclear levels involved and on the angular momenta of the transitions through the U_k– and F_k–terms in (2). In order to determine the degree of orientation of the nuclei, the temperature at the nucleus must be known. Frequently a reference nucleus, such as ^{60}Co or ^{54}Mn with well-known orientation parameters, can be incorporated into the sample to act as a thermometer. The distribution of the reference nuclei should be similar to that of the nuclei under consideration to minimize differences due to local warming.

The advantages of measuring nuclear moments by nuclear orientation stem from the fact that one is counting a single transition, rather than coincidences, so that sufficient data can be obtained in reasonable times with very dilute samples. However, the nucleus must have a lifetime of the order of hours and a sufficiently large μ or Q in order to be oriented. Temperatures below ~0.01°K are necessary.

The accuracy of such measurements is not very great. The magnetic moment can be determined to about 10%. A more recent development combines NMR techniques with low temperature orientation and leads to moments which can be determined to about 0.1%. In these experiments the NMR frequency is observed by the destruction of the orientation at resonance. A short review of this technique can be found in [68Sh25].

Measurements of the γ-anisotropy do not yield the sign of the magnetic moment, but the sign can be determined from a measurement of the γ-ray circular polarization or β-asymmetry since these depend on the polarization of the nucleus and involve the odd k terms in (1) as well as the even ones.

The major difficulties encountered in orientation experiments have to do with:

1) the knowledge of the temperature at the nuclei. There can be heat leaks, local warm-up due to radiation, and difficulties in measuring the temperatures accurately;

2) the presence of perturbations acting on the nuclei during the finite lifetimes of the intermediate levels. These cause changes in the relative populations of the levels.

For more complete discussions of nuclear orientation and the measurement of nuclear moments using oriented nuclei, see [57Bl04], [65Da10] or [65De31]. *Nuclear Orientation* edited by M. E. Rose [63Ro33] is a handy collection of early journal papers and some review articles on this subject. Discussions of more recent techniques and problems can be found in the proceedings of several recent conferences on hyperfine interactions, for example, see [71St46].

Nuclear Specific Heat:

A few moments have been determined from measurements of the specific heat at very low temperatures. The specific heat, C_P, of a system can be expressed as a sum:

$$C_P = C_L + C_E + C_M + C_N \tag{4}$$

C_L is the lattice contribution to the specific heat. For temperatures well below the Debye temperature, i.e. $T<\theta/50$, it is given by: $C_L=AT^3$, where A is a constant. C_E, the electronic specific heat, the contribution due to the conduction electrons, is given by $C_E=\gamma T$, a relation which holds up to about 1000°K. C_M, the magnetic specific heat which is due to the exchange interaction of the local electronic spins of neighboring ions, does not contribute to the total specific heat at very low temperatures of the order of 1°K. The nuclear specific heat, C_N, depends on the energies of the $2I+1$ levels of the different orientations of the nucleus with respect to the effective fields. From statistical mechanics it can be shown that:

$$C_N = [R/(kT)^2](\sum_{ij} [H_i^2 - H_iH_j] \exp[-(H_i + H_j)/kT]) \times (\sum_{ij} \exp[-(H_i + H_j)/kT])^{-1} \quad (5)$$

where H_i, H_j are the energies of levels i, j. In terms of effective magnetic and quadrupole interaction constants, A' and P', the energy can be written as:

$$H_m = A'm + P'[\, m^2 - I(I+1)/3] \quad (6)$$

for $m=-I,-I+1,\ldots +I$.

To carry out such experiments, samples of ferromagnetic or antiferromagnetic metals or alloys are thermally isolated as well as possible after being cooled to temperatures below 1°K. The samples are then heated electrically and the temperature measured. If the specific heat can be measured over a range of about 0.4 to 4°K, it may be possible to obtain C_N and the interaction constants from the temperature dependence of the specific heat. Above about 1°K, C_N can be neglected and C_L and C_E separated by plotting C_P/T vs T^2. The contributions of C_L and C_E can be subtracted from the data below 1°K to determine C_N, which dominates in this region. These measurements require samples of great purity and very reliable thermometry. Since gram quantities are needed and only average properties for the natural isotopic abundances of the elements are measured, this method has not been used for moment measurements except for the few cases of the monoisotopic rare earths.

A review of the determination of interaction constants from nuclear specific heat measurements can be found in [67Lo12].

Perturbed Angular Correlation:

In the absence of perturbing electric or magnetic fields, the angular correlation of two successive radiations can be expressed in terms of the Legendre polynomials, as:

$$W(\theta) = \sum_{k=0}^{k_{\max}} A_k(1)\, A_k(2)\, P_k(\cos\theta) \quad (7)$$

where θ is the angle between them and the A_k(j) are coefficients which depend on the angular momentum, L_j, carried off by the jth transition, on the spins of the nuclear levels involved, I_i, I_n(see figure 1) and on the kind of radiation, α, β, γ, or e^-[53Bi10]. $k_{\max}$ is the minimum of $2I$, $2L_1$, $2L_2$. In a simplified description, the observation of the first radiation choses a particular direction in space or quantization axis. The relative populations of the sublevels of the intermediate state depend on the type of radiation

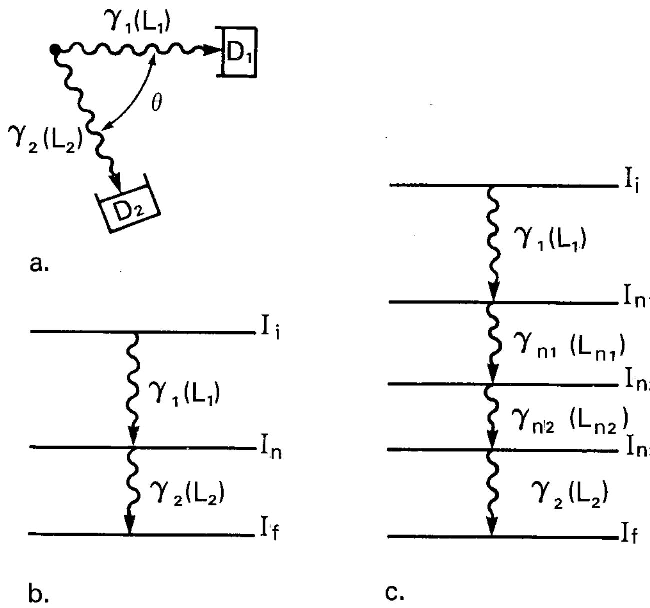

FIGURE 1a. Scheme for the detection of the correlation of γ_1 and γ_2. D_1 and D_2 are the detectors for γ_1 and γ_2, respectively.
b. Decay scheme for the emission of two successive γ's.
c. Decay scheme for the emission of γ's in a multiple cascade.

The L_j represent the angular momenta carried off in each transition: the I_j, the spins of the nuclear levels.

and the spins of the levels, I_i, I_n. The angular distribution of the second radiation with respect to the first is then a function of the angular momentum carried off, L_2, the spin of the level, I_n, and the population distribution in the intermediate state, which remains unchanged if, during the lifetime, τ, of the intermediate state, there have been no perturbing interactions. For the observation of the correlation of γ_1 and γ_2 in a multiple cascade (see figure 1c), a more general form of (7) can be written:

$$W(\theta) = \sum_{k=0}^{k_{\max}} A_{kk}P_k(\cos\theta) \quad \text{or} \quad = 1 + \sum_{N=2}^{k_{\max}} b_N \cos N\theta \quad (8)$$

where the A_{kk} are products of functions of 1) the level spins, the angular momentum and the mixing ratio for each of the observed radiations and 2) the level spins for the intervening unobserved radiations in the cascade. $k_{\max}$ is the smallest of $2L_1$, $2L_2$ and the $2I$ in the cascade. The b_N are simple algebraic functions of the A_{kk} in this alternate way of expressing the correlation.

The possibility of perturbing the angular correlation by magnetic fields was first pointed out by Hamilton [40Ha20]. The effect of hyperfine structure and of applied magnetic fields on the angular correlation was originally calculated by Goertzel [46Go05] and

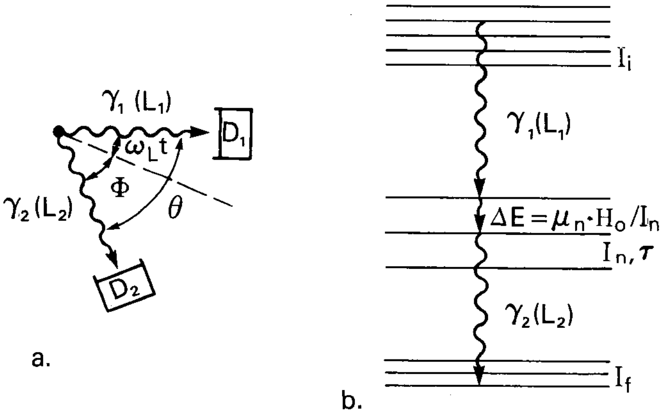

FIGURE 2a. Scheme for the observation of the correlation of two γ's in a transverse magnetic field. During the time t, between the emission of γ_1 and γ_2, the nucleus precesses through the angle $\omega_L t$. Therefore, at any given angle θ, the unperturbed correlation of $\theta-\omega_L t$ is observed. D_1 and D_2 are the detectors for γ_1 and γ_2, respectively.
b. Decay scheme for the emission of two γ's perturbed by the application of an external field, H_0, which causes a transition between the substates of the intermediate state during its lifetime, τ.

looked for by Brady and Deutsch [50Br27], but the primitive counting techniques available at that time made it impossible to observe any perturbation. In a semiclassical description, the interactions of the nuclear moments with perturbing magnetic or electric fields cause the nuclei to precess during the lifetime of the intermediate state. This results in a change in the angular distribution of the second radiation with respect to the first. A schematic representation of this is shown in figure 2. The nucleus decays to a particular sublevel of the intermediate state by the emission of the first radiation. The magnetic or electric interaction with the perturbing fields causes a transition between the sublevels of the intermediate state which is then followed by the emission of the second radiation. In the presence of perturbing fields, the angular correlation can be expressed in terms of the unperturbed correlation coefficients and the spherical harmonics for each radiation:

$$W(k_1,k_2,t) = \sum_{k_1k_2\mu_1\mu_2} A_{k1}(1)\, A_{k2}(2)\, G(k_1k_2\mu_1\mu_2t) \times Y^{\mu_1}_{k1}(\Omega_1)\, Y^{*\mu_2}_{k2}(\Omega_2) \quad (9)$$

For the exact form of the attenuation factors, $G(k_1k_2\mu_1\mu_2t)$, for many kinds of static and time-dependent perturbations, including mixed electric and magnetic interactions, see [65Fr20] or [64St29], which are essentially equivalent papers, [64Al32], or [53Ab15]. A few specific examples, for frequently encountered situations, are given below.

In the absence of any other perturbations, the application of a static magnetic field causes, in general, both an attenuation of the angular correlation as well as a rotation of the observed pattern. For the special case in which the external field, H, is perpendicular to the direction of emission of the observed γ's, the perturbed angular correlation, PAC, has a particularly simple form:

$$W_\perp(\theta,t,H) = \sum_{k=0}^{k_{max}} A_{kk}P_k[\cos(\theta-\omega_L t)]$$

or (10)

$$= 1 + \sum_{N=2}^{k_{max}} b_N \cos N(\theta-\omega_L t),$$

where $\omega_L=2\pi g\mu_N H/h$ is the Larmor precessional frequency, the A_{kk} or b_N are the unperturbed correlation functions and t is the time between the observation of the two gammas. It is assumed that the detectors can distinguish between the gammas. If the direction of the magnetic field at the nucleus is known, the sign of the magnetic moment can be determined from the direction of rotation of the correlation. If additional perturbations are present, these must be taken into account. In order to reduce the effect of any time-dependent quadrupole interactions, dilute solutions or liquid metals are frequently employed. In such sources, if the correlation time, τ_c, is small compared to the observation time or lifetime and if $\omega_L\tau_c<<1$, the effect of such perturbations is to multiply each term in (10) by an attenuation factor, $G_k=\exp(-\lambda_k t)$, where λ_k is the relaxation constant for the interaction.

For static quadrupole interactions, the attenuation factors of equation (9) cannot be expanded in terms of a single parameter 'k' as was possible in the magnetic case. However, for an axially symmetric field, they can be expressed in terms of ω_0, the smallest non-vanishing quadrupole frequency, where $\omega_0 = 3\omega_Q$ or $6\omega_Q$, for I integer or half-integer*, respectively, with $\omega_Q=-2\pi(eqQ/4hI)\times(2I-1)^{-1}$. Then

$$G(k_1, k_2, \mu_1, \mu_2, t) = \sum_{n=0}^{n_{max}} g_n(k_1, k_2, \mu) \cos n\omega_0 t \quad (11)$$

with $n = |m^2-m'^2|$ for integer I and $(1/2)|m^2-m'^2|$* for half-integer I. For a non-vanishing quadrupole perturbation, k_{max} must be greater than or equal to 4.

For randomly-oriented static fields, for example, for powdered crystalline sources, the angular correlation can be written as:

$$W(\theta) = 1 + \sum_k G_{kk}A_{kk}P_k(\cos\theta) \quad (12)$$

*Note these corrections to the corresponding expressions given in [65Fr20] or [64St29].

The form of the correlation does not change; however, the coefficients of the $P_k(\cos\theta)$ are reduced. Since there are always some nuclei in the sample aligned along the direction of observation of one of the counters, there is a lower limit to the attenuation factors. For axially–symmetric fields, this lower limit or "hard–core" value is $G_{kk} = 1/(2k + 1)$. If the perturbing fields are randomly–fluctuating, the correlation can be destroyed.

The many kinds of PAC experiments for the measurement of magnetic moments can be divided into two major classifications: (1) the time–integrated methods, with observation times longer than the lifetime of the intermediate state, which yield values of $\omega_L\tau$; and (2) the differential methods which determine ω_L directly. Because of the great variety of these experiments, only a brief discussion of a few representative techniques will be given. For more detailed information on the many modifications and variations, the reader is referred to the review articles by Frauenfelder [65Fr20], or Grodzins [68Gr31].

From equation (10), it can be seen that a measurement of the correlation as a function of delay time for a constant value of H, or as a function of H at a constant delay time yields ω_L, and therefore g, directly from the period of oscillation, T, of the correlation. A more sensitive measure of the period can be obtained by observing the correlation at some fixed angle for field up ($W_\perp \uparrow$) and down ($W_\perp \downarrow$) and plotting the ratio, $R = W_\perp \uparrow / W_\perp \downarrow$, as a function of t or H, respectively. If the resolution time, τ_0, is small, $\tau_0 << \tau$ and $\tau_0 << T$, g may be obtained from the period of oscillation of R through the relation:

$$T = h/2g\mu_N H \qquad (13)$$

R is independent of the decay of the source and the period of R is not greatly affected by small time-dependent perturbations.

If $k_{max} = 4$, the ratio,

$$r = 2(W_\perp\uparrow - W_\perp\downarrow)/(W_\perp\uparrow + W_\perp\downarrow) \qquad (14)$$

at $\theta = 3\pi/4$, is also an oscillating function of the delay time of the form: $A(\sin 2\omega_L t)/(B - C \cos 4\omega_L t)$ with period also given by (13). A, B, and C represent functions of the A_{kk}. The presence of small time–dependent perturbations does not much alter the period of r from which g is calculated, although it does cause the amplitudes of the oscillations to decrease with an increase in delay time.

Differential techniques have been used to determine moments of states with lifetimes of the order of 10^{-3} to 10^{-9} seconds.

For time–integrated measurements, IPAC, the expression for the correlation is obtained by averaging equation (9) over the observation time (zero delay time and infinite resolving time). Equation (10) then becomes:

$$W_\perp(\theta,H) = 1 + \sum_{N=2}^{k_{max}} (b_N/[1 + (N\omega_L\tau)^2]^{1/2}) \times \cos N(\theta + \Delta\theta) \qquad (15)$$

where $\Delta\theta = (1/N)\tan^{-1}(N\omega_L\tau)$. In this case, both an attenuation and a rotation of the correlation are observed. For small $\omega_L\tau$, $\Delta\theta \sim \omega_L\tau$. In the presence of time–dependent quadrupole perturbations, the precession angle, $N\omega_L\tau$, and the correlation coefficients are both reduced by an attenuation factor, which, for $\omega_L\tau << 1$, is $(G_k)_{ave} = 1/(1 + \lambda_k\tau)$.

In the early experiments, the entire correlation was obtained with and without an external field and the rotation, from which g can be calculated, was measured. As in the case of DPAC, more sensitive measurements for small rotations, $\omega_L\tau << 1$, can be made by measuring the coincidences at a constant angle for field up and field down. The ratio,

$$r(\infty) = 2[W_\perp(\uparrow) - W_\perp(\downarrow)]/[W_\perp(\uparrow) + W_\perp(\downarrow)], \qquad (16)$$

is approximately $4b_2(G_2)_{ave}\omega_L\tau$ for $k_{max} = 2$ and $\theta = 3\pi/4$ or $7\pi/4$. The product $b_2(G_2)_{ave}$ can be determined from the zero field correlation for the particular source used. A measurement of r then yields $\omega_L\tau$. Another useful ratio for the determination of g, again for $\omega_L\tau << 1$, is:

$$y(\infty) = [W_\perp(\pi/4) - W_\perp(3\pi/4)]/[W_\perp(\pi) - W_\perp(\pi/2)] \qquad (17)$$

which is approximately $2(G_2)_{ave}\,\omega_L\tau$ if $b_4 << b_2$. The slope of y vs H yields g if $(G_2)_{ave}$ is known.

If the detectors, in $\gamma\gamma$ measurements, cannot distinguish between the two gammas, only an attenuation is observed and equation (15) becomes:

$$W_\perp(\theta,H) = 1 + \sum_N (b_N/[1 + (N\omega_L\tau)^2]) \cos N\theta; \qquad (18)$$

that is, the unperturbed correlation is attenuated by the factor $[1 + (N\omega_L\tau)^2]^{-1}$.

All integral methods yield the product $\omega_L\tau$; therefore, the value obtained for the magnetic moment depends upon knowledge of the lifetime of the intermediate state. The values of μ appearing in the accompanying table have been corrected for newer values of the lifetimes. However, the uncertainty in the lifetime has not been taken into account since most of the measurements are not accurate enough to warrant such treatment.

Integral measurements have been made for states with lifetimes of the order of 10^{-7} to about 10^{-12} seconds. The upper limit is set by the number of accidental coincidences which are accepted; the lower, by the magnetic fields available.

Since other unknown perturbations may contribute to the attenuation of the correlation, attenuation measurements are much less reliable for the determination of moments than those of the rotation of the correlation. Further, the sign cannot be ascertained from the attenuation factors.

In order to extend PAC measurements to a wider range of states than are accessible with normal radioactive decay products, nuclear reactions and scattering experiments with pulsed beams have been used. The reaction orients the nucleus by preferentially populating sublevels of the excited state and the perturbed angular distribution, PAD, of the gamma-decay can be measured by integral or differential methods, using pulse repetition times greater than the lifetime of the state. Such techniques have been used for measurements on states with lifetimes of the order of milliseconds to nanoseconds.

The recent stroboscopic measurements [70Ch05] make use of a pulsed beam with a repetition time smaller than the lifetime of the intermediate state, $T_o << \tau$. For such an experiment, the counting rate at a time t after the pulse burst is given by the sum of intensities of the contributions of all previous bursts. For the observation of the gamma in a transverse field, neglecting other perturbations, the intensity can be written as:

$$k(\theta_o - \omega_{Lo} t_o) = 2m\pi \text{ or } (2m-1)\pi, \text{ respectively,}$$

$$\text{for } m = 0, 1, 2, \ldots$$

The stroboscopic method has been used for states with lifetimes from milliseconds to about 0.1 microseconds.

To measure the moments of very short-lived states by PAD, nuclei have been implanted by Coulomb excitation (IMPAC) or imbedded in ferromagnetic and paramagnetic materials to make use of the very large internal fields known to exist at impurity sites. One of the major difficulties in these experiments is knowledge of the magnetic fields perturbing the nucleus. The past history of the source and its treatment can cause wide variations in the fields present. The recoil of the nucleus can displace it from its regular position in the lattice. If the lifetimes are very short, of the order of picoseconds, the transient fields acting on the nucleus as it is slowing down become important. Some estimate of these effects can be made using states with "known" moments. For the particular case of the magnetic moments of the Pt and Os excited states, measured using Ir–Fe alloys, great variations have been observed which cannot be explained, suggesting that the Ir–Fe alloys are unsuitable for moment measurements [71Ki13].

Perturbed angular correlation has been a useful technique for the measurement of moments of a very large number of states which are not accessible by standard resonance or spectroscopic methods, that is,

$$I(\gamma) = \sum_{a=0}^{\infty} \exp[-(t + aT_o)/\tau] \sum_{k \text{ even}} [1 + A_k(1)A_k(2)\, P_k(\cos[\theta - \omega_L(t + aT_o)])]$$

$$\cong e^{-t/\tau} \sum_{k \text{ even}} \frac{b_k[\cos k(\theta-\omega_L t) - \exp[-T_o/\tau] \cos k(\theta - \omega_L(t - T_o))]}{[1 - 2\exp[-T_o/\tau] \cos k\omega_L T_o - \exp[-2T_o/\tau]]} \tag{19}$$

Here T_o is the repetition time of the beam pulses; t, the delay time or observation time of the gamma after the pulse-burst; and the A_k are the correlation functions for the reaction product and the gamma. The contributions of different bursts will add constructively if the condition:

$$k\omega_{Lo} T_o = 2n\pi \text{ for some } n = 1, 2, \ldots \tag{20}$$

is satisfied. Thus, for a given T_o, the counting rate will show resonances at values of $H_o = nh/kg\mu_N T_o$. For $k_{max}=2$ and values of $H=H_o$, the maximum or minimum of the correlation may be observed by choosing θ_o and t_o to satisfy the relation:

those states with lifetimes between about 10^{-3} and 10^{-12} seconds. However, there are several problems associated with this kind of experiment. For a non-isotropic angular correlation, the states involved must have spins greater than or equal to 1. This means that, in studying magnetic moments, the quadrupole interaction cannot easily be eliminated as is possible in many spectroscopic or resonance experiments where atomic states with $J = 1/2$ or 0 are used. However, by proper choice of sources, it is often possible to reduce the quadrupole interactions. Since PAC experiments involve the decay of radioactive nuclei, the atom can be left in highly excited states. This is especially true following K-capture or alpha-decay. If the nuclear lifetime is very short, the environment may not have reached equilibrium before the emission of the second radiation and the perturbations acting on the nucleus are not completely known.

In PAC experiments, as with all determinations of μ, the magnetic field at the nucleus must be known. For many of the measurements, the values of μ are determined only to about 5–10% and therefore the diamagnetic and Knight–shift corrections, which are less than 1–2% even for the heaviest atoms, are not important. However, for transition elements, the rare–earths, and the transuranic elements, paramagnetic corrections must be made for the large fields caused by the unfilled inner electron–shells. A table of correction factors, β, for rare–earth ions for temperatures of 50° to 2000°K can be found in [64Gu06].

In an actual angular correlation experiment the time–resolution, counter–efficiencies, geometry, accidental coincidences and the effects of other coincidences which may have been present, must all be taken into account in the evaluation of the moments. A discussion of the treatment of the raw data appears in Frauenfelder and Steffen's paper [65Fr20], p1188.

General discussions of perturbed angular correlations can be found in the many papers already cited. There are also several reviews on particular methods in Hyperfine Interactions [67Fr15]. Discussions of some of the newer techniques and problems can be found in the proceedings of several of the recent international conferences, for example, those at Asilomar, 1967 [68Ma56]; Delft, 1970 [71Va39]; Rehovot, 1970 [71Go39]; and Osaka, 1972 [72Pr21].

Explanation of Table J

Nucleus	Chemical symbol with Z– and A–number
Level	Energy, in keV, of the level for which information is given Ground state levels are indicated by gs.
$T_{1/2}$	Half–life of the level The value quoted is taken from Table of Nuclear Half–lives [68Ma49], Nuclear Data Sheets (through Volume B5), Table of Isotopes [67LeHo], or it is the value used in the referenced article.
I	Nuclear spin, in units of $h/2\pi$, used to obtain μ from the deduced g–value Values enclosed in ( )'s have been determined by resonance or spectroscopic techniques. Values enclosed in [ ]'s have been inferred from decay characteristics
μ	Nuclear magnetic dipole moment, in nuclear magnetons The values of μ obtained by Integral Perturbed Angular Correlations or Attenuated Angular Correlations, which are derived from the measurement of $\omega\tau$, have been corrected to the value of $T_{1/2}$ quoted unless otherwise indicated by an "a". In general, values of μ determined by these techniques are not accurate enough to warrant the application of a diamagnetic correction. Those marked by "d" have had a diamagnetic correction included.
Q	Nuclear electric quadrupole moment, in barns, as given by the experimenter Those values marked by an asterisk, *, indicate that the experimenter has made some polarization or Sternheimer correction in computing the moment.
Refer.	Reference key number

Method	Codes used to designate the specific techniques are:
	AAC attenuation of the angular correlation
	BAO, BAP β–asymmetry from oriented, polarized nuclei
	CDPAC constant delay perturbed angular correlation
	DAAC time differential attenuated angular correlation
	DPAC, DPAD time differential perturbed angular correlation, distribution
	GAO, GAP γ–anisotropy from oriented, polarized nuclei
	IMPAC perturbed angular correlation following implantation
	IPAC, IPAD integral perturbed angular correlation, distribution
	NMR nuclear magnetic resonance
	NRF nuclear resonance fluorescence
	PAC, PAD perturbed angular correlation, distribution
	SpHt nuclear specific heat
	Strob stroboscopic perturbed angular correlation
	SE spin exchange
	αAO α–anisotropy from oriented nuclei
Measured Quantity	Measured quantities from which the moments are derived. Units quoted are as given or as determined from graphs or data presented. There has been a confusion in the units quoted for precessional frequencies in many papers (an interchange of Hz and rad./s). We have tried to correct these, but we include a footnote to the author's quoted unit.
Environment and Comments	Nature of materials used; magnetic fields (external or internal); assumptions made; comments. If there are a series of values for a respective series of conditions, the values and conditions are set off by similar punctuation. The notation (185γ)(89γ) represents coincidences between the 185keV γ and the 89keV γ.

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{8}_{3}$Li	gs	0.85s	(2)	±1.6532[d] *8*		59Co68	BAP-NMR	ν=3.413 *1* MHz	^{7}LiF(polarized n,γ) H_0=5418 *1* G
$^{8}_{3}$Li	gs	0.85s	(2)	positive		62Co08	BAP-NMR		^{7}LiF(polarized n,γ)
								‡Compared Zeeman level transition rates for two senses of circularly polarized rf fields.	
$^{8}_{3}$Li	gs	0.85s	(2)	±1.6532[d] *8*		67Gu14	BAP-NMR	ν=2.0570 *7* MHz	^{7}LiF(polarized n,γ) H_0=3.2649 *4*kG
$^{8}_{3}$Li	gs	0.85s	(2)	±1.65362[p] *22*, ±1.65288[p] *20*, ±1.65270[p] *30*		71Ha67	BAP-NMR		^{7}Li(d,p) recoils in Au,Pt,Pd foils
$^{8}_{3}$Li	gs	0.85s	2	±1.653		71Ot04	BAP-SE		
$^{8}_{5}$B	gs	770ms	[2]	±1.03551[dp] *25*		72Mi19	BAP-NMR		^{6}Li(^{3}He,n) recoils in Pt foil.
$^{10}_{5}$B	720	690ps	[1]	+0.63 *12*		72Av01	IPAC		^{9}Be on Au(p,); H_0=17.6kG
$^{12}_{5}$B	gs	20.4ms	(1)	+1.003 *1*		67Su03 68Su05	BAP-NMR	ν_0/ν_p‡= 1.79641 *32*, 1.79637 *39*; 1.79510 *25*, 1.79526 *29*; 1.79639 *22*	^{11}B(d,p) recoils in Cu;Pt;Au foils. H_0 measured by proton resonance. μ (uncorrected for σ + K) =1.00337 *15*; 1.00270 *11*; 1.00337 *12*
								‡Includes correction of 25.6 ppm for proton resonance in H_2O	
$^{12}_{5}$B	gs	20.4ms	(1)	±0.976 *31*		68Pf03 70Wi17	DPAD		^{11}B(d,p)polarized ^{12}B recoils in Au, Pd; H_0= 8.24 to 15.95G
$^{12}_{5}$B	gs	20.4ms	1		±0.017‡*2*	70Su04 71Mi06	BAP-NMR	eqQ=154 *16* kHz; 49 *5*kHz Q^{12}/Q^{11}=± 0.42 *4*	TiB_2; ZrB_2
								‡Used Q^{11}=+0.04065 *26* (70Ne21)	
$^{12}_{5}$B	gs	20.4ms	(1)	+1.00285‡$^{+15}_{-14}$		70Wi17	BAP-NMR	μ=1.00336 *8*; 1.00324 *6*; 1.00253 *5*; 1.00261 *6*	^{11}B(d,p) recoils in Au;Cu; Pd;Pt;values uncorrected for Knight shift; H_0 measured by proton resonance.
								‡Includes Knight shift estimated from spin relaxation times.	
					+0.030 *8*		BAP-NMR	eqQ=59 *15*kHz	^{11}B(d,p)recoils in Be foils; compared with values for Be; used $\gamma_\infty(B^{3+})$=−0.145
$^{12}_{5}$B	gs	20.4ms	(1)		≈0.0346[p]	71Wi28	BAP-NMR	eqQ=54.9 *6*kHz	^{12}B implanted in Be single crystal.
$^{13}_{5}$B	gs	19ms	[3/2]	±3.17712‡ *51*		71Wi09	BAP-NMR	ν/ν_p=0.379104 *25*	^{11}B(t,p) recoils in Au, Pt, Pd foils.
								‡Includes estimate of Knight shift from ^{12}B	
$^{13}_{5}$B	gs	19ms	[3/2]		±0.08	72Ha68	BAP-NMR	Q^{12}/Q^{13}=0.358[p] *8* eqQ^{13}=130 *2*kHz eqQ^{12}=46.5 *5*kHz	^{11}B(d,p) and (t,p) recoils in Mg crystal
$^{12}_{7}$N	gs	12ms	(1)	+0.4571 *1*		68Su05 67Su09	BAP-NMR	ν/ν_p‡=0.081817 *23*; 0.081850 *23*, 0.081869 *23*; 0.081836 *13*	^{10}B(^{3}He,n) recoils in Al; Cu; Pt; H_0 measured by proton resonance; μ (uncorrected for σ and K)= 0.45699 *13*; 0.45723 *10*; 0.45709 *7*
								‡Includes correction of 25.6 ppm for proton resonance in H_20	
$^{12}_{7}$N	gs	12ms	1‡			71Mi06	BAP-NMR		^{10}B(^{3}He,n) recoils in Nb, Ta
								‡From observed quadrupole spectra	

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{14}_{7}N$	5830	12.4ps	[3]	$1.5 \leq \|\mu\| \leq 2.55^{p}$		72Be60	PAC		$^{12}C(^{3}He,p)$ recoils in He gas or vacuum; used $H_{1s,calc}$=57.3MG
$^{18}_{8}O$	1980	3.3ps	[2]	$0.40 < \|\mu\| < 0.72$		72Go06	AAC		$^{12}C(^{18}O^{7+},O')$; H_{calc} =85.5MG at oxygen nucleus
$^{17}_{9}F$	gs	66s	[5/2]	$\pm4.7224^{d}$ *12*		66Su01	BAP–NMR	ν/ν_p=0.33797, 0.33804	O(d,n)recoils in CaF_2; $H_0 \approx 5$kG
$^{18}_{9}F$	1125	153ns	[5]	+2.840 *65*		67Po09	DPAD	ω=16.6 *3*Mr/s for all cascades	(SiO on Cu)(^{3}He,p); H_0= 6.1 *6*kG
$^{18}_{9}F$	1125	153ns	[5]	+2.860 *30*		67Sc09	DPAD		(CaO on Au)(^{3}He,p); H_0= 15.71kG
$^{19}_{9}F$	197	89ms	[5/2]	+3.69 *4*		61Fr07	DPAD		LiF; CaF_2; NaF(p,p')
$^{19}_{9}F$	197	89ns	[5/2]		±0.11 *2*	64Su01	DPAD	ν_0=12.4 *6*MHz	ClF(p,p')
$^{19}_{9}F$	197	89ns	[5/2]	+3.59 *2*		67Br14	DPAD		(CaF_2 on Cu)(p,p'); (α,α'); H_0=10465G measured by proton resonance
$^{19}_{9}F$	197	89ns	[5/2]	±3.605 *8*		69Bl18	DPAD	ω_p/ω=3.874 *8*	Thick CaF_2 target (p,p'); H_0=2.5 to 18.8kG
$^{20}_{9}F$	gs	11s	[2]	$+2.094^{d}$ *2*		63Ts01	BAP–NMR		CaF_2 crystal(polarized n,); H_0measured by proton resonance
$^{20}_{9}F$	gs	11s	[2]	$\pm2.0935^{d}$ *9*		67Gu14	BAP–NMR	ν=2.1820 *7*MHz	CaF_2 crystal (polarized n,) H_0=2.7358 *4*kG
$^{20}_{9}F$	gs	11.2s	[2]		±0.064 *20*	73Ac03	BAP–NMR	eqQ=±5.77 *2*MHz Q/Q^{19}(197keV)= ±0.108 *4*	MgF_2 crystal(polarized n,); H_0=4.35kG
$^{19}_{10}Ne$	238	17.7ns	[5/2]	−0.740 *8*		69Bl02	DPAD	$\omega/\omega(^{19}F-197)$= −0.2054 *15*	CaF_2(pulsed p,n); $H_0 \approx 34$kG
$^{20}_{11}Na$	gs	408ms	2	$\pm0.3694^{p}$ *10*		71Ot04 70Bo47	BAP–SE		^{20}Ne(d,2n)
$^{22}_{11}Na$	583	243ns	[1]	+0.535 *10*		66Su07	DPAD	ω=15.65 *25*Mr/s	^{210}Po in 30N HF; H_0=6111 *30*G
$^{22}_{11}Na$	583	243ns	[1]	+0.555 *17*		67Sc09	DPAD		(CaF_2 on Cu)(α,n)
$^{29}_{15}P$	gs	4.2s	[1/2]	$\pm1.2349^{d}$ *3*		71Su13	BAP–NMR	μ=1.23374 *9*; 1.23356 *3*	(Si on Cu)(d,n) recoils in red P; Si
$^{37}_{18}Ar$	1610	4.6ns	[7/2]	−1.33 *5*		71Ra22	DPAD		K^{37}Cl(pulsed p,n); H_0=16.6 to 47kG calibrated using ^{19}F(197 level)
$^{36}_{19}K$	gs	245ms	2	$\pm0.547^{p}$ *2*		72Sc35	BAP–SE		(^{87}Rb + ^{36}Ar)(p,n)
$^{37}_{19}K$	1380	10.5ns	[7/2]	+5.2 *3*		71Ra22	DPAD		(Ca on Au)(p,α); H_0=8.2kG calibrated using ^{19}F(197 level)
$^{41}_{19}K$	1290	7.3ns	[7/2]	+4.41 *5*		69Bl07	DPAD		(^{41}K on Ta)(p,p'); H_0=34kG; used $g_{ex}(^{19}F-197)$=1.442 *3*

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{40}_{20}Ca$	3740	41ps	[3]	+0.45^{p}‡ *24*		70Be71 72He19	IMPAC	$\omega\tau$=4.0 *17* mr	(Ca on Fe)(p,p′); H_o=1 kG, H_{hf}=−92 *6*kG; neglected transient fields
								‡H_{hf} at Ca in doubt (71Be69)	
$^{40}_{20}Ca$	4490	272ps	[5]	+1.55^{p}‡ *25*		70Be71 72He19	IMPAC	$\omega\tau$=54 *9* mr	(Ca on Fe)(p,p′); H_o=1kG, H_{hf}=−92 *6*kG,neglected transients fields
								‡H_{hf} at Ca in doubt (71Be69)	
$^{42}_{20}Ca$	3190	5.5ns	[6]	−2.52 *18*		70Ma39	IPAD		(KI on Pt)(α,p); H_o=10.3kG
$^{42}_{20}Ca$	3190	5.5ns	[6]	-3.00^{+12}_{-18}		71No06	DPAD	ω=−58.0 *25*Mr/s‡ =-74.8^{+30}_{-40} Mr/s‡	Ca metal(pulsed α,2p); H_o=24.20 *15*, 31.5 *3*kG; assumed K negligible
								‡Unit given as MHz	
$^{41}_{21}Sc$	gs	0.59s	[7/2]	±5.43^{dp} *2*		72Su05	BAP−NMR		^{40}Ca(d,n)recoils in Pt foil at 4.2°K; expect K<0.26%
$^{43}_{21}Sc$	3123	450ns	[19/2]	+3.144‡ *19*		71Na10	DPAD Strob		Ca metal(pulsed α,p); H_o= 5.96 *2*, 3.64 *1*; ~7.5kG
								‡Assumed K=(0.25 *20*)%	
$^{44}_{21}Sc$	69	153ns	[1]	+0.35 *2*		62Be19	DPAC		TiOF solution;H_o=2648; 5563G
$^{44}_{21}Sc$	69	153ns	[1]	+0.342 *6*		67Ri06	DPAC	ω=12.35Mr/s	^{44}Ti in HCl; H_o=7550G
$^{44}_{21}Sc$	69	153ns	[1]		±0.18^{p}‡ *3*	69Be77	PAC		$BaTiO_3$
								‡Antishielding correction made	
$^{47}_{21}Sc$	767	274ns	[3/2]	±0.35 *5*		68Fo02	DPAC	ω=6.9 *10* Mr/s	(^{44}Ca on Cu)(α,p); H_o= 6.10 *6*kG
$^{48}_{23}V$	gs	16d	(4)	±1.63 *10*		66Ca04	GAP	μH=±1.34 *8*nm−kG	Fe−V; H_{int}=−82kG; T measured by ^{54}Mn in Cu
$^{48}_{23}V$	306	7.09ns	[2]	+0.376 *34*		67Au02	IPAC	$G_2\omega\tau$=0.331 *13*r, $G_2\omega\tau$=0.407 *23*	liquid source, H_o=36.4kG; ^{48}Cr in Cu metal, H_o=46.6kG; G_2=0.91 *7*; 0.95 *6*
$^{48}_{23}V$	306	7.09ns	[2]	±0.44^{p} *19* ±0.51^{p} *23*		69Pa12	IPAC		dilute $BaCrO_4$ in HNO_3; H_o=14.2kG
$^{51}_{23}V$	320	173ps	[5/2]	+4.2 *7*		63Kr02	NRF		(V metal powder)(γ,γ) using gaseous $^{51}CrCl_2O_2$ γ−source; H_o=24.7kG; assumed K=+0.6% (H_{int} uncertain ~10%−65Ma27)
$^{51}_{23}V$	320	173ps	[5/2]	+3.85 *32*		68Ke09	IPAD	$\omega\tau$=−0.163 *14*r, $\omega\tau$=−0.161 *21*, $\omega\tau$=−0.159 *20*	4.5%V−Fe alloy, 1%V−Fe alloy, 2%V−Fe alloy CEx with p; H_{int}=87.3 *18*kG
$^{51}_{24}Cr$	749	7.5ns	[3/2]	±1.1^{bf} *7*		69Ku18	DPAD		^{50}Cr(d,p)
$^{52}_{25}Mn$	gs	5.7d	(6)	positive‡		57Hu80	GAP		$Ce_2Mg_3(NO_3)_{12}$•*24*
								‡Measured circular polarization of γ	
$^{52}_{25}Mn$	gs	5.7d	6?	±2.98 *15*		61Je04	GAO		$La_2Mg_3(NO_3)_{12}$•*24*
$^{52}_{25}Mn$	gs	5.7d	(6)	+3.059 *2* or +3.0764 *6*	+0.53 *11*	70Ni11	GAO−NMR	g^{52}/g^{55}= 0.36961 *7* Q^{52}/Q^{55}=+1.5 *2*	(Ce,La)$_2Mg_3(NO_3)$12•*24* at 0.1°K;used μ^{55}_{cor}=+3.449 *2* or 3.4680 *3* and Q^{55}=+0.35 *5*
$^{54}_{25}Mn$	gs	312d	(3)	±2.5 *2* positive‡		60Ba42	GAP	g^{52}/g^{54}=0.60	(Zn,Ni)SiF_6•*6*; CMN; used μ^{52}=3.05
								‡Measured circular polarization of 840γ	
$^{54}_{25}Mn$	gs	312d	3	±3.28 *6*		61Je04	GAO		$La_2Mg_3(NO_3)_{12}$•*24*

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{54}_{25}$Mn	gs	312d	(3)	±3.284[d] 5 or ±3.302[d] 5		67Te01	GAP–NMR	ν=189.9 3MHz	^{54}Mn in Fe; 0.013°K; H_o=675G; H_{hf}=−229.00kG; recalculated using μ^{55}_{cor}=3.449 2 or 3.4680 3
$^{54}_{25}$Mn	gs	312d	(3)	+3.278 2 or +3.2959 4	+0.35 8	70Ni11	GAO–NMR	g^{54}/g^{55}=+0.79199 6; Q^{54}/Q^{55}=+0.99 10	$(Ce,La)_2Mg_3(NO_3)_{12}\cdot 24$ at 0.1°K, used μ^{55}=+3.449 2 or 3.4680 3 and Q^{55}=+0.35 5
$^{56}_{25}$Mn	gs	2.58h	(3)	±3.3 3 positive‡		60Ba06	GAP	g^{52}/g^{56}=0.47 5	CMN; used μ^{52}=3.05
								‡Measured circular polarization of 845γ	
$^{54}_{26}$Fe	1408	1.0ps	[2]	+2.86‡ 56		72Hu08 74Hu01	IMPAC	$\Delta\theta$=−18.9 48mr, $\Delta\theta$=−12.3 22mr	CEx with ^{16}O, recoils in Fe, $Fe_{0.8}$–$Co_{0.2}$; H_{hf}=−330, −364kG for Fe, alloy respectively
								‡Analyzed $\Delta\theta$ vs E_{recoil} with transient field theory. Assumed 12% radiation damage correction to H_{hf}.	
$^{54}_{26}$Fe	2950	1.22ns	[6]	±8.22 18		71He21	DPAD	ω=2230 50 Mr/s	^{54}Fe(p,p'); H_o=2.5kG; H_{int}=−339kG
$^{56}_{26}$Fe	847	6.9ps	[2]	+1.12 32		61Me11	NRF	$\omega\tau$=±0.485°	Fe(γ,γ)using gaseous $^{56}CoCl_2$ γ–source; H_{int}=3.17kG
$^{56}_{26}$Fe	847	6.9ps	[2]	+1.23‡ 34		63Ap01	IPAC	$\omega\tau$=7.9‡ 37mr	^{56}Co diffused into Fe; H_{int}=−330 10kG
								‡Corrected for other γ's coincident with 845γ and for influence of field on position of peaks	
$^{56}_{26}$Fe	847	6.93ps†	[2]	+1.20‡ 20		72Hu08 74Hu01	IMPAC		Fe(p,p')recoils in Fe
								‡$\Delta\theta$ vs E_{recoil} fit with transient field theory; †Value used in analysis	
$^{57}_{26}$Fe	136	8.8ns	[5/2]	±0.915 45		64Ko16	DPAD		(^{57}Fe on Cu)(p,p'); H_{int}=−333kG
$^{57}_{26}$Fe	136	8.8ns	[5/2]	+0.85 12		69Sp05	IPAD	$\omega\tau$=0.230 36r	Stainless steel (14MeV O^{3+},O'); H_o=11.0kG
$^{57}_{26}$Fe	367	7ps	[3/2]	$\lvert\mu\rvert$<0.6 or $H_{int}\neq$330kG		69Sp05	IMPAC		(^{57}Fe on Fe)(30MeV O^{4+},O'); H_{hf}=330kG assumed
$^{57}_{26}$Fe	367	7ps	[3/2]	$\lvert\mu\rvert$<0.9		74Hu01	IMPAC	$\Delta\theta$=6 9mr	^{57}Fe recoils in $Fe_{.8}Co_{.2}$ H_{hf}(Static)=−364kG; Φ_t/g=−14.5mr expected from transient field theory including radiation damage correction to H_{hf}
$^{57}_{26}$Fe	707	3ps	[5/2]	$\lvert\mu\rvert$<1.0		74Hu01	IMPAC	$\Delta\theta$=4.0 55mr	^{57}Fe recoils in $Fe_{.8}Co_{.2}$;H_{hf} (Static)=−364kG;Φ_t/g=−13.6mr expected from transient field theory including radiation damage corrections to H_{hf}
$^{58}_{26}$Fe	811	6.4ps	[2]	+1.08 34		69Si13	IPAC	$\omega\tau$=7.73 175 mr	^{58}Co in Fe; $H_o\approx$5kG, H_{hf}=323.4kG at room T
$^{59}_{26}$Fe	gs	45d	(3/2)	±1.1 2		70Ts04	GAO	A^{59}/k=6.2 11m°K	$Nd_2Zn_3(NO_3)_{12}\cdot 24$ crystal; $Ce_2Zn_3(NO_3)_{12}\cdot 24$ crystal; used $A/k(^{57}Fe)$=1.57 4m°K
$^{55}_{27}$Co	gs	18h	[7/2]	±5.3 or 4.5		60Ba20	GAP	g^{58}/g^{55}=1.33 or 1.55 10	$Ce_2Mg_3(NO_3)_{12}\cdot 24$;used I^{58}=2, μ^{58}=4.03
$^{55}_{27}$Co	gs	18h	[7/2]	±4.3 3		61Ch12	GAO		(Ni,Zn)$SiF_6\cdot 6$ crystal; ^{60}Co used as thermometer

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{57}_{27}$Co	gs	270d	(7/2)	+4.722[d] *17*	+0.49 *9*	72Ni01	GAO–NMR	A=+243.46 *48*MHz B=+317.7 *5*Mhz P=+0.28 *4*MHz	$(Ce,La)_2(Mg,Co)_3(NO_3)_{12}$•24; for ^{59}Co used A=+79.096 *4*, B=+103.91 *4*, P=+0.0720 *4* in units of (hcx10^{-4}cm^{-1}) from ENDOR and μ^{59}_{cor}=4.616 *9*, Q^{59}=+0.38
$^{57}_{27}$Co	1378	19.4ps	[3/2]	+2.8 *9*		67Be17	IPAC		Fe(α,); H_{int} =−290.6 *9*kG
$^{57}_{27}$Co	1378	19.4ps	[3/2]	+3.0 *6*		70Va10	IMPAC	ωτ=70mr	^{54}Fe(α,n); H_{int}=−290.6 *9*kG
$^{58}_{27}$Co	gs	71.3d	[2]	±3.5 *3*		52Da19	GAO		$(Co,Cu,Zn)Rb_2(SO_4)_2$•*6*
$^{58}_{27}$Co	gs	71.3d	[2]	+4.035 *8*	+0.21 *3*	72Ni01	GAP–NMR	A=+362.73 *4*MHz B=+476.75 *20*MHz P=+0.41 *2*MHz	See ^{57}Co (72Ni01) above
$^{58}_{27}$Co	54	10.2μs	[4]	+4.184 *8*		70Be33	Strob DPAD	B_o=627.4 *10* G for T_o=1μs	^{57}Fe(pulsed d,n); target at T=930°C ($T>T_C$)
$^{59}_{27}$Co	1292	564ps	[3/2]	+1.99 *35*		67Ag03	IPAC		dilute $FeCl_3$; dilute $FeCl_2$; $K_3Fe(CN)_6$; H_o=18.2kG, β=1.5
$^{59}_{27}$Co	1292	564ps	[3/2]	+1.64 *14*		71Ar07	IPAC AAC	g=+1.11 *10* g=±1.04 *16*	^{59}Co–Fe;H_o=13kG,H_{int}=−276kG; ^{59}Co–Cu, ^{59}Co–Ni, ^{59}Co–Fe
$^{60}_{27}$Co	gs	5.26y	(5)	±3.5 *5*		54Bl07	GAO	βT=0.0112°K	$(Co,Cu,Zn)Rb_2(SO_4)_2$•6; used βT^{59}=0.021°K; μ^{59}=4.62
$^{60}_{27}$Co	gs	5.26y	(5)	±4.3 *2*		55Po17	GAO		$(Co,Cu,Zn)(NH_4)_2(SO_4)_2$•*6* crystal
$^{60}_{27}$Co	gs	5.26y	(5)	positive		55Wh42	GAP		$Ce_2Mg_3(NO_3)_{12}$•*24*; measured circular polarization of γ
$^{60}_{27}$Co	gs	5.26y	(5)	+3.790 *8*	+0.42 *5*	72Ni01	GAP–NMR	A=+136.22 *7*MHz B=+179.08 *8*MHz P=+0.113 *5*MHz	See ^{57}Co (72Ni01) above
$^{63}_{28}$Ni	87.2	1.72μs	[5/2]	+0.752 *2*		70Bl06 71Bl15	DPAC		^{62}Ni(pulsed d,p); H_o=18.33kG
$^{62}_{29}$Cu	41	4.80ns	[2]	±1.21 *6*		71Bl15	DPAC		^{62}Ni(pulsed p,n); H_o=28.0kG at 870°,970°K;H_o=5.55,11.1kG at 290°K,H_{int}=−41.8, −36.4kG
$^{62}_{29}$Cu	41	4.80ns	[2]	±1.34 *12*		71Bo64	IPAC DPAC	ωτ=-0.56^{+56}_{-28}r ω=−44 *8*Mr/s	Ni(α,2n); aqueous ZnCl; H_o= 13.20 *15*kG
$^{62}_{29}$Cu	390	11.5ns	[3]	±1.89[p]		69Su13	PAC		aligned ^{60}Ni(pulsed α,np), H_{hf}=−47.2kG
$^{64}_{29}$Cu	1590	20.4ns	[6]	+1.02[p] *6*		71Su09	PAC		aligned ^{62}Ni(pulsed α,np)
$^{64}_{29}$Cu	1590	20.4ns	[6]	+1.06[p] *3*		72Bl14	DPAD		
$^{66}_{29}$Cu	1154	596ns	[6]	+1.038[p] *3*		72Bl14	DPAD		
$^{67}_{30}$Zn	185	1.01ns	[3/2]	+0.38 *12*		68Li02	IPAC	ωτ=3.1°‡	Cu foils(α,2n); H_o=31.2kG
								‡Corrected for strong annihilation background	
$^{67}_{30}$Zn	185	1.01ns	[3/2]	±0.51 *6*		69Bo41	IPAC		GaCl; H_o=18.3kG
$^{67}_{30}$Zn	185	1.01ns	[3/2]	+0.35 *12*		71Re01	DPAC IPAC		
$^{67}_{30}$Zn	605	340ns	[9/2]	−1.093[p] *20*		72Be61	DPAD		
$^{67}_{32}$Ge	734	70ns	[9/2]	−0.945[p] *30*		72Be61	DPAD		
$^{67}_{32}$Ge	734	70ns	[9/2]			72Ha69	DPAD	Q/Q^{69}(398keV)= 1.22[p] *2*	Zn(pulsed α,); Ga(pulsed p,); $T<T_{melt}$
$^{69}_{32}$Ge	398	2.8μs	[9/2]	−1.0008[d] *32*		70Ch05	Strob	$B_{o\ corr}$= 2.951 *10*kG for T_o=1μs	liquid ^{69}Ga(pulsed p,n); used K_{Ga}=4.49 *4*x10^{-3}, σ_{Ge}=2.8x10^{-3}

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{70}_{32}$Ge	1040	1.3ps	[2]	+1.18‡ *58*		69He11	IMPAC	$\Delta\theta$=−11.2 *15*mr	(^{70}Ge on Fe)(^{16}O,O′); H_o~1kG; H_{int}=+70 *3*kG
								‡Includes estimate of transient field	
$^{70}_{32}$Ge	1040	1.3ps	[2]	+1.76^{c}‡ *42*		74Hu01 (69He11)	IMPAC		H_{hf}=+70 *3*kG
								‡Included effect of decays-in-flight	
$^{71}_{32}$Ge	175	79ns	[5/2]	+1.015 *10*		68Mo12	DPAD		AuGa$_2$(pulsed p,n), H_o=15.98kG; (Ga on Au)(pulsed p,n), H_o=26.04kG
$^{71}_{32}$Ge	175	79ns	[5/2]			72Ha69	DPAD	Q/Q^{69}(398keV)= 0.219^{p} *4*	Zn(pulsed α,); Ga(pulsed p,); $T<T_{melt}$
$^{71}_{32}$Ge	198	20.2ms	[9/2]	−1.022 *23*		70Be29	DPAD		liquid ^{71}Ga(pulsed p,n);
				−1.0396^{d} *23*			Strob	B_o=355.8 *8*G for T_o=64μs	H_o=98.7, 72.4G for DPAD
$^{71}_{32}$Ge	198	20.2ms	[9/2]		±0.28^{p} *10*	72Ri13	‡		liquid Ga(pulsed p,n)
								‡Measured relaxation time as f(T) by GAO	
$^{72}_{32}$Ge	835	3.14ps	[2]	+1.00 *50*		69He11	IMPAC	$\Delta\theta$=−9.9 *17*mr	(^{72}Ge on Fe)(^{16}O,O′); H_{int}=+70 *3*kG
$^{72}_{32}$Ge	835	3.14ps	[2]	+1.16^{c}‡ *28*		74Hu01 (69He11)	IMPAC		H_{hf}=+70 *3*kG
								‡Included effect of decays-in-flight	
$^{74}_{32}$Ge	596	12ps	[2]	+0.92 *46*		69He11	IMPAC	$\Delta\theta$=−11.3 *13*mr	(^{74}Ge on Fe)(^{16}O,O′); H_{int}=+70 *3*kG
$^{74}_{32}$Ge	596	12ps	[2]	+0.94^{c}‡*20*		74Hu01 (69He11)	IMPAC		H_{hf}=+70 *3*kG
								‡Included effect of decays-in-flight	
$^{76}_{32}$Ge	563	17.6ps	[2]	+0.74 *36*		69He11	IMPAC	$\Delta\theta$=−9.9 *15*mr	(^{76}Ge on Fe)(^{16}O,O′); H_{int}=+70 *3*kG
$^{76}_{32}$Ge	563	17.5ps	[2]	+0.72^{c}‡ *16*		74Hu01 (69He11)	IMPAC		H_{hf}=+70 *3*kG
								‡Included effect of decays-in-flight	
$^{72}_{33}$As	215	80ns	[3]	+1.575^{p} *18*		72Be62	DPAD		^{72}Ge(p,n)
$^{73}_{33}$As	66.9	5.0ns	[5/2]	+1.62 *10*		63Bo26	DPAC	ν=116 *6*MHz	
$^{73}_{33}$As	427	5.8μs	[9/2]	+5.157‡ *32*		69Qu03	PAD–NMR	$\|g\|(1+K)$= 1.1495 *57*	liquid ^{71}Ga metal(α,2n); H_1, ν_1=8.5G, 858kHz; 12.4, 854; 17.0, 856; 14.6, 925
								‡Assumed K=+0.32%	
$^{73}_{33}$As	427	5.8μs	[9/2]	±5.234 *13*		70Be23	Strob		solid ^{72}Ge(d,n)
$^{74}_{33}$As	274	26.8ns	[3]	+2.428^{d} *30*		71Ch10	DPAD	$\omega/\omega(^{19}$F−197keV)= +0.555 *4*	^{74}Ge metal(pulsed p,n); H_o=21kG; Knight shift negligible
$^{75}_{33}$As	265	11.9ps	[3/2]	±1.11 *33*		71Be89	IPAC	$\omega\tau$=9.0 *24*mr	Se in Fe; H_{eff}=150 *17*kG
$^{75}_{33}$As	265	11.9ps	[3/2]	+0.93^{p} *24*		72Ch36	IPAC	$\omega\tau$=16.2 *4*mr	implantation in Fe foil by mass-separator; H_{hf}=319 *33*kG measured using 280keV level
$^{75}_{33}$As	280	0.28ns	[5/2]	+0.90 *28*		60Ma03	IPAC	$G_2\omega\tau$=−17.2 *34*mr	^{74}Se(pile n,) dissolved in HNO_3; H_o=13kG; β=1, G_2~1
$^{75}_{33}$As	280	0.28ns	[5/2]	+0.83^{p} *18*		66Ag01	IPAC	$\omega\tau$=13.6 *22*mr	material not given; H_o=20kG
$^{75}_{33}$As	280	0.28ns	[5/2]	±2.4^{p} *3*		70Az01	IPAC		^{75}Se in HNO_3; H_o=10kG; used β=1, G_2=1
$^{75}_{33}$As	280	0.28ns	[5/2]	±0.91 *12*		71Be89	IPAC	$\omega\tau/H$= 0.698 *75*r/MG	H_2SeO_3 in dilute HCl,H_o=20kG
								$\omega\tau$=104.7 *35*mr	Se in Fe, find H_{eff}=150 *17*kG and H_{hf}=145 *18*kG
$^{76}_{33}$As	45	2.60μs	[1]	+0.558 *1*		71Be90	Strob	B_o=1175 *2*G for T_o=1μs	metallic ^{76}Ge(p,n)
$^{77}_{33}$As	473	116μs	[9/2]	±5.508^{p} *9*		70Be78	Strob		liquid ^{76}Ge metal(d,n)

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{76}_{34}$Se	559	11.1ps	[2]	+0.80 *24*		67Mu10	IPAC	$\omega\tau$=20 *3*mr	pure metal; Fe–As(pile n,); H_{int}=+650 *150*kG
$^{76}_{34}$Se	559	11.1ps	[2]	+0.80 *22*		69He11	IMPAC	$\Delta\theta$=−27.1 *15*mr	(^{76}Se on Fe)(^{16}O,O′); $H_o\approx$1kG H_{int}=+650 *150*kG
$^{77}_{34}$Se	249	9.4ns	[5/2]	+1.20 *15*		64En01	DPAC	ω=75 *8*Mr/s	K^{77}Br; H_o=33kG
$^{77}_{34}$Se	440	24ps	[5/2]	+1.02 *28*		70Ro32	IMPAC	$\Delta\theta$=−53.0 *88*mr	recoils in Fe; H_{int}= +650 *150*kG; $H_t\tau_t$=+4.5 *23*MG−ps
$^{78}_{34}$Se	614	8.6ps	[2]	+0.82 *22*		69He11	IMPAC	$\Delta\theta$=−24.0 *16*mr	(^{78}Se on Fe)(^{16}O,O′); H_{int}=+650 *150*kG
$^{80}_{34}$Se	666	8.05ps	[2]	+0.84 *24*		69He11	IMPAC	$\Delta\theta$=−23.9 *11*mr	(^{80}Se on Fe)(^{16}O,O′); H_{int}= +650 *150*kG
$^{82}_{34}$Se	655	11.3ps	[2]	+0.86 *24*		69He11	IMPAC	$\Delta\theta$=−29.5 *8*mr	(^{82}Se on Fe)(^{16}O,O′); H_{int}=+650 *150*kG
$^{78}_{35}$Br	181	100μs	[4]	±4.100‡ *12*		71Br31	PAD–NMR		molten Se–Tl(pulsed p,n); H_o=6.5G
								‡Uncorrected for Knight shift or diamagnetism	
$^{78}_{35}$Br	181	100μs	[4]	+4.08‡ *8*		71In04	DPAD		Molten Se–Tl(390°C) (pulsed p,); H_o=51.5 *5*, 63.8 *1*, 96.3 *9*G τ_{relax}=40 *30*μs
								‡Uncorrected for Knight shift or diamagnetism	
$^{81}_{35}$Br	540	35μs	[9/2]	±5.84‡ *7*		71Br31	PAD–NMR		molten Se–Tl (pulsed d,n); H_o=10.4G
								‡Uncorrected for Knight shift or diamagnetism	
$^{81}_{35}$Br	540	35μs	[9/2]	±5.674‡ *45*		71Ch28	Strob	ω_o=391.70kr/s for n=2; H_o=64.87G	Se–Tl at 450°C(pulsed 10MeV d,); τ_{relax}=24 *11*μs
								‡Uncorrected for Knight shift or diamagnetism	
$^{82}_{35}$Br	gs	36h	(5)	positive		71Hi12	BAP		^{82}Br and ^{57}Co implanted in Fe; $T\sim$30m°K
$^{79}_{36}$Kr	148	77.7ns	[5/2]	+1.122 *10*		68Bl04	DPAD		aqueous(K^{19}F+K^{79}Br)(pulsed p,n); $H_o\sim$25kG; used g(^{19}F$_{ex}$)=1.445 *3*
$^{83}_{36}$Kr	9.3	143ns	[7/2]	−1.82†^{p} *25*		67Mi17	DPAC	2ω_{spin}= 29.6†Mr/s‡	RbCl at 23°C; H_o=1.7kG;
					$\approx$1^p				polycrystalline $Rb_2Mg(SO_4)_2$•6
								‡Unit given as MHz †Values as reported in paper	
$^{86}_{38}$Sr	?	460ns	[8]	−1.93^p *12*		72Ha66	DPAD	ω=8.46 *50*Mr/s	^{88}Sr(p,n); H_o=7.27kG
$^{86}_{39}$Y	243	28.5ns	[2]	−1.06 *6*		68Tr11	DPAC		As(^{16}O,5n)Zr, chem; Zr in 1M HF solution; $H_o\sim$41kG; β=1 assumed
$^{90}_{40}$Zr	3590	130ns	[8]	±10.84 *14*		70Na13 71Na16	Strob	ω=78.55 *79*Mr/s‡	Sr metal(α,2n);H_o=12.00 *4*kG; K=0.87% assumed
								‡Unit given as MHz	
$^{91}_{40}$Zr	>2265	29.0ns	[15/2]	±5.32^p *8*		72Ba82	DPAD		^{88}Sr(α,n)

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{91}_{41}$Nb	2378	10.0ns	[17/2]	$\pm10.62^{p}$ *34*		72Ba82	DPAD		^{89}Y(α,2n)
$^{95}_{41}$Nb	gs	35d	[9/2]	±6.3 *6* $\mu H<0$		67Ca07	GAP		dilute Nb–Fe; Nb–Co alloys; H_{int}(in Fe)=255kG from NMR measured circular polarization of 768γ
$^{92}_{42}$Mo	2761	190ns	[8]	±11.2 *6*		70Co28 71Co08	DPAC	ω=25.5 *12*Mr/s	^{90}Zr foil(α,2n); H_o=3.8 *1*kG
$^{92}_{42}$Mo	2761	190ns	[8]	±11.27 *13*		70Na13 71Na16	Strob	ω(1)= 70.37 *63*Mr/s‡ ω(2)= 71.05 *64*Mr/s‡ ‡Unit given as MHz	(^{90}Zr metal on Zr)(α,2n);H_o= 10.39 *2*kG; (1)=773γ, (2)= 1511γ
$^{94}_{42}$Mo	2953	97.7ns	[8]	$\pm10.54^{p}$ *16*		72Fa16	DPAD		^{92}Zr(α,2n); H_o=15.85kG
$^{95}_{42}$Mo	204	760ps	[3/2]	-0.55 *6*		66An02	IPAC	$\omega\tau$=−44 *3*mr $\omega\tau$=−37.5 *80*mr	solid Mo(d,) liquid $HTcO_4$+H_2MoO_4 in HNO_3; H_o=22.5 *3*kG
$^{95}_{42}$Mo	204	760ps	[3/2]	-0.39 *3*		70Bo28	IPAC	$\omega\tau$=+28.0 *17*mr (average for 2 cascades)	Nb foil(α,2n); H_o=20.6 *4*kG assumed
$^{98}_{42}$Mo	787	3.5ps	[2]	$+0.68$ *36*		69He11	IMPAC	$\Delta\theta$=−12.1 *30*mr	(^{98}Mo on Fe)(O,O′); H_o~1kG; H_{int}=−256 *5*kG
$^{100}_{42}$Mo	536	10ps	[2]	$+0.68$ *36*		69He11	IMPAC	$\Delta\theta$=−8.0 *10*mr	^{100}Mo on Fe(O,O′); H_{int}=−256 *5*kG
$^{96}_{43}$Tc	gs	4.3d	[6]	±4.60 *14*		71Fo24	GAP–NMR	ν=173.23 *5*MHz, 171.45 *5*, 168.88 *8*	Tc–Fe; H_o=1.317,4.39,8.78kG; Obtain g from slope of ν vs H_o and H_{int}=−298 *10*kG from intercept
$^{99}_{43}$Tc	141	192ps	[7/2]	±3.8 *12*		68Za04	IPAC	$\omega\tau$=30 *10*mr	solid MoO_3; H_o=20 *1*kG
$^{99}_{43}$Tc	141	192ps	[7/2]	$+4.7$ *12*		69In07	IPAC	$\omega\tau$=+0.58 *10*r	Mo–Fe(pile n,); assumed H_{int}=−320 *65*kG
$^{99}_{43}$Tc	181	3.59ns	[5/2]	±3.6 *5* positive		58Ra16	AAC IPAC		Mo wire disolved in HNO_3; H_o=10kG
$^{99}_{43}$Tc	181	3.59ns	[5/2]	$+3.6$ *4*		59Bo43	IPAC	G_2=0.81 *5*	fission Mo in $(NH_4)_2MoO_4$; H_o=15.55kG (H_{int} uncertain ~10%,65Ma27)
$^{99}_{43}$Tc	181	3.59ns	[5/2]	$+3.6$ *3*		65An02	IPAC		$(NH_4)_2MoO_4$; H_o=16.00 *25*kG
$^{99}_{43}$Tc	181	3.59ns	[5/2]	$+3.28$ *6*		71Wi08	DPAC		Tc–Cu; H_o=29.80 *15*kG
$^{98}_{44}$Ru	654	5.9ps	[2]	$+0.60$ *34*		69He11	IMPAC	$\omega\tau$=−5.0 *40*mr	(^{98}Ru on Fe)(^{16}O,O′); H_{int}=−505 *15*kG
$^{98}_{44}$Ru	654	5.9ps	[2]	$+0.78^{c}$‡ *60*		74Hu01 (69He11)	IMPAC	‡Used H_{hf} (IMPAC) = −359 *44*kG, based on g_{ave}(2+)=0.40 *3*, and Φ_t=−10.7 *24*mr; included effect of decays-in-flight	
$^{99}_{44}$Ru	gs	–	(5/2)	-0.623‡ *21*		65Ma27	DPAC	‡Using $\mu(90)/\mu(gs)$=+0.455 *16* from Mössbauer experiments (66Ki02) and $g(90)$=−0.189 *4*; Ru in Cu	
$^{99}_{44}$Ru	90	20.7ns	(3/2)	-0.392 *40*		64Bo28	DPAC	ω= 38.7 *11*x10^6s^{-1}‡ ‡Unit as given	liquid $RhCl_3$ in 3N HCl; (H_{int}uncertain ~10%,65Ma27)
$^{99}_{44}$Ru	90	20.7ns	(3/2)	-0.284 *6*		65Ma27	DPAC	g=−0.181 *2* g=−0.189 *2* g=±0.184 *10*	liquid source; H_o=41.6 *4*kG Ru in Cu; H_o=41.5 *4*kG, $\beta\approx$0.958 Ru in Ni; H_{int}=−180 10kG
				negative			IPAC		

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{100}_{44}$Ru	540	11.9ps	[2]	+1.02 *13*		66Au06	IPAC	$\omega\tau$=−17.8 *12*mr	^{100}Ru in Fe; H_o=10kG, H_{int}=−442 *31*kG
$^{100}_{44}$Ru	540	11.9ps	[2]			69He11	IMPAC	$\Delta\theta$=3.3 *32*mr	(^{100}Ru on Fe)(^{16}O,O′); $H_o\approx$1kG; H_{int}=−505 *15*kG
$^{100}_{44}$Ru	540	11.9ps	[2]	+0.94^{c}‡ *30*		74Hu01 (69He11)	IMPAC	‡See ^{98}Ru(654), 74Hu01	
$^{101}_{44}$Ru	127	550ps	[3/2]	−0.310 *26*		66Au06	IPAC	$\omega\tau$=+336 *13*mr	^{101}Ru in Fe; H_o=10kG, H_{int}=−442 *31*kG
								$\omega\tau$=+130 *4*mr	^{101}Ru in Ni; H_{int}=−178 *8*kG
$^{102}_{44}$Ru	475	17.6ps	[2]	+0.80 *18*		66Au06	IPAC	$\omega\tau$=−20.9 *42*mr	^{102}Ru in Fe; H_o=10kG, H_{int}=−442 *31*kG
$^{102}_{44}$Ru	475	17.6ps	[2]	±0.76^{ap} *50*		68Fr17	PAC	$\omega\tau$=−22 *14*mr	Ru diffused in Fe; H_{int}= 500 *2*kG
$^{102}_{44}$Ru	475	17.6ps	[2]			69He11	IMPAC	$\Delta\theta$=2.8 *44*mr	(^{102}Ru on Fe)(^{16}O,O′); H_{int}=−505 *15*kG
$^{102}_{44}$Ru	475	17.6ps	[2]	+0.741 *62*		72Jo06	IPAC	$\omega\tau$=−21.7 *12*mr	Rh in Fe at liquid He temp; H_o=22kG; H_{hf}=−503 9kG
$^{102}_{44}$Ru	475	17.6ps	[2]	+0.62^{c}‡ *24*		74Hu01 (69He11)	IMPAC	‡See ^{98}Ru(654), 74Hu01	
$^{104}_{44}$Ru	358	58ps	[2]	+0.58 *8*		69He11	IMPAC	$\Delta\theta$=47.8 *44*mr	(^{104}Ru on Fe)(^{16}O,O′) H_{int} =−505 *15*kG
$^{104}_{44}$Ru	358	58ps	[2]	+0.82^{c}‡ *10*		74Hu01 (69He11)	IMPAC	‡Used H_{hf} (IMPAC) =−359 *44*kG, based on g_{ave} (2+)=0.40 *3*, and Φ_t=−10.7 *24*mr; included effect of decays−in−flight	
$^{100}_{45}$Rh	74.8	215ns	[2]	+4.26 *6*		65Ma34	DPAC		metallic Rh; H_o=2.22kG; assumed K=+0.43%
$^{100}_{45}$Rh	74.8	215ns	[2]	+4.321^{d} *8*		66Ma54	DPAC	2ν=16.49 *5*, 25.10 *5*MHz	metallic Rh; H_o=4996 *10*G, 7636 *7*G; assumed K=+0.43%
$^{100}_{45}$Rh	74.8	215ns	[2]	±4.298^{d} *30*		71Re06	DPAD		^{103}Rh metal(p,4n);G'=0.79 *1*; H_o measured by proton resonance with Hall probe; assumed K=0.43%
$^{103}_{45}$Rh	93	1.13ns	[9/2]	±6.21 *90*		71BaA1	IPAC		dilute $RuCl_4$;H_o=18.5kG, β=1; Ru source in Cu
$^{103}_{45}$Rh	298	6.3ps‡	[3/2]	+0.03 *39*		70Ro32	IMPAC	$\Delta\theta$=+3.6 *50*mr	recoils in Fe; H_{int}= −543 *11*kG, $H_t\tau_t$=7.4 *15*MG−ps assumed
								‡Value of $T_{1/2}$ used in analysis	
$^{103}_{45}$Rh	298	6.3ps‡	[3/2]	±1.72 *46* or ±2.12 *63*		71Bh05	IMPAC	$\Delta\theta$=+29 *7*mr	5%Rh−Fe alloy; H_{int}=−540kG; assumed no transient fields or assumed $H_t\tau_t$=1.24MG−ps
								‡Value of $T_{1/2}$ used in analysis	
$^{103}_{45}$Rh	298	7.6ps‡	[3/2]	±0.90^{p} *30*		71Sp14	AAC	g(3/2)/g(5/2)= 1.3 *3*	Rh(^{35}Cl,Cl′)recoils in gas
								‡Value of $T_{1/2}$ used in analysis	
$^{103}_{45}$Rh	298	6.3ps	[3/2]	±0.70^{ap} *21*		72Mi20	PAC		recoils in gas
$^{103}_{45}$Rh	360	59ps	[5/2]	+1.38 *25*‡		70Ro32	IMPAC	$\Delta\theta$=+102.7 *70*mr	recoils in Fe;H_{int}=−543 *11*kG $H_t\tau_t$=7.4 *15*MG−ps assumed
								‡Uncertainty increased to ~ 20%	
$^{103}_{45}$Rh	360	59ps	[5/2]	±1.2 *2*		71Bh05	IMPAC	$\Delta\theta$=+108 *14*mr	5%Rh−Fe alloy; H_{int}=−540kG, assumed no transient field or $H_t\tau_t$=1.24MG−ps
$^{103}_{45}$Rh	360	76ps‡	[5/2]	±1.12^{p}*25*		71Sp14	AAC		Rh(^{35}Cl,Cl′) recoils in gas
								‡Value of $T_{1/2}$ used in analysis	
$^{103}_{45}$Rh	360	59ps	[5/2]	±0.95^{ap} *32*		72Mi20	PAC		recoils in gas

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{104}_{46}Pd$	556	9.7ps	[2]			69He11	IMPAC	$\Delta\theta$=−0.8 *14*mr	(^{104}Pd on Fe)(^{16}O,O′);H_o≈1kG H_{int}=−595 *12*kG
$^{104}_{46}Pd$	556	9.7ps	[2]	+0.76‡ *14*		74Hu01	IMPAC	$\Delta\theta$=1.3 *12*mr	CEx with ^{16}O, recoils in disordered $Fe_{.8}Co_{.2}$; H_{hf}(IMPAC)=−409 *31*kG, Φ_t=−9.3 *14*mr
				+0.62^c‡ *16*		(69He11)		‡Calculated assuming $g_{ave}(2+)$=0.36, H_{hf} (IMPAC)=−409kG	
$^{106}_{46}Pd$	512	12.7ps	[2]	+0.85 *11*		65Ko12 66Je02	IPAC	$\omega\tau$=2.06 *20*mr	$RuCl_3$ in 3N HCl; H_o=55.62kG
$^{106}_{46}Pd$	512	12.7ps	[2]	+0.75 *8*		66Au06	IPAC	$\omega\tau$=−17.6 *3*mr $\omega\tau$=−11.6 *7*mr $\omega\tau$=−50 *9*mr	^{106}Pd in Fe; H_{int}=−540 *40*kG ^{106}Pd in Co; H_{int}=−361 *50*kG ^{106}Pd in Ni; H_{int}=−162 *35*kG
$^{106}_{46}Pd$	512	12.7ps	[2]	±0.70 *6*		67Mu09	IPAC		Ru in Fe; H_{int}=580 *20*kG Ru in Co; H_{int}=397 *15*kG
$^{106}_{46}Pd$	512	12.7ps	[2]	±0.690 *53*		68Bo15	IPAC	$\omega\tau$=17.3 *2*mr	^{106}Ru in Fe; H_{int}=−573 *20*kG
$^{106}_{46}Pd$	512	12.7ps	[2]	±0.75 *7*		68Jo17	IPAC	$\omega\tau$=1.73 *11*mr	Ru in Cu or stainless steel; H_o=51.1kG
				±0.70 *9*				$\omega\tau$=1.42 *16*mr	$RuCl_3$ in 3N HCl; H_o=51.1kG,assumed β=1
$^{106}_{46}Pd$	512	12.7ps	[2]	+0.58 *34*		69He11	IMPAC	$\Delta\theta$=4.5 *26*mr	(^{106}Pd on Fe)(^{16}O,O′); H_{int}=−595 *12*kG
$^{106}_{46}Pd$	512	12.7ps	[2]	±0.73 *6*		70Si20	IPAC	$\omega\tau$=18.1 *8*mr	^{106}Ru−Fe;H_o=6.5kG;H_{int}=571kG
$^{106}_{46}Pd$	512	12.7ps	[2]	+0.754 *54*		72Jo06	IPAC	$\omega\tau/B$=33.7 *10*mr/MG $(\omega\tau/B)_{ave}$= 31.74 *56*mr/MG	Pd−Co at T<0.25T_C; H_o>20kG; also measured in Pd−Fe, −Ni, −steel
$^{106}_{46}Pd$	512	12.7ps	[2]	+0.64 *12*, +0.74‡ *14*		74Hu01	IMPAC	$\Delta\theta$=20 *15*mr, $\Delta\theta$=3.5 *14*mr	CEx with ^{16}O, recoils in disordered $Fe_{.8}Co_{.2}$, in Fe; H_{hf} (IMPAC)=−409 *36*kG and Φ_t=−9.3 *14*mr for both.
								‡Average value (this work and that of 69He11, recalculated) for recoils in Fe	
$^{106}_{46}Pd$	1128	2.5ps	[2]	+0.71 *13*		68Bo15	IPAC	$\omega\tau$=3.63 *47*mr	^{106}Ru in Fe; H_{int}=−573 *20*kG at room T
$^{106}_{46}Pd$	1128	2.5ps	[2]	±0.77 *23*		70Si20	IPAC	$\omega\tau$=3.8 *10*mr	^{106}Ru−Fe;H_o=6.5kG;H_{int}=571kG
$^{108}_{46}Pd$	434	23.8ps	[2]	+0.60 *8*		69He11	IMPAC	$\Delta\theta$=17.5 *16*mr	(^{108}Pd on Fe)(^{16}O,O′); H_{int}=−595 *12*kG
$^{108}_{46}Pd$	434	23.8ps	[2]	+0.74 *8* +0.80^c‡ *12*		74Hu01 (69He11)	IMPAC	$\Delta\theta$=15.6 *12*mr	CEx with ^{16}O, recoils in disordered $Fe_{.8}Co_{.2}$; H_{hf}(IMPAC)=−409 *31*kG Φ_t=−9.3 *14*mr
								‡H_{hf} + Φ_t for Fe same as for alloy	
$^{110}_{46}Pd$	374	45.8ps	[2]	+0.50 *6*		69He11	IMPAC	$\Delta\theta$=35.0 *23*mr	(^{110}Pd on Fe)(^{16}O,O′); H_{int}=−595 *12*kG
$^{110}_{46}Pd$	374	45.8ps	[2]	+0.72 *8*		74Hu01	IMPAC	$\Delta\theta$=36.9 *18*mr	CEx with ^{16}O, recoils in disordered $Fe_{.8}Co_{.2}$;H_{hf} (IMPAC)=−409 *31*kG; Φ_t=−9.3 *14*mr
				+0.68^c‡ *8*		(69He11)		‡H_{hf} and Φ_t for Fe same as for alloy	
$^{107}_{47}Ag$	325	5.9ps	[3/2]	+1.17 *72*		70Ro32	IMPAC	$\Delta\theta$=−10.4 *20*mr	recoils in Fe;H_{int}=−282 *20*kG $H_t\tau_t$=7.4 *15*MG−ps assumed
$^{107}_{47}Ag$	325	5.9ps	[3/2]	±0.75^p *22*		71Sp14	AAC	$g(3/2)/g(5/2)$= ±1.25 *30*	CEx recoils in He gas $H_t\tau_t$=7.4 *15*MG−ps assumed

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{107}_{47}$Ag	325	5.9ps	[3/2]	$\pm0.61^{ap}$ *21*		72Mi20	PAC		recoils in gas
$^{107}_{47}$Ag	423	34ps	[5/2]	+1.65 *70*		70Ro32	IMPAC	$\Delta\theta$=+22.7 *20*mr	recoils in Fe;H_{int}=−282 *20*kG
$^{107}_{47}$Ag	423	34ps	[5/2]	$\pm0.88^{p}$ *22*		71Sp14	AAC		CEx recoils in He gas
$^{107}_{47}$Ag	423	34ps	[5/2]	$\pm0.87^{ap}$ *32*		72Mi20	PAC		recoils in gas
$^{109}_{47}$Ag	309	5.2ps	[3/2]	+1.72 *70*		70Ro32	IMPAC	$\Delta\theta$=−8.9 *24*mr	recoils in Fe;H_{int}=−282 *20*kG $H_{t}\tau_{t}$=7.4 *15*MG−ps assumed
$^{109}_{47}$Ag	309	5.2ps	[3/2]	$\pm1.29^{p}$ *30*		71Sp14	AAC	$g(3/2)/g(5/2)$= ±1.4 *4*	CEx recoils in He gas
$^{109}_{47}$Ag	309	5.2ps	[3/2]	$\pm0.67^{ap}$ *22*		72Mi20	PAC		recoils in gas
$^{109}_{47}$Ag	414	33ps	[5/2]	+1.21 *56*		70Ro32	IMPAC	$\Delta\theta$=+16.5 *25*mr	recoils in Fe;H_{int}=−282 *20*kG $H_{t}\tau_{t}$=7.4 *15*MG−ps assumed
$^{109}_{47}$Ag	414	33ps	[5/2]	$\pm1.06^{p}$ *27*		71Sp14	AAC		CEx recoils in He gas
$^{109}_{47}$Ag	414	33ps	[5/2]	$\pm0.67^{p}$ *22*		72Mi20	PAC		recoils in gas
$^{110}_{47}$Ag	gs	24.4s	(1)	$\pm2.7210^{d}$ *8*		69Ac02	BAP− NMR	$\gamma/2\pi$= 2.0645 *4*kHz/G	AgF,AgCl,AgBr,Ag_2O, and Ag_2O_2(polarized n,);T~8°K; $2H_1$=0.6G
$^{110}_{47}$Ag	116	253d	(6)	+2.9 *13*		65We02	GAP	μH=±1.00 *7* nm−MG μH=±0.31 *4*nm−MG μH negative from β asymmetry	Ag in Fe; H_{int}=−350 *100*kG Ag in Ni; H_{int}=−108 *30*kG; used GAO in ^{60}Co to measure temperature
$^{109}_{48}$Cd	469	8.9μs	[11/2]	-1.091^{p} *2*		71Bl16	Strob		^{109}Ag(pulsed p,n); T= 1000 *10*°C
$^{110}_{48}$Cd	656	5.0ps	[2]	$\pm0.54^{p}$ *22*		68Ke17	IPAC		Cd in Fe; H_{int}=−348kG; $AgNO_3$ melted into Fe; $AgNO_3$ diffused into Fe
$^{110}_{48}$Cd	656	5.0ps	[2]	+0.78 *30*		69He11	IMPAC	$\Delta\theta$=−10.7 *38*mr	(^{110}Cd on Fe)(^{16}O,O′); H_{int}= −348 *10*kG
$^{110}_{48}$Cd	656	5.0ps	[2]	+0.64 *13*		72Jo06	IPAC	$\omega\tau$=3.2 *6*mr	Ag−Gd at 77°K; H_o=22kG, H_{hf}=−310 *7*kG
$^{110}_{48}$Cd	656	5.0ps	[2]	$+1.00^{c}$‡ *44*		74Hu01 (69He11)	IMPAC	‡Assumed $g_{ave}(2+)$=0.36;H_{hf}(IMPAC)=−238 *131*kG; included effect of decays−in−flight	
$^{111}_{48}$Cd	247	84ns	[5/2]	-0.70^{a}		52Ae01	PAC		
$^{111}_{48}$Cd	247	84ns	[5/2]	−0.72 *5*		54Al49	AAC		$InCl_3$ in H_2O
$^{111}_{48}$Cd	247	84ns	[5/2]	−0.783 *23*		56St63	CDPAC		dilute $InCl_3$ solution
$^{111}_{48}$Cd	247	84ns	[5/2]		+0.9	62Be12	PAC	$\omega_0\tau$=−1.5 *5* ‡Unit not given	In crystal;measured circular polarization of 247γ
$^{111}_{48}$Cd	247	84ns	[5/2]	-0.794^{d} *6*		63Bo09	DPAC		Cd in HCl; H_o=10337 *50*G
$^{111}_{48}$Cd	247	84ns	[5/2]	-0.794^{d} *18*		63Ma10	DPAC		In in HNO_3, H_o=32.6kG
				-0.781^{d} *38*		63Sa19	DPAC	ω=47.35 Mr/s	In in HNO_3; H_o=31.81kG
$^{112}_{48}$Cd	617	6.2ps	[2]	+0.60 *12*		69He11	IMPAC	$\Delta\theta$=−7.3 *9*mr	(^{112}Cd on Fe)(^{16}O,O′); H_{int}=−348 *10*kG
$^{112}_{48}$Cd	617	6.2ps	[2]	$+0.72^{c}$‡ *22*		74Hu01 (69He11)	IMPAC	‡See ^{110}Cd(656), 74Hu01	
$^{114}_{48}$Cd	558	9.0ps	[2]	+0.89 *12*		67Bh03	IPAC	$\omega\tau$=+9.69 *106*mr	Cd in Fe; H_{int}=348 *10*kG
$^{114}_{48}$Cd	558	9.0ps	[2]	+0.64 *26*		69He11	IMPAC	$\Delta\theta$=−5.2 *25*mr	(^{114}Cd on Fe)(^{16}O,O′); H_{int}= −348 *10*kG
$^{114}_{48}$Cd	558	9.0ps	[2]	$+0.62^{c}$‡ *38*		74Hu01 (69He11)	IMPAC	‡See ^{110}Cd(656), 74Hu01	
$^{116}_{48}$Cd	513	13.7ps	[2]	+1.42 *76*		69He11	IMPAC	$\Delta\theta$=−4.0 *19*mr	(^{116}Cd on Fe)(^{16}O,O′); H_{int}= −348 *10*kG
$^{116}_{48}$Cd	513	13.7ps	[2]	$+0.80^{c}$‡ *62*		74Hu01 (69He11)	IMPAC	‡See ^{110}Cd(656), 74Hu01	

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat – Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{114}_{49}$In	gs	72s	[1]	≤±1.7‡ *4*		62Ko16	BAP	‡Assumed allowed β–decay	In–Fe alloy; H_{int}≥250kG; H_{int} negative
$^{116}_{49}$In	gs	14s	[1]	±1.12	~±0.03	66Ra17	BAP		^{115}In (polarized n,γ); measured relaxation times in InF_3,In_2O_3,InP, and In–metal
$^{116}_{49}$In	gs	14s	[1]	±2.7860^{d} *12*	±0.09‡ *2*	71Wi12	BAP–NMR	$\gamma/2\pi$=2.1132 *8*kHz/G; ‡From temperature dependence of τ_{relax}; used Q^{115}=+0.83b	InP(polarized th n,)at 77°K
$^{117}_{49}$In	660	60ns	[3/2]	+0.95 *8*		67Pa16	DPAC		^{116}CdO(pile n,); H_o=8.6kG
$^{117}_{49}$In	660	60ns	[3/2]		±0.64* *4*	72Ra27	DPAC	ν_Q=32.1 *5*MHz	$In_{0.99}Cd_{0.01}$ at 4.2°K and 295°K; used ν_Q^{115}=43.2 *1*MHz and Q^{115}=0.861* *15*b
$^{114}_{50}$Sn	3210 or 3090	700ns	[9] or [7]	g=−0.081^{dp} *3*		72Bo44	DPAD		molten ^{112}Cd(α,2n); used K~−0.8%
$^{115}_{50}$Sn	619	3.3μs	[7/2]	<±0.98‡		71Br03	PAD–NMR	‡Searched for resonance in range 0.15<|g|<0.8	liquid In metal(pulsed p,n)
$^{115}_{50}$Sn	726	159μs	[11/2]	±1.361 *4*		71Br03	PAD–NMR	ν,B_0=100.03‡,530G; 274.52‡,1450G; 274.52‡,1460G ‡kHz	liquid In metal(pulsed p,n) H_o=14; 35; 47G, τ_{relax}=0.75 *18*ms
$^{115}_{50}$Sn	726	159μs	[11/2]	−1.32 *11*		71Iv04	DPAC		liquid ^{113}Cd(pulsed α,2n); liquid ^{114}Cd(pulsed α,3n); H_o=6.48G
$^{115}_{50}$Sn	726	159μs	[11/2]	±1.40 *8*		72Me15	DPAD	ν=7.81 *37*kHz	In(pulsed p,); H_o=0 during pulse, H_o=40 *1*G between pulses
$^{115}_{50}$Sn	726	159μs	[11/2]		±0.8^{p} *3*	72Ri13	‡	‡Measured relaxation times as f(T) by GAO	liquid In(pulsed p,n)
$^{116}_{50}$Sn	2369	350ns	[5]	−0.325 *25*		66RG02	DPAC		Sb dissolved in HCl; H_o=30.2kG
				−0.30 *4* or −0.4 *2*			IPAC	$G_2\omega\tau$=312 *43*mr	H_o=2.09kG; G_2=1 or 0.7 *3*
$^{118}_{50}$Sn	2320	21.7ns	[5]	−0.340 *14*		62Bo16	IPAC	$\omega\tau$=417 *38*mr	^{118}Sb in 3N HCl; H_o=40.95kG
$^{118}_{50}$Sn	2320	21.7ns	[5]	−0.300 *25*		64De19	DPAC IPAC		Sb diffused into Fe foils; H_{int}=78.5 *30*kG, determined by Möss. on ^{119}Sb
$^{120}_{50}$Sn	2300	5.5ns	[5]	−0.37 *5*		62Bo16	IPAC	$\omega\tau$=150 *20*mr	^{120}Sb in 3N HCl, H_o=53.2kG
$^{120}_{50}$Sn	2300	5.5ns	[5]	−0.280 *25*		64De19	DPAC IPAC		Sb diffused into Fe foils; H_{int}=78.5 *30*kG, determined by Möss. on ^{119}Sb
$^{120}_{50}$Sn	2300	5.5ns	[5]		±0.021‡*8*	70Wo02	DPAC	ν_Q=1.15 *4*MHz; ν_Q=0.68 *7*MHz; Q/Q^{119}(23.8keV))=±2.86 *15*, using interaction constants obtained by Mossbauer for ^{119}Sb in the same compounds ‡Using Q^{119}(23.8keV)=0.06 *2*	$KSbC_4H_4O_7 \cdot 1/2$; $(SbO)_2SO_4$
$^{117}_{51}$Sb	3130	340μs	[21/2?]	+1.21 *16*		71Iv04	DPAD		liquid ^{115}In(pulsed α,2n); H_o=30 to 100G
$^{117}_{51}$Sb	3130	340μs	[21/2?]	±1.22 *3*		72Me15	DPAD	ν=3.54 *3*kHz	In(pulsed α,2n); H_o=0 during pulse, H_o=40 *1*G between pulses

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{122}_{51}$Sb	gs	2.73d	(2)	±1.9 *2*		71Kr15	GAP		Sb–Fe(pile n,)
$^{122}_{51}$Sb	61	1.8μs	[3]	+2.979^{dp} *12*		72He26	Strob	ν=2.5MHz	molten ^{122}Sn(p,n)
$^{124}_{51}$Sb	gs	60d	(3)	±1.26 *7*		68Kn02	GAP	μH=240 *29*, 270 *19*, 305 *24*nm–kG	^{124}Sb in Fe, 3 different sources; H_{int}=218 *5*kG; T measured by ^{60}Co and ^{124}Te γ–anisotropy
$^{124}_{51}$Sb	gs	60d	(3)	±1.42 *10*		70Si17	GAP		^{124}Sb + ^{54}Mn in Fe foil; H_{hf}=230kG; T=8m°K; T measured by ^{54}Mn γ–anisotropy
$^{125}_{51}$Sb	gs	2.7y	(7/2)	±3.55^{p} *30*		64He08	GAP		^{125}Sb + ^{54}Mn in Fe foil; H_{int}≈200kG, T=0.024°K
$^{125}_{51}$Sb	gs	2.7y	(7/2)			68An05	GAP	μH=572 *3*nm–kG	^{125}Sb + ^{60}Co diffused in Fe; H_{int}(at Co)=286.3kG assumed
$^{125}_{51}$Sb	gs	2.7y	7/2‡	±2.62 *6*		68Ba70	GAP–NMR	γ/2π= 0.570 *14*kHz/G	^{125}Sb in Fe at 0.015°K; obtained g from slope of ν vs H_o; H_{hf}=+231 *6*kG
								‡From μ(68St16) and g(68Ba70)	
$^{125}_{51}$Sb	gs	2.7y	(7/2)	±2.59 *3*		68St16	GAP		Sb–Fe alloy; H_{int}=+230kG; ^{60}Co used for thermometry
$^{126}_{51}$Sb	gs	12.5d	[8]	±1.28 *7*		72Kr15	GAP	Δ/T=±0.094 *5*	Sb–Fe; ^{125}Sb used for thermometry; T=14.5m°K; H_{int}=231kG
$^{127}_{51}$Sb	gs	3.9d	[7/2]	±2.59 *12*		72Kr15	GAP	Δ/T=±0.431 *20*	Sb–Fe; ^{125}Sb used for thermometry; T=14.5m°K; H_{int}=231kG
$^{128}_{51}$Sb	gs	8.6h	[8]	±1.31 *19*		72Kr15	GAP	Δ/T=±0.087 *13*	Sb–Fe; ^{125}Sb used for thermometry; T=16m°K; H_{int}=231kG
$^{120}_{52}$Te	560	9.3ps	[2]	+0.42 *12*		69He11	IMPAC	Δθ=–15.6 *36*mr	(^{120}Te on Fe)(^{16}O,O'); H_{int}= +620 *20*kG from Möss.
$^{120}_{52}$Te	560	9.3ps	[2]	+0.58^{c}‡*16*		74Hu01 (69He11)	IMPAC	‡Assumed g_{ave}(2+)=0.30; H_{hf}(IMPAC)= +342 *163*kG, Φ_t=10.8mr; included effect of decays–in–flight	
$^{122}_{52}$Te	564	7.6ps	[2]	+0.91 *12*		66Au05	IPAC	ωτ=15.4 *15*mr	Te in Fe; H_o=10kG; H_{int} =+620 *20*kG from Möss.
$^{122}_{52}$Te	564	7.6ps	[2]	+0.79 *12*		66Jo06	IPAC	ωτ=–13.2 *13*mr	Sb diffused into Fe; H_o=10kG; H_{int}=637 *21*kG
$^{122}_{52}$Te	564	7.6ps	[2]	+0.62 *6*		67Bh06	IPAC	ωτ=10.5 *10*, 9.9 *12*, 7.0 *14*mr	three different Sb–Fe sources; assumed H_{int}= +620 *20*kG
$^{122}_{52}$Te	564	7.6ps	[2]	+0.70 *14*		67Mu10	IPAC	ωτ=11.5 *20*mr	Sb–Fe(pile n,); H_{int}=600 *25*kG
$^{122}_{52}$Te	564	7.6ps	[2]	+0.48 *12*		69He11	IMPAC	Δθ=–15.8 *12*mr	(^{122}Te on Fe)(^{16}0,0'); H_{int}= +620 *20*kG from Möss.
$^{122}_{52}$Te	564	7.6ps	[2]	+0.64^{c}‡ *10*		74Hu01 (69He11)	IMPAC	‡See ^{120}Te(560), 74Hu01	
$^{123}_{52}$Te	159	190ps	[3/2]	±0.72 *12*		70Ro31	AAC	ωτ=±0.42 *6*r G_2=±0.774 *42*	^{123}Te implanted in Fe; H_{int}= 620 *20*kG from NMR for dilute Te in Fe
$^{123}_{52}$Te	248	117d	[11/2]	–1.00^{p} *5*		72Va25	GAP		Te implanted in Fe by mass separator; T<20m°K
$^{123}_{52}$Te	440	?	?	g=+0.22^{p}‡ *3*		70Bo48	IMPAC	ωτ=–38.5 *33*mr	(^{123}Te in Fe)(^{16}O,O'); H_{hf}= 620 *20*kG; $H_t\tau_t$=7.1 *16*MG–ps
								‡Estimated τ from	^{125}Te data
$^{123}_{52}$Te	506	?	?	g=+0.032^{p}‡*7*		70Bo48	IMPAC	ωτ=–4.4 *23*mr	(^{123}Te in Fe)(^{16}O,O'); H_{hf}= 620 *20*kG
								‡Estimated τ from	^{125}Te data

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat – Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{124}_{52}$Te	603	6.6ps	[2]	+0.39 *8*		67Bh06		$\omega\tau$=−6.6‡ *24* or −5.4‡ *13*mr	^{123}Sb–Fe(pile n,); H_{int}= 620 *20*kG assumed
								‡For (1690γ)(603γ) or (722γ)(603γ)	
$^{124}_{52}$Te	603	6.6ps	[2]	+0.70 *16*		67Mu06	IPAC	$\omega\tau$=9.7 *13*mr	Sb in Fe; H_{int}=+610 *25*kG from Möss., includes temperature correction
$^{124}_{52}$Te	603	6.6ps	[2]	+0.53 *44*		68Bo41	IPAC	$\omega\tau$=7.5 *44*mr	(Sb in Fe)(pile n,); H_{int}= 627 *20*kG
$^{124}_{52}$Te	603	6.6ps	[2]	+0.42 *10*		69He11	IMPAC	$\Delta\theta$=−12.9 *9*mr	(^{124}Te on Fe)(^{16}O,O′); H_{int}= +620 *20*kG from Möss.
$^{124}_{52}$Te	603	6.6ps	[2]	+0.54^{c}‡ *8*		74Hu01 (69He11)	IMPAC	‡See ^{120}Te(560); 74Hu01	
$^{125}_{52}$Te	145	58d	[11/2]	±0.93 *5*		72Si21	GAP		^{125}Te implanted in Fe by mass separator; H_{int}= 657 *20*kG; T<20m°K
$^{125}_{52}$Te	321	695ps	[9/2]	−0.909 *72*		69Kn03	IPAC	$\omega\tau$=81 *33*mr $\omega\tau$=200 *15*mr	liquid $^{125}SbCl_3$; H_o=19.1 *1*kG ^{125}Sb dissolved in Ni; H_o= 20.0 *1*kG, H_{int}=205 *10*kG

$^{125}_{52}$Te	321	695ps	[9/2]	−0.918‡ *32*		70Cr07	IPAC	For (321γ)(177γ): $\omega\tau$=47.7 *33*, 179^{+44}_{-29}, 830^{+240}_{-570}mr
								For (204γ)(177γ): $\omega\tau$=54.2 *48*, 47.8 *48*mr;
								$\omega\tau$=52.8 *25*, 234 *17*mr
									dilute solutions of ^{125}Sb in Cu, Ni, Fe; H_{int}=51.5, 236, 679kG
									$[SbCl_4]^-$, $[SbCl_6]^-$ in HCl; H_o=51.5kG;
									^{125}Sb in Cu, Ni; H_{int}=51.5, 236kG

								‡From weighted average of $\omega\tau/H$=0.976 *30*r/MG	
$^{125}_{52}$Te	321	695ps	[9/2]	−0.66 *9*		71Ro17	IPAC	$\omega\tau_{ave}$=132 *17*mr, for two cascades	fission ^{125}Sb in Ni; H_{int}= 186 *10*kG assumed
$^{125}_{52}$Te	443	21ps	[3/2]	+0.52^{p} *16*		70Ro35 71Ro37	IMPAC	$\omega\tau$=−43.0 *54*mr	(Te in Fe)(^{16}O,O′); H_{hf}= 620 *20*kG; $H\tau_l$=7.1 *16*MG−ps
$^{125}_{52}$Te	463	13ps	[5/2]	+0.58 *27*		70Cr07	IPAC	$\omega\tau$=14 *6*mr	^{125}Sb in Fe; H_o=51.5kG, H_{int}=679kG
$^{125}_{52}$Te	463	13ps	[5/2]	+0.30^{p} *12*		70Ro35 71Ro37	IMPAC	$\omega\tau$=−10.8 *33*mr	(Te in Fe)(^{16}O,O′); H_{hf}= 620 *20*kG; $H\tau_l$=7.1 *16*MG−ps
$^{125}_{52}$Te	463	13ps	[5/2]	+0.79 *30*		71Ro17	IPAC	$\omega\tau_{ave}$=18.7 *69*mr $\omega\tau$(1)=21 *14*mr, $\omega\tau$(2)=15 *8*mr	fission ^{125}Sb in Fe; H_{int}= 620 *20*kG; (1)=(209γ)(428γ), (2)=(172γ)(428γ)
$^{125}_{52}$Te	525	?	[7/2?]	negative		71Ro17	IPAC	$\omega\tau$=+107 *24*mr	fission ^{125}Sb in Fe
$^{126}_{52}$Te	667	4.42ps	[2]	+0.50 *14*		69He11	IMPAC	$\Delta\theta$=−13.1 *25*mr	(^{126}Te on Fe)(^{16}O,O′); H_{int}= 620 *20*kG
$^{126}_{52}$Te	667	4.42ps	[2]	+0.62^{c}‡ *16*		74Hu01 (69He11)	IMPAC	‡See ^{120}Te(560), 74Hu01	
$^{127}_{52}$Te	gs	9.4h	[3/2]	±0.66^{p} *5*		72Si31	GAO		
$^{127}_{52}$Te	89	109d	[11/2]	−0.91^{p} *5*		72Va25	GAP		Te implanted in Fe by mass separator; T<20m°K
$^{128}_{52}$Te	743	3.18ps	[2]	+0.42 *12*		69He11	IMPAC	$\Delta\theta$=−10.1 *20*mr	(^{128}Te in Fe)(^{16}O,O′); H_{int}= 620 *20*kG
$^{128}_{52}$Te	743	3.18ps	[2]	+0.54^{c}‡ *14*		74Hu01 (69He11)	IMPAC	‡See ^{120}Te(560), 74Hu01	
$^{129}_{52}$Te	gs	69m	[3/2]	±0.67^{p} *5*		72Si31	GAO		
$^{129}_{52}$Te	106	34d	[11/2]	−1.15^{p} *5*		72Va25	GAP		Te implanted in Fe by mass separator; T<20m°K
$^{130}_{52}$Te	840	2.0ps	[2]	+0.50 *14*		69He11	IMPAC	$\Delta\theta$=−10.6 *22*mr	(^{130}Te in Fe)(^{16}O,O′); H_{int}= 620 *20*kG
$^{130}_{52}$Te	840	2.0ps	[2]	+0.64^{c}‡ *18*		74Hu01 (69He11)	IMPAC	‡See ^{120}Te(560), 74Hu01	

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat – Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{125}_{53}$I	188	35ns	[3/2]	±2.8^{ap} *12*		72Le32	PAC		gaseous I at normal pressure
$^{127}_{53}$I	58	1.92ns	[7/2]	±1.70^{p} *33*		65Ta14	IPAC		H_o=12.8kG
$^{127}_{53}$I	58	1.92ns	[7/2]	±2.02 *15*		67Sv01	IPAC	$\omega\tau$=216 *15*mr	^{126}Te in HNO_3 and in HCL; H_o=28.1kG
$^{127}_{53}$I	58	1.92ns	[7/2]	±2.78^{p} *23*		69Be78	IPAC		H_o=100kG
$^{127}_{53}$I	203	330ps	[3/2]	≥±1.07		67Sv01	IPAC	$\omega\tau$=88 *15*mr	^{127}Xe in Al foil; H_o=51.2kG
$^{131}_{53}$I	150	0.95ms	[5/2]	+2.77‡ *50*		67Ta07	IPAC	$\omega\tau$=97 *12*mr	^{131}Te in HCl; H_o=13.2kG
								‡Assumed time–dependent perturbations small	
$^{131}_{53}$I	1797	5.9ns	[9/2, 11/2?]	−0.72 *23*, −0.88 *28*		67Ta07	IPAC	$G_2\omega\tau$=73 *16*mr g=−0.16 *5*	^{131}Te in HCl; H_o=12.8kG; G_2=0.9 *1*
$^{132}_{53}$I	49.7	0.95ns	[3]	+2.22 *30*		69Si06	IPAC	$\omega\tau$=94.4 *123*mr	^{132}Te metal in HCl; H_o= 19.5kG, assumed G_2=1
$^{132}_{54}$Xe	668	7ps	[2]	+0.92^{p} *42*		69Si09	IPAC	$\omega\tau$=22.3 *71*mr	^{132}Te diffused in Fe; H_{hf}= 1040 *20*kG
$^{131}_{55}$Cs	133	9.3ns	[5/2]	+2.48 *15*		64Br20	DPAC	ω=138 *8*Mr/s‡	$BaCO_3$ powder; H_o=29.1 *3*kG
								‡Unit given as MHz	
$^{131}_{55}$Cs	133	9.3ns	[5/2]	±2.30^{p} *20*		69Be79	IPAC		G_2=0.88 *8*
$^{131}_{55}$Cs	133	9.3ns	[5/2]	+1.97 *12*		69Fe02	DPAC IPAC		$Ba(NO_3)_2$ in dilute HNO_3; H_o=9.3, 18kG
$^{131}_{55}$Cs	133	9.3ns	[5/2]	±1.85^{p} *7*		72Ao01	DPAC		$^{130}Ba(NO_3)_2$(th n,), dis–solved in HCl; H_o=15.9kG
$^{133}_{55}$Cs	81	6.31ns	[5/2]	+3.1 *3*		59Bo56	IPAC		$BaCl_2$ aqueous solution; H_o= 22.4kG
$^{133}_{55}$Cs	81	6.31ns	[5/2]	+3.25^{d} *15*		64Ag02	CDPAC		$BaCl_2$; delay time=22.9ns
$^{133}_{55}$Cs	81	6.31ns	[5/2]	+3.7 *8* ±3.5 *5*		66He12	IPAC AAC		H_o~10kG
$^{133}_{55}$Cs	81	6.31ns	[5/2]	±3.55 *40*		68Re05	DPAC		H_o=24.2kG
$^{133}_{55}$Cs	160	190ps	[5/2]	+1.65 *50*		59Bo56	IPAC	$\omega\tau$=+21 *6*mr	$BaCl_2$ aqueous solution; H_o= 24.2kG
$^{133}_{55}$Cs	160	190ps	[5/2]	+1.42 *32*		65Ag01	IPAC	$\omega\tau$=11.3 *36*mr, $\omega\tau$=17.8 *34*mr	dilute $BaCl_2$ in H_2O; H_o= 15.16, 21.17kG
$^{134}_{55}$Cs	11.2	47.0ns	[5]	+3.32 *6*		71Dr10	DPAC		CsCl(pile n,) dissolved in H_2O; H_o=9.9, 11.0kG
$^{134}_{56}$Ba or	605 1400	5ps ≤30ps	[2] [4]	~0.006 ≥0.002		70Be50	PAC	$\omega\tau$=0.05 3‡	^{134}CsCl aqueous solution, H_o=41.4kG
								‡Unit not given, appears to be 10^{-1}mr	
$^{137}_{56}$Ba	662	2.55m	[11/2]		negative ~0.05	65Lu02	GAO	$\|Q\|\approx\|Q(^{137}Cs)\|$	Co–Cs Tutton salt, Cu–Cs Tutton salt
$^{133}_{57}$La	535	49ns	[11/2‡]	±7.7		69Ge06, 70Ge14	DPAC		liquid sources Ce^{2+} or Ce^{3+}, La^{2+}; H_o=4kG
								‡Author's original value, I=3/2	
$^{140}_{57}$La	gs	40.2h	(3)		+0.092 *13* +0.115 *16* +0.104‡*10*	66Bl05	GAO	P= +0.110 *16*x10^{-4}/cm −1.42 *12*x10^{-5}/cm	CMN at 1/T~500 NES at 1/T~88
								‡Average, based on Q^{139} =+0.22	
$^{137}_{58}$Ce	gs	9.0h	(3/2)	±0.74‡ *12*		63Ha07	GAO		*NES*, 1.2 to 4.2°K
								‡Using $<r^{-3}>$=4.44 au	
$^{137}_{58}$Ce	255	34.4h	(11/2)	±0.69 *3*		66Bl17	GAO		*NES*,*CMN*; used $<r^{-3}>$=4.44 au and new temperature scale

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{139}_{58}$Ce	gs	140d	(3/2)	±0.95^P *20*		61Kn02	GAO		*NES*; G_2~1
$^{139}_{58}$Ce	gs	140d	(3/2)	±0.92‡ *16*		62Gr17	GAO		*NES*, *CMN*
								‡Using $<r^{-3}>=4.44$ au	
$^{139}_{58}$Ce	gs	140d	(3/2)	±0.78‡ *16*		63Ha07	GAO		*NES*, *CMN*
								‡Using $<r^{-3}>=4.44$ au	
$^{140}_{58}$Ce	2083	3.41ns	[4]	±4.60‡ *32*		63Ka03	DPAC		$La(NO_3)_3$ in HNO_3; H_o= 20.07 *10*kG
								‡Average for two different cascades	
$^{140}_{58}$Ce	2083	3.41ns	[4]	+4.44 *16*		63Ko07	DPAC	ω=210 *5*Mr/s	liquid $La(NO_3)_3$ in 3N HNO_3; H_o=39.5kG
				±4.40 *20*			IPAC	ω=63.4 *27*Mr/s,	$La(NO_3)_3$ in 3N HNO_3; $LaCl_3$+ $FeCl_3$ in 2N HNO_3; H_o=12.1kG
$^{140}_{58}$Ce	2083	3.41ns	[4]	±3.80 *40*		64Sc16	DPAC		$La(OH)_3$ in $Ce(HSO_4)_4$; H_o= 16.5, 20, 24.5kG; β=1
$^{140}_{58}$Ce	2083	3.41ns	[4]	+4.06 *15*		65Le16	DPAC		La_2O_3 in 3M HNO_2 aqueous solution; H_o=29.7, 42.1kG; β=1
$^{140}_{58}$Ce	2083	3.41ns	[4]		±0.404* *80*	73Kl17	DPAC	ν_Q=1.17 *15*MHz	$La_2Mg_3(NO_3)_{12}$•*24*; used $Q(^{139}La)$=+0.230 *10*b
$^{141}_{58}$Ce	gs	33d	(7/2)	±1.0^c‡ *1*		62Gr17 55Ca48	GAO	‡Using $<r^{-3}>=4.44$ au	Ce in *NES*
$^{141}_{58}$Ce	gs	33d	(7/2)	±1.10‡ *16*		63Ha07	GAO	‡Using $<r^{-3}>=4.44$ au	Ce in *NES* and *CMN*
$^{143}_{58}$Ce	gs	34h	(3/2)	~±1‡		63Ha07, 72Sh01	GAO	‡Using $<r^{-3}>=4.44$ au. Analysis based on I=7/2; value not greatly affected by I	^{143}Ce in *NES* and *CMN*
$^{142}_{59}$Pr	gs	19.2h	(2)	±0.19 or ±0.14‡		58Da12 62Li06	GAO	‡For ΔI_β= 1 or 0	Pr in CMN
$^{142}_{59}$Pr	gs	19.2h	(2)	±0.22 *3* or ±0.14‡ *1*		58Gr92 62Li06	GAO	A=0.0027 *3* or 0.0042‡ *5*cm^{-1} ‡For ΔI_β=1 or 0	^{142}Pr in CMN
$^{142}_{59}$Pr	gs	19.2h	(2)	negative^P		70Hi14	BAO	μB_{eff}~+0.8a−ergs	^{142}Pr in Te
$^{143}_{59}$Pr	57	4.17ns	[5/2]	+3.25 *12*		64Ko15	DPAC		metallic and liquid sources; H_o≤58kG
$^{143}_{59}$Pr	57	4.17ns	[5/2]	+2.58 *20*		66Zm01	IPAC	$\omega\tau$=0.377 *26*r $g\beta$=+2.06 *16*; $g\beta$=1.13 *11*	$^{143}Ce_2(SO_4)_3$ or $^{143}Ce(SO_4)_2$ in H_2SO_4; H_o=6.3kG, β=2.00; CeO_2 at 1400°K; H_o=5.3 *2*kG, β=1.1
$^{143}_{59}$Pr	57	4.17ns	[5/2]	±2.68^a *28*		68Ta12	IPAC	$G_2\omega\tau$=0.223 *33*, 0.39 *11*r $G_2\omega\tau$=145 *20*, 284 *64*, 404 *96*mr	cubic CeO_2; H_o=5.6, 8.5kG; G_2=0.98, β=2.0 dilute $CeCl_3$; H_o=2.8, 5.6, 8.5kG; G_2=0.80 *4*, β=1.42
$^{144}_{60}$Nd	695	3.4ps	[2]	+0.26 *4*		72Ku10	IMPAC	$\Delta\theta$=−11 *2*mr, corrected for beam-bending g/g^{150}_{2+}=0.40 *10*	CEx with $^{16}O^{5+}$ on ^{144}Nd, recoils in Fe; H_o=1.4kG, H_{int}= 2.4 *3*MG; $H\tau_r$=10.8 *89*MG−ps at 300°K
$^{144}_{60}$Nd	1314	90ps	[4]	+0.18 *19*		67Jo11	IPAC		$PmCl_3$ in H_2O; H_o=51.8 *5*kG; used β=2.25

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{146}_{60}Nd$	454	21ps	[2]	±0.51‡ *5*		68Be42	IMPAC	$g/g_{2+}(^{152}Sm)$= 0.735 *77*	CEx with O, recoils in He, Ar; H_{ave}~25.5 *25*MG
								‡Used g/g_{2+}^{148}=1.2 *1*[67Be08]; $g_{2+}(^{152}Sm)$=0.35	
$^{146}_{60}Nd$	454	‡	[2]	+0.44 *6*		72Ku10	IMPAC	$\Delta\theta$=−83mr corrected for beam−bending g/g_{2+}^{150}=0.69 *14*	CEx with $^{16}O^{5+}$ on ^{146}Nd, recoils in Fe;H_o=1.4kG,H_{int}= 2.4 *3*MG,$H_i\tau_i$=10.8 *89*MG−ps at 300°K
								‡$T_{1/2}$=19.4ps used in analysis	
$^{148}_{60}Nd$	300	116ps	[2]	+0.48 *10*		67Be08	IMPAC	$\omega\tau$=6.9 *12*mr	$Nd^{3+}(^{16}O,O')$ recoils in Cu; H_o=16.6kG,β(320°K)=2.17 *17*
								$\omega\tau$=0.36 *3*, 0.24 *2*, 0.021 *2*r	Nd recoils in Fe, Co, Ni
$^{148}_{60}Nd$	300	116ps	[2]	±0.43‡ *3*		68Be42	AAC	$g/g_{2+}(^{152}Sm)$ = 0.61 *4*	CEx with O, recoils in gas
								‡Used $g_{2+}(^{152}Sm)$=0.35	
$^{148}_{60}Nd$	300	116ps	[2]	±0.412 *32*		70Be36	AAC	$\omega^2\tau_c$=0.079 *12*r^2/ns g/g_{2+}^{150}=0.638 *52*	CEx recoils in He;
$^{148}_{60}Nd$	300	‡	[2]	+0.50 *8*		72Ku10	IMPAC	$\Delta\theta$=−0.38 *4*r corrected for beam−bending g/g_{2+}^{150}=0.80 *18*	CEx with $^{16}O^{5+}$ on ^{148}Nd, recoils in Fe;H_o=1.4kG,H_{int}= 2.4 *3*MG,$H_i\tau_i$=10.8 *89*MG−ps at 300°K
								‡$T_{1/2}$=85.2ps used in analysis	
$^{150}_{60}Nd$	132	1.52ns	[2]	+0.48 *8*		58Go72	IPAD	$\omega\tau$=94.5 *5*mr	CEx with ^1H on aqueous solution of $Nd(NO_3)_3$ in HNO_3; H_o=16.0 *3*kG, β=2.3 *3*
$^{150}_{60}Nd$	132	1.52ns	[2]	+0.620 *42*		67Ku07	DPAC		CEx with ^1H on solid Nd metal, 930°C; H_o=25kG,β=1.32
$^{150}_{60}Nd$	132	1.52ns	[2]	±0.694 *24*		68Be42	AAC	$g/g_{2+}(^{152}Sm)$= 0.99 *5*	CEx with O, recoils in He, Ar, Kr
				±0.644 *18*		70Be36		$\omega^2\tau_c$=0.194 *11*r^2/ns	recoils in He
								$\omega^2\tau_c$=0.103 *16*r^2/ns	recoils in Ar
$^{150}_{60}Nd$	132	1.52ns	[2]	+0.68 *10*		68Be51 70Be36	IPAC		CEx recoils in Ar; H_o= 17.4 *6*kG
$^{150}_{60}Nd$	397	55.9ps	[4]	+1.28 *20*		72Ku10	IMPAC	$\Delta\theta$=−0.31 *3*r corrected for beam−bending g/g_{2+}^{150}=1.00	CEx with $^{16}O^{5+}$ on ^{150}Nd, recoils in Fe;H_o=1.4kG,H_{int}= 2.4 *3*MG,$H_i\tau_i$=10.8 *89*MG−ps at 300°K
$^{143}_{61}Pm$	gs	265d	[5/2or	±3.75 *50* or		63Gr10	GAO	A=±0.029 *3*cm^{-1} P''=0.0022 *3*cm^{-1}or	Pm^{3+} in NES CMN
			7/2]	±3.9 *5*				A=±0.022 *2*cm^{-1} P''=0.00125 *20*cm^{-1}	
$^{144}_{61}Pm$	gs	360d	[5 or 6]	±1.68 *14* or ±1.75 *14*		61Sh02	GAO	A/k=±0.0091°K or A/k=±0.0079°K	Pm^{3+} in NES; used <r^{-3}>= 36.8x$10^{24}cm^{-3}$
$^{144}_{61}Pm$	gs	360d	[5 or			63Gr10	GAO	A=±0.0065 *5*cm^{-1} P''=0.00011 *1*cm^{-1}or	NES CMN
			6]					A=±0.0056 *5*cm^{-1} P''=7.3 *4*x$10^{-5}cm^{-1}$	
$^{147}_{61}Pm$	91	2.55ns	[5/2]	+3.42 *50*		60Bo17	IPAC	$\omega\tau$=+0.79 *11*r	aqueous solution of $NdCl_3$; H_o=15kG, β=2.2
$^{147}_{61}Pm$	91	2.55ns	[5/2]	~+3		60Ma03		$G_2\omega\tau$=−0.38 *9*r where 0.5<G_2<1.0	Nd_2O_3 in alcohol; H_o=13kG
$^{148}_{61}Pm$	gs	5.4d	(1)	±1.82 *19*		63Gr10	GAO	A=±0.035 *4*cm^{-1} P''=+0.0033 *7*cm^{-1}	NES CMN
$^{148}_{61}Pm$	137	43d	[6]	±1.80 *18*		63Gr10	GAO	A=±0.0058 *3*cm^{-1}	NES

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{149}_{61}Pm$	gs	53h	(7/2)	±3.3 *5*		63Gr10, (60Ch15)	GAO	P''=0.00088 *20*cm^{-1}	CMN
$^{149}_{61}Pm$	114	2.58ns	[5/2]	±2.34 *30*		66Sv01	IPAC AAC	$\omega\tau$=0.377‡ *66*r, $\omega\tau$=1.81‡ *16*r	$NdCl_3$ in H_2O; H_o=13.90 *40*, 51.6 *5*kG; used G_2=0.81 *3*, β=1.92
								‡Corrected for Compton events of (542γ)(114γ) of ~8%	
$^{149}_{61}Pm$	114	2.58ns	[5/2]	±2.51 *33*		69Ta08	IPAC	$G_2\omega\tau$=394 *106*mr, 223 *36*mr; 354 *146*mr	$^{149}Nd_2O_3$ in dilute HCl; H_o=12.8,8.5kG for (424γ)(114γ); H_o=12.8kG for (542γ)(114γ); used G_2=0.80 *3*, β=1.92
$^{149}_{61}Pm$	114	2.58ns	[5/2]	±2.08^P *15*		70Be67, 69Be25	IPAC		^{148}Nd(th n,),dissolved in aqua regia; used G_2=0.81
$^{149}_{61}Pm$	114	2.58ns	[5/2]	±1.95 *20*		70Se11	IPAC	$G_2\omega\tau$=0.37 *3*‡ or $G_2\omega\tau$=0.39 *14*‡ ‡Unit not given	Nd_2O_3 in HCl; (542γ)(114γ) or (424γ)(114γ); used β=1.93 and G_2=0.878 *31*
$^{149}_{61}Pm$	188	3.24ns	[3/2]	+1.08^P *15*		70Be67	IPAC		^{148}Nd(th n,),dissolved in aqua regia, used G_2=0.77
$^{149}_{61}Pm$	188	3.24ns	[3/2]	±2.2 *6*		70Se11	IPAC	$G_2\omega\tau$=0.74 *16*‡ ‡Unit not given	Nd_2O_3 in HCl; used β=1.93 and G_2=0.62 *12* calculated from data on 114 and 270keV levels; time-dependent interactions assumed
$^{149}_{61}Pm$	211	80ps	[5/2]	+2.18^P *35*		70Be67	IPAC		^{148}Nd(th n,),dissolved in aqua regia; used G_2=1
$^{149}_{61}Pm$	270	2.59ps	[7/2]	+2.21^P *11*		70Be67, 69Be25	IPAC		^{148}Nd(th n,), dissolved in aqua regia; used G_2=0.84
$^{149}_{61}Pm$	270	2.59ps	[7/2]	±3.64 *20*		70Se11	IPAC AAC	$G_2\omega\tau$=0.42 *6*‡ or $G_2\omega\tau$=0.46 *2*‡ ‡Unit not given	Nd_2O_3 in HCl; (268γ)(156γ) or (268γ)(270γ); used β=1.93 and G_2=0.781 *18*
$^{145}_{62}Sm$	gs	340d	[7/2]	±0.92 *6*		69Ka21	GAO	μ/μ^{147}=1.12 *11*, 1.15 *12*	NES, CMN
$^{147}_{62}Sm$	121	780ps	[5/2]	−0.30 *18*		68Bo47	IPAC		aqueous $EuCl_3$; H_o=18.3 *3*kG; used β=1.16
$^{147}_{62}Sm$	121	780ps	[5/2]	−0.26^P *15*		70Be67	IPAC		Sm(p,); G_2=1
$^{147}_{62}Sm$	198	1.31ns	[3/2]	−0.28 *10*		68Bo47	IPAC		aqueous $EuCl_3$; H_o=18.3 *3*kG; used β=1.16
$^{147}_{62}Sm$	198	1.31ns	[3/2]	−0.28^P *6*		70Be67	IPAC		Sm(p,); G_2=1
$^{148}_{62}Sm$	551	7.35ps	[2]	+0.34 *9*		72Ku10	IMPAC	$\Delta\theta$=−30 *2*mr g/g_{2+}^{154}=0.752 *88*	CEx with $^{16}O^{5+}$ on ^{148}Sm, recoils in Fe;H_o=1.4kG,H_{int}=+2.3 2MG, $H_{\Gamma}\tau_r$=10.8 *89*MG−ps at 300°K
$^{150}_{62}Sm$	334	48ps	[2]	±0.636 *34*		70Be36 (68Be42)	AAC	$\omega^2\tau_c$=0.177 *19*r^2/ns g/g_{2+}^{152}=0.936 *60*	CEx recoils in He gas
$^{150}_{62}Sm$	334	48ps	[2]	+0.55 *6*		72Ku10	IMPAC	$\Delta\theta$=−22.6 *11*mr g/g_{2+}^{154}=0.903 *98*	CEx with $^{16}O^{5+}$on^{150}Sm; see ^{148}Sm(551), 72Ku01
$^{151}_{62}Sm$	105	480ps	[5/2]	+0.52^P *18*		71Be23	IPAC		^{150}Nd(pile n,); used β=1.16 at 320°K; G=1
$^{151}_{62}Sm$	168	760ps	[3/2]	+0.57^P *12* +0.58^P *12*		71Be23	IPAC		^{150}Nd(pile n,); used β=1.16 at 320°K; G=1
$^{152}_{62}Sm$	122	1.4ns	[2]	±0.62 *12*		58Go72	IPAD	$\omega\tau$=56.8 *40*mr	CEx with ^{1}H on aqueous solution of $Sm(NO_3)_3$ in HNO_3; H_o=16.0 *3*kG, β=1.16
$^{152}_{62}Sm$	122	1.4ns	[2]	+0.72 *32*		58Su55	PAC		CEx with ^{1}H on Sm_2O_3 on Cu foil; H_o=22kG, G_2~0.6

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{152}_{62}Sm$	122	1.4ns	[2]	±0.23 *15* ±0.64‡ *11*		60De16	IPAC	$\omega\tau$=0.063 *7*r $\Delta\theta/H$=−2.12 *18*mr/kG or −1.00 *29*mr/kG	Eu_2O_3 in HNO_3; G_2=1, H_o=19.0 *2*kG; β=3.0 Eu_2O_3, H_o=22kG; G_2(300°K)=0.68 *8* or G_2(1200°K)=0.55 *7*
								‡Using β=1.16 for liquid source and 300°K data	
$^{152}_{62}Sm$	122	1.4ns	[2]	±0.56 *14*		60Ma38	IPAC	$G_2\omega\tau$=37 *9*mr	Eu_2O_3 in nitric acid; H_o=12kG G_2=1.00 *13*, β=1.15
$^{152}_{62}Sm$	122	1.4ns	[2]	+0.700 *60*		62Ba38	IPAC		$EuCl_3$ in HCl, 300°K, β=1.15; anhydrous $EuCl_3$, ~1200°K, β=1.04; H_o=23, 26kG
$^{152}_{62}Sm$	122	1.4ns	[2]	+0.554 *56*		67Wo06	DPAD		^{152}Sm powder(p,p'); β(330°K)=1.135
$^{152}_{62}Sm$	122	1.42ns	[2]	±0.678 *24* ±0.692 *26*		70Be36 (68Be51, 68Be42)	AAC	$\omega^2\tau_c$=0.202 *14*, 0.094 *7*r^2/ns	CEx recoils in He, Ar
$^{152}_{62}Sm$	122	1.42ns	[2]	±0.60 *7*		71Do17	IPAC		dilute aqueous $^{152}Eu_2Cl_3$; H_o=21.8 *1*kG, β=1.15; observed three distinct cascades
$^{152}_{62}Sm$	366	57ps	[4]	+1.22 *15*		72Ku10	IMPAC	$\Delta\theta$=−0.313 *10*mr g/g_{2+}^{154}=1.00	CEx with $^{16}O^{5+}$ on ^{152}Sm; see ^{148}Sm(551), 72Ku01
$^{154}_{62}Sm$	82	3.02ns	[2]	+0.53 *12*		58Go72	IPAC	$\omega\tau$=110 *8*mr	see ^{152}Sm(122), 58Go72
$^{154}_{62}Sm$	82	3.02ns	[2]	+0.576 *58*		67Wo06	DPAD		^{154}Sm metal powder(p,p'); β(330°K)=1.135
$^{154}_{62}Sm$	82	3.02ns	[2]	±0.634 *56* ±0.620 *64*		70Be36 (68Be42)	AAC	$\omega^2\tau_c$=0.079 *14*r^2/ns g/g_{2+}^{152}=0.917 *28*	CEx recoils in Ar
$^{154}_{62}Sm$	267	165ps	[4]			67Bo32	IMPAC	$\omega\tau$=−0.45^P *5*r	CEx with ^{16}O on ^{154}Sm, ^{152}Sm
								g/g_{4+}^{152}=0.68^P *12*, using $T_{1/2}^{152}$(4+)=57.3ps	
$^{154}_{62}Sm$	267	165ps	[4]	+1.35 *14*		72Ku10	IMPAC	$\Delta\theta$=−889 *44*mr g/g_{2+}^{154}=1.07 *12*	CEx with $^{16}O^{5+}$ on ^{154}Sm; see ^{148}Sm(551), 72Ku01
$^{154}_{62}Sm$	549	23.5ps	[6]	+1.90 *28*		72Ku10	IMPAC	$\Delta\theta$=−141 *10*mr g/g_{2+}^{154}=1.12 *13*	CEx with $^{16}O^{5+}$ on ^{154}Sm; see ^{148}Sm(551), 72Ku01
$^{147}_{63}Eu$	625	765ns	[11/2]	+6.00 *33*		70Kl07	DPAC	ω=2.73 *16*Mr/s	$GdCl_3$ in HCl; H_o=1kG, β(300°K)=0.52
$^{149}_{63}Eu$	497	2.43μs	[11/2]	+6.05 *16*		70Kl07	DPAC	ω=2.75 *7*Mr/s	$GdCl_3$ in HCl; H_o=1kG, β(300°K)=0.52
$^{153}_{63}Eu$	103	3.8ns	[3/2]	+1.05^P *26*		71Be23	IPAC		^{152}Sm(pile n,); used G_2=0.85 *5*, β(320°K)=0.55
$^{154}_{63}Eu$	gs	16y	(3)		±1.88 *21*	62Ju06, 66Bl05	GAO	Q/Q_{gs}^{152}=+0.62‡ *7*	^{154}Eu in NES; used Q^{152}/Q^{151}=±2.75 *17* and Q^{151}=1.1 *1*
								‡Using P^{154} as corrected in [66Bl05]	
$^{155}_{63}Eu$	105	400ps	[5/2]	+2.47^P *27*		71Be23	IPAC		^{154}Sm(pile n,); used G=1 and β(320°K)=0.55
$^{152}_{64}Gd$	344	29ps	[2]			67Pr16	IPAC	$\omega\tau$=+21^P *9*mr	^{152}Eu in Fe
$^{152}_{64}Gd$	344	29ps	[2]	+1.16 *22*		69Zm01	IPAC	$(\omega\tau)_{ave}$=37.5 *33*mr	Eu–Gd metal; H_{int}(85°K)=−320 *15*kG
$^{152}_{64}Gd$	344	29ps	[2]	±0.856 *62*		70Be36	AAC	$\omega^2\tau_c$=0.378 *55*r^2/ns g/g_{2+}^{154}=1.003 *80*	CEx recoils in He
$^{154}_{64}Gd$	123	1.18ns	[2]	±0.72 *12*		61St04	IPAC	ω=26.6 *35*Mr/s	$GdCl_3$ at 980°C; H_o=15kG, β=1.042; G_2=0.8
$^{154}_{64}Gd$	123	1.18ns	[2]	+0.74 *8*		62Ba38	IPAC	ω=48 *4*Mr/s	anhydrous $^{154}EuCl_3$ at 1300°K H_o=26kG, β=1.042; G_2=0.93 *1*
$^{154}_{64}Gd$	123	1.18ns	[2]			67Pr16	IPAC	$\omega\tau$=+0.14^P *2*r	^{154}Eu in Fe

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{154}_{64}$Gd	123	1.18ns	[2]	+0.90 *10*		70Be36 (68Be42)	CDPAC	$\omega(t_{ave})$=28.1 *41*mr	^{154}Gd recoils in He; H_o=17.4 *6*kG; t_{ave}=735 *30*ps; for t/τ=1.043 *48*: G_2=0.838 *15* and G_4=0.587 *29*
				±0.854 *28*			AAC	$\omega^2\tau_c$=0.376 *24*, 0.161 *13*r^2/ns	CEx recoils in He,Ar
$^{154}_{64}$Gd	123	1.18ns	[2]	±0.86 *7*		70Wa26	AAC	g/g_{2+}^{156}=1.11 *8* G_2/G_2^{156}=1.23 *17*	$^{154}Eu_2O_3$ and $^{156}Eu_2O_3$ in 1.0N $HClO_4$; assumed electric interaction negligible and g_{2+}^{156}=0.389 *11*
$^{154}_{64}$Gd	371	39ps	[4]			67Pr16	IPAC	$\omega\tau$=+15^p *4*mr g/g_{2+}^{152}=±0.53 *27*	^{154}Eu in Fe
$^{155}_{64}$Gd	87	6.66ns	(5/2)	±0.73$^{+12}_{-10}$ ±0.90‡$^{+23}_{-10}$		64Bo16 66Hr02	AAC	A=20.6$^{+36}_{-28}$MHz	$^{155}TbCl_3$ in H_2O; used μ_{gs}^{155}=0.254 *2*, A_{gs}^{155}=11.9 *4*MHz
								‡Internal field corrected for H_o=28kG	
$^{155}_{64}$Gd	87	6.66ns	(5/2)	−0.97^d *23*		66Hr02	IPAC DPAC	ω=+45.8 *103*Mr/s, ω=+45.3 *33*Mr/s	anhydrous $TbCl_3$+$GdCl_3$ at 1300°C; H_o=23.7kG, β=1.044
$^{155}_{64}$Gd	87	6.66ns	(5/2)	−0.92^p *10*		71Be23	IPAC		Gd(p,); used β(320°K)=1.22; G=0.92 *2*
$^{155}_{64}$Gd	105	1.1ns	(3/2)	+0.68^p *19*		71Be23	IPAC		Gd(p,); used β(320°K)=1.22; G=1
$^{156}_{64}$Gd	89	2.22ns	[2]	+0.64 *6*		62Ba38	IPAC	$\omega\tau$=133 *5*mr	anhydrous $^{156}EuCl_3$ at 1300°K H_o=26kG, β=1.042; G_2=0.89 *2*, G_4=0.85 *2*
$^{156}_{64}$Gd	89	2.22ns	[2]	+0.592 *36*		67Wo06	DPAD		CEx with ^{1}H on ^{156}Gd–Cu liquid metal at 1120°K, β=1.086 *15*
$^{156}_{64}$Gd	89	2.22ns	[2]	=0.680 *26*		70Be36	AAC	$\omega^2\tau_c$=0.245 *18*r^2/ns g/g_{2+}^{154}=0.807 *39*	CEx recoils in He
$^{156}_{64}$Gd	288	115ps	[4]	±1.32^{dp} *48*		67Bo32	IMPAC	$\omega\tau$=0.087 *20*r	CEx with ^{16}O on ^{156}Gd on Fe
$^{156}_{64}$Gd	288	115ps	[4]	+1.48 *20*		68We17	IPAC		Gd metal(d,2n) at 77°K; H_o~13.2kG, H_{eff}=−312 *15*kG
$^{156}_{64}$Gd	1513	190ps	[4]	+3.12 *20*		68We17	IPAC	g(1513)/g(288)=2.10 *27*	Gd metal(d,2n) or Tb metal(γ,3n) at 77°K; H_o~13.2kG, H_{eff}=−312 *15*kG
$^{158}_{64}$Gd	79.5	2.49ns	[2]	+0.630 *50*		67Wo06	DPAD		CEx with ^{1}H on Gd–Cu liquid metal at 1120°K; β=1.086 *15*
$^{158}_{64}$Gd	79.5	2.49ns	[2]	±0.664 *36*		70Be36	AAC	$\omega^2\tau_c$=0.220 *24*r^2/ns g/g_{2+}^{154}=0.765 *48*	CEx recoils in He
$^{159}_{64}$Gd	gs	18h	(3/2)	±0.44 *3*		71Kr19 70Pr13	GAP	$\|\mu H/IkT\|$=0.24 *1*	$GdFe_2$(pile n,); H_{hf}=+453kG, T=20 *1*m°K; sign of μ not measured
$^{160}_{64}$Gd	75	2.7ns	[2]	+0.606 *52*		67Wo06	DPAD		CEx with ^{1}H on Gd–Cu liquid metal at 1120°K, β=1.086 *15*
$^{160}_{64}$Gd	75	2.7ns	[2]	±0.646 *30*		70Be36	AAC	$\omega^2\tau_c$=0.215 *20*r^2/ns g/g_{2+}^{154}=0.756 *43*	CEx recoils in He
$^{156}_{65}$Tb	gs	5.4d	(3)	±1.45 *18* ±1.41^c *18*	+1.4 *5* +1.40^c*45*	62Lo01 63Bl25	GAO	A/k=±0.113 *10*°K P/k=+0.0045 *15*°K	Tb in NES
$^{159}_{65}$Tb	gs	–	(3/2)		+1.30	63Bl24 (62Lo12)	SpHt	A/k=+0.150°K P/k=+0.021°K	Tb metal; T=0.37 to 4.2°K; used $<r^{-3}>$=8.63a.u.
$^{159}_{65}$Tb	gs	–	(3/2)		+1.32^c *10*	63Bl25	SpHt		

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{159}_{65}$Tb	gs	–	(3/2)		(+0.82‡)	64Va27	SpHt	A/k=+0.152 *2*°K	Tb metal; T=0.05 to 0.9°K
								P/k=+0.013 *4*°K	
								‡Used 63Bl24, 63Bl25 and 62Lo12	
$^{159}_{65}$Tb	gs	–	(3/2)		(+0.99‡)	69Kr19	SpHt	A/k=+0.149°K	Tb metal; T=0.03 to 0.5°K
								P/k=+0.0158°K	
								‡Used 63Bl24, 63Bl25 and 62Lo12	
$^{160}_{65}$Tb	gs	72d	(3)	±1.60 *25*	+1.9 *5*	60Jo12	GAO	A/k=+0.125 *20*°K	Tb in NES at 0.02°K
				±1.56^{c} *25*	+1.87^{c}*70*	63Bl25		P/k=+6.1 *22*m°K	
$^{155}_{66}$Dy	gs	10h	[3/2]	±0.21 *5*		61Na04	GAO	A/k=0.032 *8*°K	Dy in NES at 0.02°K
$^{157}_{66}$Dy	gs	8.1h	[3/2]	±0.32 *2*		61Na04	GAO	A/k=0.048 *3*°K	Dy in NES at 0.02°K
$^{158}_{66}$Dy	630	?	[6]	±2.16‡*42*		71Ka68	IMPAC		natural metallic Gd(α,), at 77,170,257,300°K; finds H_{eff}~2.8,2.3,0,0‡MG; $H\tau_{t}$~ 15‡MG−ps from $\omega\tau$(t)
								‡Assumed $g(6+)=g(8+)=g(2+)$=0.36 for ^{160,162}Dy	
$^{160}_{66}$Dy	87	2.0ns	[2]	±0.48 *14*		60Ma38	IPAC	$G_2\omega\tau$=0.19 *3*r	Tb_2O_3 in HCl at 340°K; H_o=
				±0.54‡ *16*				‡For β=5.4	12kG, G_2=0.80 *12*, β=6.0
$^{160}_{66}$Dy	87	2.0ns	[2]	±0.83 *9*		61Ku03	IPAC		Tb_2O_3 at 300,540,1333°K; H_o=
				±0.99‡ *11*					18.3kG; used β=7.2,4.55,2.4
								‡For β=6.02, 3.8, 2.0	
$^{160}_{66}$Dy	87	2.0ns	[2]	+0.58 *18*		62Co28	IPAC	$\omega\tau$=−2.50 *70*r	DyFeGarnet; used H_{eff}=600kG from Mössbauer
$^{160}_{66}$Dy	87	2.0ns	[2]	±0.728 *22*		65Gu02	DPAC	ω=358 *11*Mr/s	$TbCl_3$ in 3M HCl; H_o=33.5kG,
				+0.704 *38*			IPAC	$G_2\omega\tau$=439 *12*mr	β=6.02 for DPAC; H_o=20.19kG,
					±5 *1*		AAC	G_2=0.740 *20*, G_4= 0.597 *25*	β=6.07 for IPAC
$^{160}_{66}$Dy	87	2.0ns	[2]		±1.67‡*36*	69Fo08,	DPAC		^{160}Tb in $HClO_4$, H_2SO_4, HCl;
					±1.76‡*39*	70Wa25	DPAC	‡$Q(1-R)$	used g=0.346 *11*
$^{160}_{66}$Dy	87	2.05ns	[2]	±0.712 *34*		70Be36	AAC	$\omega^2\tau_c$=0.281 *27*r^2/ns	CEx recoils in He
$^{160}_{66}$Dy	966	2.2ps	[2]	+0.46^{ap} *22*		68Ca26	PAC		magnetized Gd alloy
$^{160}_{66}$Dy	966	2.2ps	[2]	+0.36 *12*		69Si01	IPAC	$\omega\tau$=14.3 *13*mr	Dy in Tb metal, single crystal; H_o=13.6kG, H_{int}= 5.6 *4*MG
$^{161}_{66}$Dy	26	28.4ns	(5/2)	+0.75^{P} *9*		71Be23	IPAC		^{160}Gd(pile n,); used G=
				+0.78^{P} *9*			DPAC		0.38 *10*, β(320°K)=5.7
$^{161}_{66}$Dy	75	3.4ns	[3/2]	−0.35^{P} *5*		71Be23	IPAC		^{160}Gd(pile n,); used G=0.89 β (320°K)=5.7
$^{162}_{66}$Dy	80.7	2.25ns	[2]	+0.724 *48*		67Ku07	DPAC		Dy−Cu eutectic liquid at 880°C(pulsed p,p′); H_o=25kG, β=2.30
$^{162}_{66}$Dy	80.7	2.25ns	[2]	±0.686 *28*		70Be36	AAC	$\omega^2\tau_c$=0.261 *22*, 0.100 *14*r^2/ns	CEx recoils in He, Ar
								g/g^{160}_{2+}=0.964 *62*	
$^{164}_{66}$Dy	73.3	2.39ns	[2]	+0.642 *50*		67Ku07	DPAC		Dy−Cu eutectic liquid at 880°C(pulsed p,p′); H_o=25kG, β=2.30
$^{164}_{66}$Dy	73.3	2.39ns	[2]	±0.730 *30*		70Be36	AAC	$\omega^2\tau_c$=0.296 *24*r^2/ns	CEx recoils in He
								g/g^{160}_{2+}=1.026 *65*	
$^{165}_{67}$Ho	gs	stable	(7/2)			64Va27	SpHt	A/k=+0.320 *5*°K	Ho metal
								P/k=+8.0 *15*m°K	
$^{165}_{67}$Ho	gs	stable	(7/2)			69Kr19	SpHt	A/k=+0.319°K	Ho metal, T=0.03 to 0.5°K
								P/k=+4m°K	
$^{166}_{67}$Ho	9	1.2ky	[7]	±4.14^{P}‡*17*		59Po62	GAO	A/k=0.24 *2*°K, for I=7	Ho in NES single crystal
								‡Used μ^{165}=4.12 *2*, A^{165}/k=0.478 *2*°K	

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat – Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
${}^{156}_{68}$Er	344 453	47.9ps 7.83ps	[2] [4]	$g_{av}\sim\pm0.39$ to 0.42‡		70No01	AAC	$G_2(344)=0.23$ 4 $G_2(453)=0.73$ 8 ‡Depends on model used	^{120}Sn(^{40}Ar,Ar′) recoils in vacuum; assumed $H\sim41$ 7MG, τ_c=3ps
${}^{158}_{68}$Er	193 356 434	433ps 20.8ps 4.04ps	[2] [4] [6]	$g_{av}\sim\pm0.34$ to 0.39‡		70No01	AAC	$G_2(193)=0.07$ 5 $G_2(356)=0.47$ 4 $G_2(434)=0.93$ 8 ‡Depends on model used	^{122}Sn(^{40}Ar,Ar′) recoils in vacuum; assumed $H\sim41$ 7MG, τ_c=3ps
${}^{160}_{68}$Er	264 376 465	49.8ps 7.77ps 4.04ps	[4] [6] [8]	$g_{av}\sim\pm0.26$ to 0.39‡		70No01	AAC	$G_2(264)=0.31$ 5 $G_2(376)=0.82$ 5 $G_2(465)=1.08$ 9 ‡Depends on model used	^{124}Sn(^{40}Ar,Ar′) recoils in vacuum; assumed $H\sim$ 41 7MG τ_c=3ps
${}^{166}_{68}$Er	80.6	1.82ns	[2]	±0.56 10 ±0.62‡ 12		60Ma38	IPAC	$\omega\tau=0.14$ 2r ‡For $\beta=7.0$	^{166}Ho in dilute HNO_3; H_o=5kG $\beta=7.7$, $G_2=0.78$ 12, $G_4=0.55$ 5
${}^{166}_{68}$Er	80.6	1.82ns	[2]	+0.520 68 +0.614‡80		61Bo05 63Ge09	IPAC	$\omega=+140$Mr/s ‡For $\beta=7.08$	$HoCl_3$ aqueous solution; H_o=13.55kG, $\beta=8.36$
${}^{166}_{68}$Er	80.6	1.82ns	[2]	±0.71 12 ±0.76‡ 12		61Ku03	IPAC	‡For $\beta=25.5$, 6.8, 2.35	Ho_2O_3 at 80, 300, 1333°K; used $\beta=25.2$, 7.9, 2.6
${}^{166}_{68}$Er	80.6	1.82ns	[2]	+0.658 54		67Ku07	DPAC		Er–Cu eutectic liquid at 930°C(pulsed p,p′); H_o=25kG, $\beta=2.48$
${}^{166}_{68}$Er	265	120ps	[4]	+1.08 10		63Ge09	IPAC	$\omega\tau=83$ 6mr, corrected for other cascades	dilute aqueous $HoCl_3$ solution; H_o=53kG, $\beta=7.08$
${}^{166}_{68}$Er	265	120ps	[4]			68De28	IMPAC	$\omega\tau=0.60$ 5r	CEx with ^{16}O on ^{166}Er on polarized Fe foil; find H_{hf}= −2.2 3MG
${}^{166}_{68}$Er	265	120ps	[4]	$\pm1.18^{p}$7		72Mi21	IPAC	$\omega\tau/\beta=6.20$ 21mr	Ho metal(n,); $HoCl_3$; H_o=25.4 3kG
${}^{168}_{68}$Er	79.8	1.91ns	[2]	+0.50 6 +0.53‡6		62Bo18	IPAC	$\omega\tau=485$ 51mr $G_2=0.86$ 7 ‡For $\beta=6.82$	$Tm(NO_3)_3$ in 3N HNO_3; H_o= 20.3kG, β(300°K)=7.26
${}^{168}_{68}$Er	79.8	1.91ns	[2]	+0.688 56		67Ku07	DPAC		Er–Cu eutectic liquid at 930°C(pulsed p,p′); H_o=25kG, $\beta=2.48$
${}^{168}_{68}$Er	79.8	1.91ns	[2]	±0.610 20		70Be36	AAC	$\omega^2\tau_c=0.199$ 13, 0.100 11r^2/ns	CEx recoils in He, Ar
${}^{168}_{68}$Er	264	120ps	[4]	+1.08‡16		68De28	IMPAC	$\omega\tau=0.60$ 5r $g/g_{4+}^{166}=1.00$ ‡Used $g_{4+}^{166}=1.08$ 10	CEx with ^{16}O on ^{168}Er on Fe foil; $H_{hf}=-2.2$ 3MG
${}^{168}_{68}$Er	~7800	?	[4]	−0.45 74		70Be13	‡	$\Delta E=0$ 6μeV ‡Measured energy shift of neutron resonance in strong magnetic field	^{167}Er metal crystal (polarized n,); $H_{eff}\sim6.2$MG; assumed $\mu^{167}=-0.56$
${}^{168}_{68}$Er	~7800	?	[3]	±5.9 12		70Be13	‡	$\Delta E=-43.5$ 80 μeV ‡Measured energy shift of neutron resonance in strong magnetic field	^{167}Er metal crystal (polarized n,−); $H_{eff}\sim6.2$MG; assumed $\mu^{167}=-0.56$
${}^{170}_{68}$Er	79	1.90ns	[2]	+0.658 50		67Ku07	DPAC		Er–Cu eutectic liquid at 930°C(pulsed p,p′); H_o=25kG, $\beta=2.48$
${}^{170}_{68}$Er	79	1.90ns	[2]	±0.714 30		70Be36	AAC	$\omega^2\tau_c=0.273$ 23r^2/ns $g/g_{2+}^{168}=1.171$ 62	CEx recoils in He

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{170}_{68}Er$	261	135ps	[4]	±1.25‡*21*		68De28	IMPAC	$\omega\tau$=0.62 *6*r g/g^{166}_{4+}=0.92 ‡Used g^{166}_{4+}=1.08 *10*	CEx with ^{16}O on ^{170}Er on Fe foil; H_{hf}=−2.2 *3*MG
$^{169}_{69}Tm$	118	62ps	[5/2]	+0.50 *15* +0.54‡ *16*		60Ma38	IPAC	$G_2\omega\tau$=5.6 *17*mr ‡For β=5.2	$^{169}Yb_2O_3$ in dilute HNO_3; H_o= 13kG, β~5.6, G_2~1
$^{169}_{69}Tm$	118	62ps	[5/2]	+0.61 *12*		65Bo08	PAC	$G_2\omega\tau$=5.9 *2*mr	$YbCl_3$ in H_2O; H_o=10.8 *4*kG, β=5.31, G_2=0.99
$^{169}_{69}Tm$	118	62ps	[5/2]	±0.73‡ *12*		66Ko01	IPAC	g(139)/g(118)= 1.28 *12* ‡Used g(139)=0.37 *4*	LuIG at liquid N temperature
$^{169}_{69}Tm$	118	62ps	[5/2]	+0.79 *8*		68Ka14	IPAC	$\omega\tau$=−21.8 *22*mr $\mu\tau$=70.2 *71*nm−ps	Yb_2O_3 in HCl; H_o=32.57 *30*kG, β(308°K)=4.98, G_2~1
$^{169}_{69}Tm$	118	62ps	[5/2]	+0.72 *8*		69Gu01	IPAC	$\mu\tau$=64.5 *70*nm−ps	$YbCl_3$ in 3N HCl; H_o=22.0 *6*kG β(300°K)=5.08
$^{169}_{69}Tm$	139	320ps	[7/2]	±1.22 *17*		65Bo08	IPAC	$G_2\omega\tau$=41.7 *40*mr	$YbCl_3$ in H_2O; H_o=10.8 *4*kG, β=5.31, G_2=0.95
$^{169}_{69}Tm$	139	320ps	[7/2]	+1.30 *7*		68Ka14	IPAC	$\omega\tau$=−133 *4*mr $\mu\tau$=600 *24*nm−ps	Yb_2O_3 in HCl; H_o=32.57 *30*kG, β(308°K)=4.98, G_2=0.956 *12*
$^{169}_{69}Tm$	139	320ps	[7/2]	+1.28 *8*		69Gu01	IPAC	$\mu\tau$=588 *29*nm−ps	$YbCl_3$ in 3N HCl; H_o=22.0 *6*kG β(300°K)=5.08
$^{169}_{69}Tm$	139	320ps	[7/2]			72Be43	PAC AAC	Q(139)/Q(118)= 1.0^p *2*	^{168}Yb implanted in Fe
$^{169}_{69}Tm$	316	660ns	[7/2]	±0.154 *8*		72Ni03	DPAC	ω=6.30 *35*Mr/s	$^{169}Yb(C_2H_3O_2)_3$ solution; H_o~5.98kG, β(300°K)=5.08
$^{169}_{69}Tm$	379	36ns	[7/2]	±0.959^{dp}*74*		67Ni05	DPAC	ω=85.1 *34*Mr/s	$YbCl_3$ in HCl; H_o=12.87kG, β=5.08
$^{171}_{69}Tm$	117	55ps	[5/2]	+0.81 *37*		68Ka14	IPAC	$\omega\tau$=−20.2 *80*mr $\mu\tau$=65 *26*nm−ps	$^{171}Er_2O_3$ in HCl; H_o=32.57 *30* kG, β(308°K)=4.98, G_2~1
$^{171}_{69}Tm$	129	362ps	[7/2]	+0.94 *18*		65Ag02	IPAC		$ErCl_3$ in H_2O; H_o=21.47kG, β(300°K)=5.08, assumed G_2=1
$^{171}_{69}Tm$	129	362ps	[7/2]	+1.44 *14*		68Ka14	IPAC	$\omega\tau$=−168 *15*mr $\mu\tau$=756 *67*nm−ps	$^{171}Er_2O_3$ in HCl; H_o=32.57 *30* kG,β(308°K)=4.98;G_2=0.949 *13*
$^{169}_{70}Yb$	gs	32d	[7/2]	±0.63 *9*		72Kr18	GAO	B_2=0.59 *10* Δ/k=±11.7 *15*m°K	Yb−Au;H_{int}=1.77MG; T=18 *2*m°K
$^{170}_{70}Yb$	84	1.58ns	[2]	+0.66 *4*		65Ti02	DPAD		CEx of ^{170}Yb metal target
$^{172}_{70}Yb$	78.7	1.6ns	[2]	+0.608 *68*		64Gu01	PAC	$\omega\tau$=305 *31*mr‡ ‡Unit not given	$LuCl_3$ in dilute HCl; H_o=35.9 kG, β=2.58 *10*, G_2=0.95 *2*
$^{172}_{70}Yb$	78.7	1.6ns	[2]	+0.558 *28*		66Ti01	DPAD		^{172}Yb metal(p,p′)
$^{172}_{70}Yb$	78.7	1.6ns	[2]		+2.7 *7*	69Fo07 70Wa25	DPAC	$Q(1-R)$=2.16 *37*b	Er_2O_3 in $HClO_4$; used R~0.2, g=0.328 *5*
$^{172}_{70}Yb$	1174	7.95ns	[3]	+0.67 *4*		65Gu01	IPAC		$LuCl_3$ in 0.1M HCl; H_o=28kG, β=2.58 *13*
$^{172}_{70}Yb$	1174	7.95ns	[3]		±3.6‡ *10*	70Ra18	DPAC	ω_o(1174)/ω_o(79)= 0.53 *6* Q(1174)/Q(79)= ±1.33 *15* ‡Used Q(79)=2.7 *7*	Yb in Tm metal; Tm_2O_3
$^{172}_{70}Yb$	1174	7.95ns	[3]		±3.6‡ *10*	70Wa25	DAAC	Q(1174)/Q(79)= 1.32 *14* ‡Used Q(79)=2.7 *7*	$^{171}Er_2O_3$ in 1N $HClO_4$, in 16.4N HCl at −30°C, and in ethyl alcohol at +20°C,−84°C
$^{172}_{70}Yb$	1174	7.95ns	[3]	+0.61 *9*		71Wa03	IPAC	$\omega\tau$(1174)/$\omega\tau$(79)= 3.01 *33*	used g^{172}_{2+}=0.332 *8* from Möss.

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{173}_{70}$Yb	79	38ps	[7/2]	−0.203^p *66*		72Ka13	PAC		
$^{173}_{70}$Yb	179	36ps	[9/2]	+0.27^p *36*		72Ka13	PAC		
$^{173}_{70}$Yb	351	0.45ns	[11/2]	−0.71^p *71*		72Ka13	PAC		
$^{174}_{70}$Yb	76.5	1.79ns	[2]	+0.494 *26*		66Ti01	DPAD		^{174}Yb metal(p,p′)
$^{175}_{70}$Yb	gs	4.2d	[7/2]	±0.15 *4*		57Gr51	GAO	A/k=6.4m°K	Yb($C_2H_5SO_4$)$_3$•9
				±0.18^c *5*		62Li06			
$^{175}_{70}$Yb	gs	4.2d	[7/2]	±0.23^c‡		71Sp16	GAO		ion implantation in YES;
				or 0.33^c‡		(57Gr51)			H_{eff}=1.77MG
					6† *2*				ion implantation in Au
								‡For γ−mixing ratio + or −	
								†Assumed H_{eff}=1.77MG as for YES	
$^{175}_{70}$Yb	gs	4.2d	[7/2]	±0.40 *5*		72Kr18	GAO	B_2=0.315 *32*	Yb−Au;H_{int}=1.77MG; T=18 2m°K
$^{176}_{70}$Yb	82	1.76ns	[2]	+0.598 *30*		66Ti01	DPAD		^{176}Yb metal(p,p′)
$^{175}_{71}$Lu	114	100ps	[9/2]	+1.5 *5*		60Ma03	IPAC	$G_2\omega\tau$=−3.0 *10*mr	^{174}Yb$_2$O$_3$ in dilute HNO$_3$; H_o=13kG
$^{175}_{71}$Lu	114	100ps	[9/2]	+1.81 *20*		65Ka05	IPAC	$\omega\tau$=14.5 *14*mr	Yb metal from Yb$_2$O$_3$(pile n,) H_o=52.25 *50*kG, assumed β~1
								$\omega\tau$=15.6 *12*mr	Yb(NO$_3$)$_3$ in H$_2$O; H_o=52.3 *5*kG
				+1.99‡ *15*		69Wa30		$\omega\tau$=17.5 *16*mr	^{175}YbIG
								‡Based on average $\omega\tau$=15.86 *85*mr	
$^{175}_{71}$Lu	251	42ps	[11/2]	+1.9‡ *6*		66De08	IPAC		^{175}Yb in Fe foil
								‡Used g^{175}(114)=+0.403 *44* to obtain H_{int}= −338 *42*kG	
$^{177}_{71}$Lu	971	155d	[23/2]		+12.6 *14*	66Bl05	GAO	Q/Q_{gs}=+2.33 *25*	Lu in NES
$^{176}_{72}$Hf	88.4	1.40ns	[2]	+0.532 *42*		68Be04	IPAC	$\omega\tau$=43.9 *30*mr	CEx recoils in liquid Ga; G=0.982 *23*; H_o not given
$^{177}_{72}$Hf	113	500ps	[9/2]	+0.82 *22*		60Ma03	IPAC	$G_2\omega\tau$=−9.1 *14*mr	Lu$_2$O$_3$ in nitric acid; H_o= 13kG; assumed β=1, G_2=1
$^{177}_{72}$Hf	113	500ps	[9/2]	±1.14 *15*		62Bo27	IPAC		Lu(NO$_3$)$_3$+H$_2$O; H_o=26.30 *24*kG
$^{177}_{72}$Hf	113	500ps	[9/2]	+1.09^d *6*		62Ma42	IPAC	$\omega\tau/H$=+0.824^d *25* mr/kG	dilute aqueous LuCl$_3$(pile n) H_o=29.2, 53.1kG; G_2>0.98 (H_{int} uncertain ~10%,65Ma27)
$^{177}_{72}$Hf	113	500ps	[9/2]	±1.13^p *5*		69Ni15	IPAC		H_o=18.48kG
$^{177}_{72}$Hf	250	98ps	[11/2]	+1.43 *50*		68Br15	IPAC	$\omega\tau_{250}/\omega\tau_{113}$= 0.23 *6*	Lu(pile n,) implanted in Fe
				+2.6‡ *8*					
								‡For $T_{1/2}$=55 *5*ps [73Go47]	
									foils; H_{int}=−140 *10*kG
$^{177}_{72}$Hf	321	660ps	[9/2]	−0.508 *17*		69Hu10	IPAC		Lu in Fe foil; H_o=10kG, H_{hf}= −286 *40*kG using data of 62Ma42 for $g\tau$(113)
$^{178}_{72}$Hf	93	1.50ns	[2]	+0.71 *7*		62Bo13	IPAC	$\omega\tau$=182 *17*mr	aqueous (NH$_4$)$_2$WO$_4$;H_o=49.55kG (H_{int} uncertain ~10%,65Ma27)
$^{178}_{72}$Hf	93	1.50ns	[2]	+0.58^d *4*		62Ka14	IPAC	$\omega\tau/H$=+3.0 2mr/kG	^{178}W in HF acid;H_o=25.2,45.7 kG; G_2=0.74 *9*, G_4=0.818 *46* (H_{int} uncertain ~10%,65Ma27)
$^{178}_{72}$Hf	93	1.50ns	[2]	+0.59 *8*		67Gi02	IMPAC	$\omega\tau$=46.1 *28*mr	CEx with O, recoils in Cu; H_o=16.6kG; X=0.913 *87*
$^{178}_{72}$Hf	93	1.50ns	[2]	+0.464 *28*		68Be04	IMPAC	$\omega\tau$=41.2 *18*mr	CEx with O, recoils in liquid Ga; G_2=0.982 *23*, H_o not given
$^{178}_{72}$Hf	93	1.50ns	[2]			71Gu06	IMPAC	$\omega_Q\tau$(^{178}Hf+^{180}Hf) =0.34 *3*r at room T	CEx with ^{4}He and ^{16}O on Hf metal crystal

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat – Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{180}_{72}$Hf	93	1.50ns	[2]	+0.757 *65*		61Bo25	IPAC	$\omega\tau$=166‡ *13*mr	liquid HfF_4 in HF; H_o=42.5kG (H_{int} uncertain~10%,65Ma27)
								‡Paper quotes $\omega\tau$=1.66 *13* (Unit not given)	
$^{180}_{72}$Hf	93	1.50ns	[2]	+0.626 *70*		67Gi02	IMPAC	$\omega\tau$=49.2 *25*mr	CEx with O, recoils in Cu; H_o=16.6kG, X=0.913 *87*
$^{180}_{72}$Hf	93	1.50ns	[2]	+0.526 *30*		68Be04	IPAC	$\omega\tau$=46.7 *20*mr	CEx with O, recoils in liquid Ga; G=0.982 *23*; H_o not given
$^{180}_{72}$Hf	309	71ps	[4]	+2.3 *4*		61Bo25	IPAC	$\omega\tau$=0.91 *16*°	liquid HfF_4 in HF; H_o=53.2kG (H_{int} uncertain ~10%,65Ma27)
$^{181}_{73}$Ta	482	10.8ns	[5/2]	±3.34[d] *4*		62Bo09	DPAC	ω=134.3 *7*Mr/s	HfF_4+H_2O; H_o=21.15 *20*kG
$^{181}_{73}$Ta	482	10.8ns	[5/2]		positive	63Be46	‡		$HfOCl_2$•*8*; $(NH_4)_2HfF_6$ single crystals
								‡Observed circular polarization of 482γ	
$^{181}_{73}$Ta	482	10.8ns	[5/2]	+3.23[d] *5*		63Ma10	DPAC		HfO_2(pile n,), dissolved in 26N HF; H_o=29.8 *3*,32.05 *32*kG (H_{int} uncertain~10%, 65Ma27)
$^{181}_{73}$Ta	482	10.8ns	[5/2]	+3.23[d] *5*		64Ag02	CDPAC		HfF_4 in 27N HF; H_o≤20kG t_{delay}=30.6, 40.0, 41.0ns
$^{181}_{73}$Ta	482	10.8ns	[5/2]	+3.03[dp] *18*		67Ka26	DPAC	ω=114Mr/s	dilute HfF_4 solution;H_o=20kG
$^{181}_{73}$Ta	482	10.8ns	[5/2]	±3.320[p] *25*		69Ni14	DPAC		H_o=22kG
$^{181}_{73}$Ta	482	10.8ns	[5/2]	±3.30[d] *12*		70Li16	DPAC IPAC	ν_Q=52.6 *6*MHz ν=152 *5*MHz	Hf single crystal H_{res}=24.2kG
$^{182}_{73}$Ta	gs	115d	[3]	±2.6 *2*		72Kr05	GAP	B_2==0.705 *23* B_4=0.082 *5* Δ/k=21 *2*m°K	^{182}Ta + ^{54}Mn in Fe; H_{hf}=−656 kG; T=24 *2*m°K
$^{182}_{74}$W	100	1.37ns	[2]	+0.403 *38*		62Go17	IPAD		CEx with ^{1}H on ^{182}W metal; H_o=20.3 *2*kG; G_2=0.925 *30*
$^{182}_{74}$W	100	1.37ns	[2]	±0.49[a] *7* ±0.65[a] *10*		63Kl04	IPAC	$G_2\omega\tau$=2° 5′ $\omega\tau$=2° 56′	Ta metal; H_o=35kG; G_2=0.82 Ta in $HF+HNO_3$; H_o=35kG, G_2=1
$^{182}_{74}$W	100	1.37ns	[2]	+0.67 *9* +0.74 *12*		63Ko02	DPAC IPAC	ω=47.5 *56*Mr/s $\omega\tau$=103 *16*mr	liquid TaF in HF; G_2=1.5 *12*, G_4=0.91 *5* (H_{int} uncertain~10%, 65Ma27)
$^{182}_{74}$W	100	1.37ns	[2]	+0.478 *40*		64Sc21	DPAD		CEx with ^{1}H on ^{182}W metal; H_o~34kG
$^{182}_{74}$W	100	1.37ns	[2]	+0.466‡ *54*		65Ch14 72Gr22	IPAD		Möss. scattering from W foil using Ta source at 15°K; H_o= 22.5kG, assumed β=1, ω_E=0
								‡Coherence effects ignored in analysis	
$^{182}_{74}$W	100	1.37ns	[2]	+0.498 *48*		65Eb03	IPAD		CEx with ^{1}H on ^{182}W metal; H_o≤41.6kG
$^{182}_{74}$W	100	1.37ns	[2]	±0.520 *22*		70Be36	AAC	$\omega^2\tau_c$=0.0506 *41* r^2/ns	CEx with O, recoils in He gas
$^{182}_{74}$W	100	1.37ns	[2]	+0.38 *10*		71Se12	IPAC	$G_4\omega\tau$=0.028 *7*r	powdered Ta metal(pile n,); H_o=15.9kG
$^{182}_{74}$W	329	64ps	[4]	+0.64[p]‡ *28*		67Bo32	IMPAC	$\omega\tau_{4+}$=+32 *13*mr $\omega\tau_{2+}$=+1.00 *25*r	CEx with O on WO_3, recoils in Fe; used g_{2+}=0.244 to obtain H_{int}=−430 *100*kG
								‡Assumed pure magnetic interaction	
$^{182}_{74}$W	329	64ps	[4]	+0.73 *24*		67Gi03	IMPAC	$\omega\tau$=35 *9*mr	CEx with O, recoils in Fe; assumed H_{int}=460 *45*kG, X= 0.97 *3*, G_{ave}=0.87 *4*
				+0.84[c] *28*		67Be45		Used conical magnetic field calculations to account for anomalous field on recoils	

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{182}_{74}W$	1289	1.04ns	[2]	+1.00 *24*		68Bh02	IPAC	$\omega\tau$=−116 *26*mr	H_0=32.5kG
$^{182}_{74}W$	1289	1.04ns	[2]	±1.83^p *24*		72Se15	IPAC	$\omega\tau$=98 *13*mr	Ta powder(n,); H_0=15.9kG
$^{182}_{74}W$	1374	2.25ns	[3]	±0.096^p *12*		72Se15	IPAC	$\omega\tau$=207 *26*mr	Ta–Fe(n,); H_{int}=598 *13*kG
$^{183}_{74}W$	99	700ps	[5/2]	+0.55 *28*		67Gi03	IMPAC	$\omega\tau$=17.4 *90*mr	CEx with O on W, recoils in Cu; H_0=16.6kG, X=0.97 *3*, G_2=0.95 *2*, G_4=0.97 *2*
$^{184}_{74}W$	111	1.26ns	[2]	±0.63 *8*		64Ko13	IPAC		$KReO_4+H_2O$; H_0=49.8kG; G_2=0.90 *20*, G_4=0.85 *8*
				±0.557 *34*			IPAC		W metal(d,p); H_0=49.8kG, $G_4 \geqslant$0.93 *5*
$^{184}_{74}W$	111	1.26ns	[2]	+0.564 *36*		65Eb03	IPAD		CEx with ^1H on ^{184}W metal; $H_0 \leqslant$41.6kG, G_2=0.916 *21*
$^{184}_{74}W$	111	1.26ns	[2]	+0.550 *50*		65Sc05	DPAD		CEx with ^1H on W metal
$^{184}_{74}W$	111	1.26ns	[2]	+0.62^a *8*		67Gi02	IMPAC		CEx with O, recoils in Cu; X=0.912 *88*
$^{184}_{74}W$	111	1.26ns	[2]			71Ka33	AAC	$Q/Q^{182}(100)$=1.0 *1*	CEx implantation into Gd single crystal
$^{184}_{74}W$	364	43.5ps	[4]	+1.20 *36*		67Gi03	IMPAC	$\omega\tau$=40 *10*mr	CEx with O, recoils in Fe; assumed H_{int}=460 *45*kG; G_2=0.849 *25*, G_4=0.900 *18*
				+1.38^c *40*		67Be45		Used conical field calculations to account for anomalous magnetic field on recoils	
$^{184}_{74}W$	364	43.5ps	[4]	+1.14 *14*		70Ge06	IPAC	$\omega\tau$=−51.7 *30*mr $\omega\tau_{2+}$=−1461 *66*mr g/g_{2+}=1.02 *14*	W in Fe at 300°K; used g_{2+}= 0.282 *9* and T_{2+}=1.26ns to get H_{int}=−610 *35*kG
$^{186}_{74}W$	123	1.01ns	[2]	+0.584 *54*		62Go17	IPAD		CEx with ^1H on ^{186}W metal; H_0=20.3 2kG; G_2=0.940 *25*
$^{186}_{74}W$	123	1.01ns	[2]	+0.77‡ *7*		65Ch14 72Gr22	IPAD		Möss. scattering from W foil using ^{186}Re source at 15°K; H_0=22.5kG, assumed β=1,ω_E=0
								‡Coherence effects ignored in analysis	
$^{186}_{74}W$	123	1.01ns	[2]	+0.56^a *12*		65Eb03 63Kl02	IPAC	$g_{2+}^{182,184,186}$=0.276	W metal
$^{186}_{74}W$	123	1.01ns	[2]	+0.70 *7*		67Gi02	IMPAC	$\omega\tau$=38.9 *23*mr	CEx with O, recoils in Cu; H_0=16.6kG, X=0.94 *6*; G_2=0.900 *27*, G_4=0.947 *19*, G_{ave}=0.929 *10*
$^{186}_{74}W$	123	1.01ns	[2]	+0.702 *60*		67Ku07	DPAD		CEx with ^1H on polycrystalline W metal at room T; H_0=33kG
$^{186}_{74}W$	123	1.01ns	[2]	±0.644 *26*		70Be36	AAC	$\omega^2\tau_c$=0.0774 *63* or 0.0463 *36*r^2/ns $g/g^{182}(100)$= 1.237 *71*	CEx recoils in He or Ar gas
$^{186}_{74}W$	123	1.01ns	[2]			71Ka33	AAC	$Q/Q^{182}(100)$= 1.2 *2*	CEx implantation into Gd single crystal
$^{186}_{74}W$	399	25.4ps	[4]	+0.76 *52*		67Gi03	IPAD	$\omega\tau$=12.5 *80*mr	CEx with O, recoils in Fe; assumed H_{int}=460 *45*kG; G_2=0.900 *27*, G_4=0.947 *19*
				+0.87^c *60*		67Be45		Used conical field calculations to account for anomalous magnetic field on recoils	

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{183}_{75}Re$	gs	70d	[5/2]	±2.88^{p} *12*		72Va26	GAP		Re–Fe; H_{hf}=−760 *15*kG
$^{183}_{75}Re$	gs	70d	[5/2]	±3.19 *15*		73Kr01	GAP	Δ=±35.5 *15*m°K	Re–Fe; H_{int}=760 *15*kG; used ^{54}Mn in Fe as thermometer
$^{183}_{75}Re$	496	7.89ns	[9/2]	±5.31 *31*		68Ge08	DPAC	ω=168 *10*Mr/s	Os electroplated on Cu foil, then melted; H_o=29.6 *3*kG
$^{184}_{75}Re$	gs	38d	[3]	±2.67^{p} *16*		72Va26	GAP		Re–Fe; H_{hf}=−760 *15*kG
$^{184}_{75}Re$	gs	38d	[3]	±2.48 *12*		73Kr01	GAP	Δ=±23 *1*m°K	Re–Fe; H_{int}=760 *15*kG; used ^{54}Mn in Fe as thermometer
$^{184}_{75}Re$	188	165d	[8]	±2.77^{p} *14*		72Va26	GAP		Re–Fe; H_{hf}=−760 *15*kG
$^{184}_{75}Re$	188	165d	[8]	±2.90 *15*		73Kr01	GAP	B_2=1.044 *38* B_4=0.311 *64* Δ=±10.1 *5*m°K	Re–Fe; H_{int}=760 *15*kG; used ^{54}Mn in Fe as thermometer
$^{187}_{75}Re$	206	560ns	[9/2]	±4.71^{d} *14*		63Ko19	DPAC		$Li_2WO_4+H_2O$; H_o=1.72,5.02kG (H_{int} uncertain∼10%, 65Ma27)
								No appreciable attenuation, $\Delta\nu_Q$<18MHz	
$^{187}_{75}Re$	206	560ns	[9/2]	+5.02 *6*		63Wa16	DPAC	ω=16.83 *11*Mr/s‡	saturated $(NH_4)_2WO_4+H_2O$; H_o= 3.15 *3*kG (H_{int} uncertain ∼10%, 65Ma27)
								‡Unit given as MHz	
$^{187}_{75}Re$	206	560ns	[9/2]	+4.68^{d} *18*		71Ni01	DPAC	ω=15.31 *53*Mr/s	$(NH_4)_2WO_4$ in aqueous solution; H_o=3.10 *3*kG measured by proton resonance with Beckman–Hall probe
$^{186}_{76}Os$	137	840ps	[2]	+0.632 *56*		61Bo08	IPAC	ωτ=98 *8*mr	$HReO_4$ aqueous solution; H_o= 53.50 *15*kG (H_{int} uncertain ∼10%, 65Ma27)
$^{186}_{76}Os$	137	840ps	[2]	+0.50 *13*		61Le06	IPAC	ωτ=43 *10*mr	Re metal dissolved in HNO_3; H_o=29.2kG
$^{186}_{76}Os$	137	840ps	[2]	+0.64‡ *3*		65Ch14 72Gr22	IPAD		Möss. scattering from ^{186}Os metal powder using ^{186}Re source at 15°K; H_o=22.5kG; assumed β=1, ω_E=35.6Mr/s
								‡Coherence effects ignored in analysis	
$^{186}_{76}Os$	137	840ps	[2]	+0.548 *38*		67Gi02	IPAC	ωτ=25.0 *14*mr	CEx with ^{16}O, recoils in Cu; H_o=16.6kG, X=0.963 *37*
$^{188}_{76}Os$	155	710ps	[2]	+0.59 *7*		61Ka09	IPAC	ωτ=42.3 *34*mr	powdered Re metal in dilute HNO_3; H_o=29.2kG (H_{int} uncertain ∼10%, 65Ma27)
$^{188}_{76}Os$	155	710ps	[2]	+0.41 *4*		63Go05	IPAD	ωτ=20 *1*mr	CEx with ^{1}H on Os metal; H_o=19.8 *2*kG
$^{188}_{76}Os$	155	710ps	[2]	+0.46 *6*		64Sp02	IPAD		CEx with ^{1}H on ^{188}Os metal; H_o=41.07kG, X_2=0.91 *10*, G_2=0.894 *20*
$^{188}_{76}Os$	155	710ps	[2]			64Sp09	AAC	$\Delta\nu_Q$=278 *32*MHz $Q/Q^{190}_{2+}=1.11^{+28}_{-19}$	CEx with ^{1}H on Os powder
$^{188}_{76}Os$	155	710ps	[2]	+0.61‡ *5*		65Ch14 72Gr22	IPAD		Möss. scattering from Os metal powder using ^{188}Re source at 15°K; H_o=22.5kG, assumed β=1, $\omega_E\tau$=0.034 *4*
								‡Coherence effects ignored in analysis	
$^{188}_{76}Os$	155	710ps	[2]	+0.540 *36*		66Go06	IMPAC	ωτ=21.9 *12*mr	CEx with O on ^{188}Os, recoils in Cu; H_o∼17kG, G_2=0.956, G_4=0.917
				+0.560^{c} *42*		67Gi02		Recalculated using X=0.964 *36*, H_o=16.6kG	

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{188}_{76}Os$	155	710ps	[2]	±0.570 *24*		70Be36	AAC	$\omega^2\tau_c$=0.078 *6* or 0.046 *4*r^2/ns	CEx recoils in He or Ar gas
$^{188}_{76}Os$	155	710ps	[2]	±0.512^{aP}*52*		71Si33	IMPAC		CEx recoils in Fe; compared with g^{188}(633); $H_f\tau_f$= 17.9MG−ps
$^{188}_{76}Os$	633	5.6ps	[2]	+1.16 *36*		67Ke01	IPAC		Fe−Re(pile n,); H_{int}=1.4MG; corrected for (1308γ)(633γ)
$^{188}_{76}Os$	633	5.6ps	[2]	+0.86 *16*		67Mu05	IPAC		Re in Fe; H_{int}=1.145 *25*MG
$^{190}_{76}Os$	187	350ps	[2]			64Sp09	AAC	Q/Q^{192} (206)= 1.03 *30*	CEx with ^{1}H on Os powder
$^{190}_{76}Os$	187	350ps	[2]	+0.74 *10*		66Go06	IMPAC	$\omega\tau$=14.8 *13*mr	CEx with O on ^{190}Os, recoils in Cu; H_o~17kG; G_2=0.956, G_4=0.917
				+0.75^c *10*		67Gi02		Recalculated using X=0.978 *23*, H_o=16.6kG	
$^{190}_{76}Os$	187	350ps	[2]	±0.662 *32*		70Be36	AAC	$\omega^2\tau_c$=0.062 *6*r^2/ns g/g^{188}(155)=1.162 *76*	CEx recoils in Ar gas
$^{190}_{76}Os$	187	350ps	[2]	+0.37‡ *4*		70Le04	IPAC	$\omega\tau$=650 *5*mr	^{190}Ir−Os in Fe; H_{int}=−1.43MG
								‡Value of H_{int} may be uncertain, 71Ki13	
$^{190}_{76}Os$	548	28ps	[4]	+0.88‡ *48*		70Le04	IPAC	$\omega\tau$=60 *14*mr	^{190}Ir−Os in Fe; H_{int}=−1.43MG
								‡Value of H_{int} may be uncertain, 71Ki13	
$^{192}_{76}Os$	206	280ps	[2]	+0.77 *11*		66Go06	IMPAC	$\omega\tau$=12.4 *11*mr	CEx with O on ^{192}Os, recoils in Cu; H_o~17kG; G_2=0.956, G_4=0.917
				+0.79^a *10*		67Gi02		Recalculated using X=0.979 *21*; H_o=16.6kG	
$^{192}_{76}Os$	206	280ps	[2]			71Av06	AAC	Q/Q^{190}_{2+}=0.97‡ *15*	CEx implantation into fused quartz
								‡Assumed only quadrupole interactions	
$^{192}_{76}Os$	206	280ps	[2]	+0.815 *37*		71Ki13	IPAC	$\omega\tau_{ave}$=223 *5*mr	Ni−Ir(pile n,); H_{int}= 282.3 *10*kG
								Great variation in $\omega\tau$ and A_2 in Fe−Ir samples casts doubt on earlier measurements in Fe hosts	
$^{192}_{76}Os$	206	280ps	[2]	±0.754^{aP}*48*		71Si32	IMPAC	$\omega\tau$=197 *8*mr	CEx with ^{16}O on Os metal on polarized Ni; used $H_f\tau_f$= 4.57 *88*MG−ps
$^{192}_{76}Os$	489	28ps	[2]	±0.66^P≈21		71Si25	IMPAC	g/g^{192}(206)= 0.86^a *22*	CEx on Os on Fe; $H_f\tau_f$= 17.9 *51*MG−ps
								‡Used μ(206)=0.77 *11*	
$^{191}_{77}Ir$	129	131ps	[5/2]	±3.00 *58*		68Da19	IPAD		Möss. scattered γ's from Ir; H_o=24.5kG
$^{191}_{77}Ir$	129	131ps	[5/2]	+0.42 *5*		69Ow02	IPAC	$\omega\tau$=229 *13*mr	^{191}Pt in Fe; H_{int}=1.510 *52*MG
$^{191}_{77}Ir$	129	131ps	[5/2]	±0.56 *10*		70Av02	AAC	$\omega^2\tau_c$=0.034 *7*r^2/ns $g/g^{193}_{5/2}$=0.79 *12*	CEx on H_2IrCl_6, recoils in Ar
$^{192}_{77}Ir$	171	4.9s	[11/2]	±6.3^b *15*		64Ca11	GAP	μH=43 *3*a−ergs	^{191}Os and ^{60}Co in Fe; H_{int}= 135 *30*MG Observed 0.129γ(θ,T)
$^{191}_{77}Ir$	171	4.9s	[11/2]	±6.03 *36*		71Es03	GAP−NMR	ν=389.690‡ *13*, 1174.85‡ *12*MHz	0.08% ^{191}Os−Ni; H_{int}=−467 *3*kG 0.04% ^{191}Os−Fe; H_{int}=−1405 *8* kG
								‡Extrapolated to H_o=0	
$^{192}_{77}Ir$	gs	74d	(4)	±1.8$^{+6}_{-5}$		63Ko21	GAP SpHt	μH=12$^{+2}_{-1}$ a−ergs	Fe−Ir alloys
$^{192}_{77}Ir$	gs	74d	(4)	±1.8 *2*		64Ca15	GAP	μH=13.5 *3*a−ergs μH(^{191,193}Ir)= 1.14 *9*a−ergs	Ir in Fe; ^{60}Co in Fe used to measure T~0.1 to 0.012°K; used $\mu^{191,193}$=0.15 *1*

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{192}_{77}Ir$	gs	74d	(4)	±1.41 *8*		69Re06		μH=10.8 *3*a−ergs	^{192}Ir in Fe; $^{60}Co+^{192}Ir$ in Fe; $T\sim0.013$°K; assumed H_{eff}= −1.52 *3*MG
$^{192}_{77}Ir$	gs	74d	(4)	positive		70Hi12	BAP GAP	μH=13a−ergs	^{192}Ir in Fe; H_{eff} negative
$^{192}_{77}Ir$	gs	74d	(4)	±1.901[d] *11*		71Es03	GAP−NMR	ν=167.661‡ *35*, 504.192‡ *50*MHz	0.03% ^{192}Ir−Ni;H_{int}=−467 *3*kG ^{192}Ir−Fe; H_{int}=−1405 *8*kG
								‡Extrapolated to H_o=0	
$^{193}_{77}Ir$	139	90ps	[5/2]	+0.46 *8*		67Gu10	IPAC	$\omega\tau$=6.0 *7*mr	$^{193}OsO_4$ dissolved in aqua regia and H_2O; H_o=52.0 *5*kG
$^{193}_{77}Ir$	139	90ps	[5/2]	±0.71 *12*		70Av02	AAC	$\omega^2\tau_c$=0.055 *10*r^2/ns	CEx recoils in Ar gas
$^{194}_{77}Ir$	gs	17h	(1)	±0.37 *4*		69Re06	GAP	μH=2.8 *3*a−ergs	1% Ir in Fe; H_{int}=−1.52 *3*MG; assumed no hyperfine anomaly
$^{192}_{78}Pt$	316	35ps	[2]	+0.51 *8*		66Ag02	IPAC	$\omega\tau$=80 *5*mr	dilute Ir−Fe; H_{int}=1.32 *8*MG
$^{192}_{78}Pt$	316	35ps	[2]	±0.60 *6*		69Ke11	IPAC	$\omega\tau$=88 *5*mr	1% Ir in Fe; H_{int}=1.25 *3*MG; G_2=0.94, G_4=0.80
$^{192}_{78}Pt$	316	35ps	[2]	+0.584 *44*		70Be08	IPAC	$\omega\tau$=87.5 *24*mr	Ir−Fe; H_{int}=−1.235 *20*MG
$^{192}_{78}Pt$	316	35ps	[2]	+0.54 *4*		70Gr25	IPAC	$\omega\tau$=80 *2*mr	Pt implanted in Ir−Fe; H_{int}= −1.24 *3*MG
$^{192}_{78}Pt$	316	35ps	[2]	+0.56 *6*		70Le04	IPAC	$\omega\tau$=88 *6*mr	Ir melted into Fe; H_{int}= −1.235MG
$^{192}_{78}Pt$	316	35ps	[2]	+0.92 *11*		71Ki13	IPAC	$\omega\tau$=36 *4*mr	(Ni−Ir)(pile n,); H_{int}= 323 *10*kG
								Fe−Ir alloys not suitable for PAC	
$^{192}_{78}Pt$	316	34.6ps	[2]	+0.550[cp] *32*		72Ro30	IPAC		
$^{192}_{78}Pt$	612	20ps	[2]	±0.86‡ *21*		69Ke11	IPAC	$\omega\tau$=47† *11*mr	1% Ir in Fe; H_{int}=1.25 *3*MG
								‡From $\omega\tau$−ratio and μ(316)=+0.92 †Corrected for (604γ)(316γ)	
$^{192}_{78}Pt$	612	20ps	[2]	+0.98‡ *17*		70Be08	IPAC	$\omega\tau$=53 *9*mr	Ir−Fe; H_{int}=1.235 *20*MG
								‡From $\omega\tau$−ratio and μ(316)=+0.92	
$^{192}_{78}Pt$	612	20ps	[2]	$+1.13‡^{+20}_{-12}$		70Gr25	IPAC	$\omega\tau=56†^{+10}_{-6}$mr	Pt implanted in Ir−Fe;$H_o\sim$2kG H_{int}=−1.24 *3*MG
								‡From $\omega\tau$−ratio and μ(316)=+0.92 †Corrected for (604γ)(316γ)	
$^{192}_{78}Pt$	612	20ps	[2]	+0.99‡ *20*		70Le04	IPAC	$\omega\tau$=54 *11*mr	^{192}Ir in Fe, melted; H_{int}= −1.235MG
								‡From $\omega\tau$−ratio and μ(316)=0.+92	
$^{192}_{78}Pt$	612	20ps	[2]	+0.62[cp] *9* +1.04‡ *10*		72Ro30	IPAC		
								‡From $\omega\tau$−ratio and μ(316)=+0.92	
$^{192}_{78}Pt$	785	12ps	[4]	±0.86‡ *60*		69Ke11	IPAC	$\omega\tau$=14 *10*mr	1% Ir in Fe; H_{int}=1.25 *3*MG
								‡From $\omega\tau$−ratio and μ(316)=+0.92	
$^{194}_{78}Pt$	328	35ps	[2]	±0.54 *8* ±0.61‡ *9*		65Ke11	IPAC	$\omega\tau$=91.6† *67*mr ‡For H_{int}=1.25MG	Ir−Fe; H_{int}=1.42 *11*MG
								†Corrected for other cascades	
$^{194}_{78}Pt$	328	35ps	[2]	$+0.79^{+36}_{-24}$		65Sp03	IPAC	$\omega\tau$=3.92mr	CEx with ^1H on ^{194}Pt metal; H_o=41.6kG
$^{194}_{78}Pt$	328	35ps	[2]	+0.62 *8* +0.66‡ *9*		66Ag02	IPAC	$\omega\tau$=99† *9*mr ‡For H_{int}=1.25MG	Dilute Pt−Fe; H_{int}=1.32 *8*MG
								†Corrected for other cascades	
$^{194}_{78}Pt$	328	35ps	[2]	+0.64 *8*		67Ka16	IMPAC	$\omega\tau$=70 *5*mr, corrected for ^{196}Pt γ's	CEx with O, ^{194}Pt recoils in polarized Fe; H_{int}=−890 *70*kG
				+0.54[c]‡ *12*		69Ku06		‡Used data on $\omega\tau$ and τ to correct for transient fields. Used $H_t\tau_t$=17.7 *34*MG−ps and H_{int}=−1.21 *5*MG	

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat – Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{194}_{78}$Pt	328	35ps	[2]	±0.57 *8* ±0.59‡ *6*		70Ke14	IPAC	$\omega\tau$=87 *4*mr $\omega\tau$=89‡ *3*mr ‡Weighted average of 70Ke14, 66Ag02, 65Ke11	Ir–Fe; H_{int}=1.25 *5*MG
$^{194}_{78}$Pt	328	35ps	[2]			70Ke18	IMPAC	$\omega\tau$=77 *5*mr If transient fields responsible for precession, $H_t\tau_t$~+11.6 *43*MG–ps	CEx with 2.5MeV ^{1}H
$^{194}_{78}$Pt	328	35ps	[2]	+0.596^{cp} *36*		72Ro30	IPAC		
$^{194}_{78}$Pt	622	44ps	[2]	±0.36 *10* ±0.41‡ *11*		65Ke11	IPAC	$\omega\tau$=78 *13*mr ‡For H_{int}=1.25MG	Ir–Fe; H_{int}=1.42 *11*MG
$^{194}_{78}$Pt	622	44ps	[2]	+0.42 *14* +0.44‡ *14*		66Ag02	IPAC	$\omega\tau$=83 *20*mr ‡For H_{int}=1.25MG	Dilute Pt–Fe; H_{int}=1.32 *8*MG
$^{194}_{78}$Pt	622	44ps	[2]	±0.48 *12* ±0.44‡ *8*		70Ke14	IPAC	$\omega\tau$=91 *15*mr $\omega\tau$=84‡ *9*mr ‡Weighted average (70Ke14, 66Ag02, 65Ke11)	annealed Ir–Fe;H_{int}=1.25 *5*MG
$^{194}_{78}$Pt	622	35‡ps	[2]	+0.56^{cp} *9*		72Ro30	IPAC	‡Remeasured	
$^{195}_{78}$Pt	210	67ps	[3/2]	+0.24 *9*		69Ku06	IMPAC	$\omega\tau$=80 *24*mr	CEx with ^{16}O; ^{195}Pt recoils in Fe; H_o=1.4kG; assumed H_{int}=–1.21 *5*MG and $H_t\tau_t$=17.7 *34*MG–ps
$^{195}_{78}$Pt	210	67ps	[3/2]	+0.33 *9*		69Va05	IPAC	$\omega\tau$=108 *25*mr	CEx with ^{1}H on Fe–Pt; H_{int}= 980 *80*kG measured with ^{194}Pt assumed g^{194}(328)=+0.32 *4*
$^{195}_{78}$Pt	240	230ps	[5/2]	+0.18 *5*		69Ku06	IMPAC	$\omega\tau$=135 *27*mr or $\omega\tau$=124 *48*mr	CEx with ^{16}O, recoils in Fe; observed (^{16}O′)(240γ) or (^{16}O′)(140γ); assumed H_{int}=–1.21 *5*MG and $H_t\tau_t$=17.7 *34*MG–ps
$^{195}_{78}$Pt	240	230ps	[5/2]	+0.26 *6*		69Va05	IPAC	$\omega\tau$=160 *22*mr	CEx with ^{1}H on Fe–Pt; assumed no transient fields; H_{int}=980 *80*kG measured with ^{194}Pt, assumed g^{194}(328)= +0.32 *4*
$^{195}_{78}$Pt	259	4.1d	[13/2]	±0.597‡ *15*		72Ba22	GAP–NMR	ν=89.5 *5*MHz ‡Uncorrected for hyperfine anomaly	Pt–^{60}Co–Fe; H_{hf}=–1280 *26*kG
$^{196}_{78}$Pt	356	35ps	[2]	+0.50 *8*		67Ka16	IMPAC	$\omega\tau_{ave}$=55‡ *3*mr ‡Corrected for ^{194}Pt γ's	CEx with O, ^{196}Pt recoils in polarized Fe; H_{int}=–890 *70*kG
$^{196}_{78}$Pt	356	35ps	[2]	+0.54 *7*		68Be61	IPAC	$\omega\tau$=4.97 *40*° $\omega\tau$=4.74 *44*° $\omega\tau_{ave}$=85.0 *52*mr	Au in Fe–Pt; H_{int}=–1.235 *5*MG Au implanted in Fe foils
$^{196}_{78}$Pt	356	35ps	[2]	+0.56 *7*		68Mu02	IPAC	$\omega\tau$=81.8 *47*mr	Au diffused into Fe; H_{int}= 1.25 *3*MG
$^{196}_{78}$Pt	356	35ps	[2]	+0.52^c‡ *22*		69Ku06	IMPAC	‡Used data on $\omega\tau$ and τ to correct for transient fields; used $H_t\tau_t$=17.7 *34*MG–ps and H_{int}= –1.21 *5*MG	
$^{196}_{78}$Pt	356	35ps	[2]	+0.556^{cp} *35*		72Ro30	IPAC		
$^{198}_{78}$Pt	408	19ps	[2]	+0.52 *8*		67Ka16	IMPAC	$\omega\tau_{ave}$=30.5 *20*mr	CEx with O, ^{198}Pt recoils in polarized Fe; H_{int}=–890 *70*kG
$^{195}_{79}$Au	gs	192d	(3/2)	±0.13 *4*		65Ca12	GAP		Au+^{60}Co in Fe; H_{int}=1.32 *5*MG based on μ^{198}=0.590 and μ^{199}=0.270
$^{196}_{79}$Au	596	9.7h	(12)	±5.35^d‡ *20*		71Ba94 72Ba86	GAP	$\|\mu H\|_{ave}$=30.6 *12* or 6.4 *4*a–erg ‡Includes hyperfine anomaly correction	^{196}Au+^{60}Co in Fe or Ni; H_o~4kG

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{198}_{79}$Au	367	123ns	[3]	$\pm3.60^{p}$ *24*		70Kl13	DPAC		
$^{198}_{79}$Au	?	49h	[12?]	$\pm5.55^{dp}$ *34*		72Ba86	GAO		2.5% hyperfine anomaly included
$^{200}_{79}$Au	?	18.7h	[12]	$\pm6.10^{dp}$ *10*		72Ba86	GAO–NMR		2.5% hyperfine anomaly included
$^{183}_{80}$Hg	gs	8.8s	1/2	$+0.518^{d}$ *9*		72Bo09	BAO–NMR		on–line mass separator
$^{185}_{80}$Hg	gs	50s	1/2	$+0.504^{d}$ *4*		72Bo09	BAO–OP		on–line mass separator
$^{187}_{80}$Hg	gs	2.4m	3/2	-0.586^{dp} *6*	-0.3^{p} *11*	72Ot03 71Bo31	BAO–OP		on–line mass separator
$^{197}_{80}$Hg	134	7.3ns	[5/2]	+0.950 *65*		70Ge01	DPAC		Cu–Hg amalgam; H_0=29.5 *3*kG, 33.2 *2*kG
$^{198}_{80}$Hg	412	22.0ps	[2]	+0.76 *22*		64Ke02	IPAC	$\omega\tau$=81 *16*mr	Fe–Au; H_{int}=1.42MG
$^{198}_{80}$Hg	412	22.0ps	[2]	$+1.10^{p}$ *22*		64Ko15	IPAC		^{198}Au–metal; H_0=57.15kG
$^{198}_{80}$Hg	412	22.0ps	[2]			70Ka09	IMPAC	$\Delta\theta$=24.5 *22*mr	CEx with O on ^{198}Hg, recoils in polarized Fe; H_0=1.4kG; $H_t\tau_t$=5.9 *23*MG, used $\omega\tau$=40 *4* mr of Murray to get transient fields
$^{199}_{80}$Hg	158	2.32ns	[5/2]		$+0.7^{+4}_{-2}$	56Po14	AAC	$eqQ=1100^{+650}_{-230}$MHz or 593^{+150}_{-100}MHz	Compared anisotropy in liquid metal with powdered $HgCl_2$ or frozen metal; used Q^{201}=0.45 and $eqQ^{201}(HgCl_2)$= 720MHz, eqQ^{201}(liquid metal) =708MHz
$^{199}_{80}$Hg	158	2.32ns	[5/2]	$+1.03^{d}$ *8*		61Gr29	PAC		Au(α,2n); H_0=26000 *75*G
$^{199}_{80}$Hg	533	44m	13/2		$+2.0^{p}$ *13*	72Ot03	GAO–OP		on–line mass separator
$^{200}_{80}$Hg	368	42ps	[2]	+0.86 *22*		70Ka09	IMPAC	$\Delta\theta$=47.8 *24*mr g/g^{198}_{2+}=0.79 *12*	CEx with O on ^{200}Hg, recoils in polarized Fe(See ^{198}Hg–70Ka09); used g^{198}_{2+}=0.55 *11*
$^{202}_{80}$Hg	439	26μs	[2]	+1.18 *30*		70Ka09	IMPAC	$\Delta\theta$=33 *3*mr g/g^{198}_{2+}=1.07 *17*	CEx with O on ^{202}Hg, recoils in polarized Fe(See ^{198}Hg–70Ka09); used g^{198}_{2+}=0.55 *11*
$^{204}_{80}$Hg	437	46ps	[2]	+0.80 *20*		70Ka09	IMPAC	$\Delta\theta$=50 *3*mr g/g^{198}_{2+}=0.73 *12*	CEx with O on ^{204}Hg, recoils in polarized Fe(See ^{198}Hg–70Ka09); used g^{198}_{2+}=0.55 *11*
$^{205}_{80}$Hg	gs	5.5m	1/2	$+0.5911^{p}$ *5*		72Ot03	BAO–OP		on–line mass separator
$^{202}_{81}$Tl	950	560μs	[7]	$\pm0.896^{p}$ *42*		72Ha67	DPAD	ω=48.6 *10*kr/s	liquid Hg(pulsed p,); maximum H_0=80 *3*G
$^{203}_{81}$Tl	279	280ps	[3/2]	+0.16 *5*		65Ka02	IPAC	$\omega\tau$=10.7 *27*mr	$PbCl_2$ in 6N HCl; H_0=50.6kG
$^{204}_{82}$Pb	1274	260ns	[4]	+0.22 *2*		55Kr06	CDPAC		Tl in HNO_3; T_{delay}=352ns, Tl in H_2SO_4; T_{delay}=237ns
$^{204}_{82}$Pb	1274	260ns	[4]	+0.226 *8*		63Sa19	DPAC	ν=8.609MHz	Bi in HNO_3; H_0=31.81kG
$^{204}_{82}$Pb	1274	260ns	[4]	+0.220 *12*		67Li12	DPAC	ν=9.27 *5*MHz	liquid sources; H_0=35.2kG, G_2=0.978 *33*
$^{204}_{82}$Pb	1274	260ns	[4]		~±0.3	71Bo65 (67Li12)	AAC	ν_0=2.23MHz	Pb in polycrystalline Tl; assumed $\gamma_\infty(Pb^{4+})$~−50.88
$^{205}_{82}$Pb	1014	5.55ns	[13/2]	−0.975 *40*		71Ma59	DPAD		liquid ^{204}Hg(pulsed α, 3n); diamagnetic correction ≈ −Knight shift (~1.7%)

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat — Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{206}_{82}Pb$	803	6ps	[2]	−0.02 *14*		70Za03	IPAC	$\omega\tau$=+0.4 *23*mr	Pb in Fe; H_{int}=660 *45*kG
$^{206}_{82}Pb$	2200	123μs	[7]	−0.57^{p}‡ *5* or −0.35^{p}‡		69Qu04	AAC	‡If $\tau_{relax}<\tau$ or >200μs	
$^{206}_{82}Pb$	2200	123μs	[7]	−0.1519 *28*		72Ma24	DPAD Strob		liquid ^{204}Hg(pulsed α,2n); diamagnetic correction ≈ −Knight shift (~1.7%)
$^{206}_{82}Pb$	2385	29ps	[6]	+0.78 *42*		70Za03	IPAC	$\omega\tau$=−16.7 *90*mr	Pb in Fe; H_{int}=660 *45*kG
$^{206}_{82}Pb$	4027	200ns	[12]	−1.860^{p} *48*		72Na16	DPAD		liquid Hg(pulsed α,)
$^{207}_{82}Pb$	570	129ps	[5/2]	+0.72 *10*		64Gu03	IPAC	$\omega\tau$=+13.0 *13*mr	liquid $BiCl_3$; H_o=50.6kG
$^{207}_{82}Pb$	570	129ps	[5/2]	+0.96 *22*		65He10	IPAC	$\omega\tau$=3.4 *21*mr	liquid source; H_o=10kG
$^{207}_{82}Pb$	570	129ps	[5/2]	+0.65 *5*		66Ko16	IPAC	$\omega\tau$=12.9 *9*mr	liquid $^{207}BiCl_3$ in HCl; H_o=55.2kG
$^{207}_{82}Pb$	570	129ps	[5/2]	±0.79^{p} *3*		72Sc36	IPAC	$\omega\tau$=26.6 *9*mr	H_o=94.4 *5*kG
$^{208}_{82}Pb$	2615	15ps	[3]	+1.74 *42*		69Bo12	IPAC	$\omega\tau$=1.80 *45*mr	^{228}Th in HCl; H_o~30.5kG
$^{208}_{82}Pb$	2615	15ps	[3]	±1.89^{p} *29*		72Sc36	IPAC	$\omega\tau$=5.97 *79*mr	H_o=94.4 *5*kG
$^{208}_{82}Pb$	3198	298ps	[5]	+0.105 *35*		69Bo01	IPAC	$\omega\tau(2615)/\omega\tau(3198)$ =1.36 *21*	^{228}Th in Fe, Co; used g(2615)=+0.58 *14*
$^{207}_{83}Bi$	2102	182μs	[21/2]	+3.41 *6*		72Ma24	DPAD Strob		liquid Hg(^{7}Li,4n); diamagnetic correction ~ −Knight shift (~1.7%)
$^{210}_{83}Bi$	gs	5.0d	(1)	negative^{p}	positive^{p}	72Na17	BAP	observed positive asymmetry	ferromagnetic BiMn; H_{hf}~1MG; used $\mu/Q<0$ from atomic beams
$^{211}_{83}Bi$	405	318ps	[7/2]	+4.41 *67*		65Ag03	IPAC		liquid sources ^{211}Pb or ^{223}Ra + ^{211}Pb; H_o=18.3kG
$^{204}_{84}Po$	~1700	190ns‡	[8]	±8.32^{p} *64*		72Br42	DPAD	‡quoted value	^{204}Pb foil (pulsed α,)
$^{204}_{84}Po$	~1700	140ns‡	[8]	±7.24^{p} *32*		72Na18	Strob	‡quoted value	
$^{206}_{84}Po$	?	160ns‡	[8]	±7.60^{p} *32*		72Br42	DPAD	‡quoted value	^{204}Pb foil (pulsed α,); H_o=15.9kG
$^{206}_{84}Po$	?	212ns‡	[8]	±7.24^{p} *32*		72Na18	Strob	‡quoted value	^{206}Pb(pulsed ^{3}He,)
$^{207}_{84}Po$	1115	47μs	[13/2]	−0.930^{dkp} *13*		72Fo19	DPAD		liquid ^{206}Pb(pulsed α,)
$^{208}_{84}Po$	>1520	380ns	[8]	±7.22 *5* ±7.48 *40*		70Na11	Strob DPAD	H_o=11.62 *8*kG ω=63.2 *34*Mr/s‡ ‡Unit given as MHz	^{206}Pb(α,2n); T_o=123.43ns ^{208}Pb(^{3}He,3n); H_o=13.9kG; assumed Knight shift~1.47%
$^{208}_{84}Po$	1532	380ns	[8]	±7.29^{p} *8*		72Na18	Strob		^{208}Pb(pulsed ^{3}He,)
$^{209}_{84}Po$	>1327	~100ns	[17/2?]	+7.48 *43* +7.37^{c} *43*		68Ya08 70Na11	DPAD	ω=11.6 *7*Mr/s‡ ‡Unit given as MHz	metallic Pb(pulsed α,xn); H_o =2.760kG; recalculation includes Knight shift~1.4%
$^{209}_{84}Po$	?	100ns	[17/2]	±7.62^{p} *13*		72Na18	Strob		^{207}Pb(pulsed α,)
$^{210}_{84}Po$	1472	38ns	[6]	±5.58^{dkp} *12*		72Ba87	DPAD		^{208}Pb(pulsed α,); H_o=13.76 *7*kG
$^{210}_{84}Po$	1552	110ns	[8]	+7.29 *8*		70Ya02	DPAD	ω=48.44 *4*Mr/s‡ ‡Unit given as MHz	metallic ^{208}Pb(pulsed α,2n); H_o=10.93kG; assumed Knight shift~1.47%
$^{210}_{84}Po$	1552	110ns	[8]	±7.27^{dkp} *12*		72Ba87	DPAD		^{208}Pb(pulsed α,); H_o=13.76 *7*kG
$^{210}_{84}Po$	1552	110ns	[8]	±7.21^{p} *10*		72Na18	Strob		^{208}Pb(pulsed α,)
$^{210}_{84}Po$	2800	24ns	[11]	+11.99 *18*		70Ya06	DPAD	ω=101.0 *15*Mr/s‡ ‡Unit given as MHz	metallic ^{208}Pb(pulsed α,2n); H_o=19.05kG; assumed Knight shift~1.47%

Table J: Nuclear Moments by Perturbed Angular Correlation, Aligned Nuclei, and Specific Heat – Continued

Nucleus	Level	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment & Comments
$^{210}_{84}$Po	4372	93ns	[13]	$\pm7.10^{p}$ *16*		72Ya08	DPAD	ω=56.2 *13*Mr/s	metallic ^{208}Pb(pulsed α,); H_o=21.03 *10*kG
$^{211}_{84}$Po	1064	16ns	[15/2]	$\pm0.38^{p}$ *15*		72Fa17	IPAD		^{208}Pb(pulsed α,); H_o=16.6kG
$^{211}_{85}$At	1416	50ns	[21/2]	$\pm9.42^{dkp}$ *17*		72In03	DPAD		^{209}Bi(pulsed α,); H_o=21.0kG
$^{211}_{85}$At	4816	4.2μs	[39/2, 41/2]	±14.0 *14*, ±14.8 *14*		71Ma70	DPAD		pulsed ^{4}He or ^{16}O on separated Hg, Tl, Pb, Bi
$^{212}_{86}$Rn	~1700	1.0μs	[8]	±7.12 *24*		71Ma70	DPAD		pulsed ^{4}He or ^{16}O on separated Hg, Tl, Pb, Bi
$^{222}_{86}$Rn	186	320ps	[2]	+0.90 *14*		70Or02	PAC	$\Delta\theta=-1.59°$‡	α–decay recoils from Ra or $RaCl_2$ in Gd, Pb, U_2O_3; H_o= 27.6 *5*kG
								‡Corrected for beam deflection	
$^{223}_{88}$Ra	50	630ps	[3/2]	+0.42 *6*		70Le13	PAC	$\omega\tau$=34 *3*mr	liquid ^{227}Ac in HNO_3;H_o=28kG
$^{233}_{92}$U	gs	162ky	(5/2)			58Da21 60Ro27	αAO	Anisotropy negative; $P\sim\pm0.03cm^{-1}$	$UO_2Rb(NO_3)_3$
$^{233}_{92}$U	gs	162ky	(5/2)			68Ma42	αAO		$UO_2Rb(NO_3)_3$
								α's emitted perpendicular to alignment axis	
$^{235}_{92}$U	gs	710My	(7/2)			58Da21	αAO	Anisotropy negative	$UO_2Rb(NO_3)_3$
$^{237}_{93}$Np	gs	2.1My	(5/2)		positive	58Da21 61Ha34	αAO	Anistropy negative; $A<0$, $P>0$	$NpO_2Rb(NO_3)_3$ crystal
								α's emitted parallel to nuclear spin	
$^{237}_{93}$Np	60	63ns	[5/2]	+3.5‡ *5*		55Kr02 57Kr52	DPAC		liquid source in 1N $HClO_4$
								‡Solutions may have been imperfect	
$^{237}_{93}$Np	60	63ns	[5/2]	$\pm2.45^{p}$ *10*		66He13	DPAC	ω=245.1 *10*Mr/s‡	concentrated $^{241}AmCl_3$ in HCl H_o=41.1 *4*kG; used β(20°C)= 1.28 *4* and G_2=0.45
								‡Unit given as MHz	
$^{237}_{93}$Np	60	63ns	[5/2]	+1.90 *15*		67Gu08	DPAC IPAC	ω=−76.5 *35*Mr/s $g^{239}(75)/g^{237}(60)$= 1.04 *9*	AmO in 6N HCl; H_o=12.5kG, β=1.68 *11*
$^{239}_{93}$Np	75	1.40ns	[5/2]	+1.98 *24*		67Gu08	IPAC	$\omega\tau$=−238 *17*mr G_2=0.935 *10*	AmO in 6N HCl; H_o=18.5kG, β=1.68 *11*
$^{253}_{99}$Es	gs	20.5d	[7/2]	±2.7 *13*		70So09 62Na14	αAO	A_{ave}=0.26 *3*cm^{-1}	Es^{3+} in NES crystal; used $<r^{-3}>_{5f}$=10.92au

*Polarization or Sternheimer correction included.
[a] Half–life used by authors not known, therefore μ not corrected to quoted half–life.
[b] Spin-value used by authors not known, therefore μ not corrected to quoted spin.
[c] Recalculation of earlier data.
[d] Diamagnetic correction included.
[k] Includes Knight shift correction.
[p] Preliminary value from meeting abstract, report, thesis, or private communication.

Table K: Nuclear Moments by Coulomb Excitation Reorientation and Inelastic Electron–Scattering

The following table lists values of nuclear moments derived from Coulomb excitation reorientation measurements and inelastic electron–scattering experiments. The possibility of determining nuclear electric quadrupole moments by the reorientation effect in Coulomb excitation was first proposed by Breit, [55Br64] and [56Br69]. He explained the effect as an interaction of the excited–state quadrupole moment with the electromagnetic field of the projectile after the nucleus is Coulomb–excited by the projectile. The name is derived from considering the effect as a second–order perturbation process where the E2 multipole interaction first causes a transition from the ground state to an excited state of the nucleus and then causes a transition from one magnetic sub–level to another of the same state, i.e. a reorientation of the nuclear axis. This is pictorially represented in figure 1. The second order excitation probability then depends on the static quadrupole moment of the excited state.

In Coulomb excitation the projectile does not penetrate the nucleus and the interactions with the nucleus are reasonably well understood. The major assumptions made in a semi–classical treatment are that 1) the projectile orbit can be treated classically and 2) that perturbation theory can be applied. For the first assumption to apply, the energy of the projectile must be low enough so that it can be described by a 'wave–packet' which is small with respect to nuclear dimensions. If the dimensionless parameter, η, is defined by:

$$\eta = 2\pi a/\lambda = 2\pi Z_1 Z_2 e^2/hv_\infty \qquad (1)$$

where a is 1/2 the distance of closest approach in a head–on collision; $\lambda = h/mv_\infty$, the deBroglie wavelength of the projectile; v_∞, the velocity of the projectile at infinity; and Z_1 and Z_2 are the projectile and target charges respectively, then this condition is fulfilled when $\eta >> 1$. For the energies used in Coulomb excitation, where $2a$ is greater than the nuclear radius, this condition is usually satisfied. A further requirement that the projectile may be treated as a classical particle moving in a hyperbolic orbit is that the energy loss in the excitation process be small compared to the incident energy. If we define an adiabaticity parameter:

$$\xi = 2\pi a \Delta E/hv_\infty \cong \tau_{\text{collision}}/\tau_{\text{nuclear}} \qquad (2)$$

where ΔE is the excitation energy between the initial and final states, then for $\xi << 1$, the excitation process can be treated as a sudden one and this condition obtains. For a classical particle, $\xi = 0$. For $\xi >> 1$, the process is adiabatic and the excitation probabilities vanish. The second assumption requires that the first–order excitation probabilities be small.

For a classical projectile, the angular distribution of the elastically scattered particle is given by the Rutherford cross section:

$$d\sigma_R = (a^2/4)\ \sin^{-4}(\theta/2)\ d\Omega \qquad (3)$$

where θ is the scattering angle; see figure 2. To obtain the cross section for Coulomb excitation of the nucleus, the Rutherford cross section is multiplied by the probability of exciting the nucleus to the final state. If the excitation probabilities are small, the first–order transition amplitudes can be calculated from:

$$b_{if}^{(1)} = (2\pi i/h) \int_{-\infty}^{\infty} \langle f|H_{\text{int}}|i\rangle \ \exp[(2\pi i/h)(E_f - E_i)t]dt \qquad (4)$$

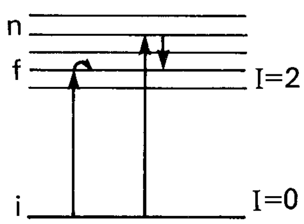

FIGURE 1. A pictorial representation of the reorientation effect. The E2 multipole interaction first causes a transition to an excited state and then a transition from one sublevel to another of the excited state.

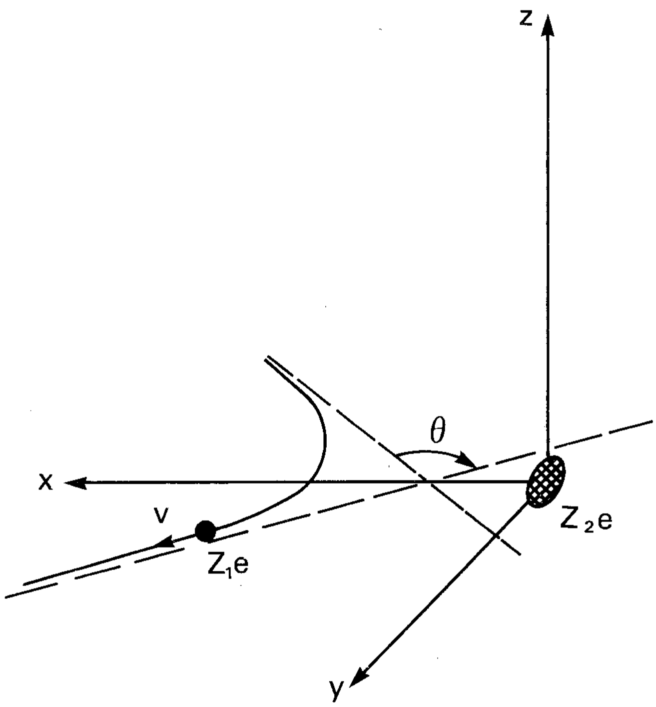

FIGURE 2. Focal–coordinate system of the scattering of a classical projectile of charge Z_1e by a nucleus of charge Z_2e. The path of the projectile is in the xy=plane and θ is the scattering angle.

where H_{int} denotes the time-dependent electromagnetic interaction and E_f and E_i, the energies of the final and initial states. In the semi-classical treatment, H_{int} is expanded in multipoles. The monopole interaction gives rise to the Rutherford scattering which is already accounted for by considering the projectile moving in a classical hyperbolic orbit. The magnetic multipole excitation amplitudes are smaller than the electric ones by the factor v/c, which is small for the energies of the projectiles used in Coulomb excitation. Magnetic excitation is therefore negligible except when the electric matrix elements vanish.

To first order, the electric Eλ multipole excitation amplitudes can be shown to be:

$$b_{if}^{(1)} = -i(-1)^{I_i-M_i}\left(\frac{8\pi^2 Z_1 e}{h v_\infty a^\lambda}\right)\frac{\langle I_i\|\mathrm{ME}\lambda\|I_f\rangle}{(2\lambda+1)} \times \sum_\mu \begin{pmatrix} I_i & \lambda & I_f \\ -M_i & \mu & M_f \end{pmatrix} Y_{\lambda\mu}(\pi/2,0)\, I_{\lambda\mu}(\theta,\xi) \quad (5)$$

where the reduced nuclear matrix element is defined by:

$$\langle I_i\|\mathrm{ME}\lambda\|I_f\rangle \equiv (-1)^{I_i-M_i}\begin{pmatrix} I_i & \lambda & I_f \\ -M_i & \mu & M_f \end{pmatrix}^{-1} \times\langle I_iM_i|\textstyle\int r_2^\lambda\, \rho(r_2)\, Y_{\lambda\mu}(\Omega_2)\, d^3r_2|I_fM_f\rangle \quad (6)$$

with $\rho(r_2)$ the nuclear charge density and where the $Y_{\lambda\mu}(\pi/2,0)$ and $I_{\lambda\mu}(\theta,\xi)$ are functions of the projectile orbits, see [68De34], page 7*. The functions $Y_{\lambda\mu}(\pi/2,0)$ and $I_{\lambda\mu}(\theta,\xi)$ are defined and tabulated in references [60Al23] and [56Al54]. This amplitude leads to the first order differential excitation cross section:

$$\begin{aligned} d\sigma &= P^{(11)}_{i\to f} d\sigma_R = (2I_i+1)^{-1}\sum_{M_iM_f}|b_{if}|^2 d\sigma_R \\ &= \frac{64\pi^4 Z_1^2 e^2}{h^2 v_\infty^2 a^{2\lambda}}\ \frac{B(\mathrm{E}\lambda, I_i\to I_f)}{(2\lambda+1)^3} \times\sum_\mu |Y_{\lambda\mu}|^2\, |I_{\lambda\mu}|^2 a^2\, (4\sin^4\theta/2)^{-1} d\Omega \quad (7)\end{aligned}$$

$$\text{where } B(\mathrm{E}\lambda,\, I_i\to I_f) \equiv (2I_i+1)^{-1}\, |\langle I_i\|\mathrm{ME}\lambda\|I_f\rangle|^2 \quad (8)$$

In order to evaluate the reorientation effect, the calculations for the excitation must be carried out to second order.

$$b_{if}^{(2)} = b_{if}^{(1)} + \Sigma_n\, b_{inf} \quad (9)$$

where

$$b_{inf} = (ih/2\pi)^{-2}\int_{-\infty}^{\infty}\langle f|H_{int}|n\rangle \exp[(2\pi i/h)(E_f-E_n)t]dt \times\int_{-\infty}^{t}\langle n|H_{int}|i\rangle\exp[(2\pi i/h)(E_n-E_i)t']dt'$$

The sum extends over all intermediate states "n", including the initial and final states. This double integral can be simplified, see Alder [56Al54], p469, so that the total amplitude to second order is of the form:

$$\begin{aligned} b_{if}^{(2)} = A[&i\langle I_i\|\mathrm{ME}\lambda\|I_f\rangle Y_{\lambda\mu} I_{\lambda\mu}/(v_\infty a^\lambda) \\ &+ \Sigma_n B\langle I_i\|\mathrm{ME}\lambda_1\|I_n\rangle\langle I_n\|\mathrm{ME}\lambda_2\|I_f\rangle \\ &\times(\alpha_{\lambda,-\mu}+i\beta_{\lambda,-\mu})/v_\infty^2 a^{\lambda 1+\lambda 2}] \quad (10)\end{aligned}$$

where A and B are functions of λ, Z_1, Z_2, I_i, I_f, M_i, M_f and where α and β are functions of the projectile parameters θ, λ_j, μ_j, and ξ_j. The last three quantities, with j=1 and 2, are defined for the transitions i$\to$n and n$\to$f respectively. The differential cross section to second order is then:

$$\begin{aligned} d\sigma &= [P^{(11)} + P^{(12)} + O(P^{(22)})]d\sigma_R \\ &= d\sigma_R(2I_i+1)^{-1}\sum_{M_iM_f}[(b_{if}^{(1)})^2 + 2\mathrm{Re}\,(b_{if}^{(1)}\sum_n b_{inf}) + O(\mathrm{ME}\lambda)^4] \quad (11)\end{aligned}$$

For the case of λ=2, the crossover term is seen to contain terms proportional to $[B(\mathrm{E}2, I_i\to I_f)]Q$, since, for "n" equal to "i" or "f",

$$Qe = (16\pi/5)^{1/2}\,[I(2I-1)/(2I+1)(2I+3)(I+1)]^{1/2} \times\langle I\|\mathrm{ME}2\|I\rangle.$$

In order to account for the different velocities of the projectile before and after the excitation, the semiclassical expressions can be symmetrized by replacing $v_\infty\to\sqrt{(v_iv_f)}$, $a\to Z_1Z_2e^2\times(1+A_1/A_2)/A_1v_iv_f$, $\xi\to\eta_f-\eta_i$ and by multiplying the resulting excitation probability by a factor v_f/v_i. With these substitutions, the semiclassical Coulomb excitation probabilities closely approximate the quantum mechanical results; see [56Al54, 65Bi14].

The application of perturbation theory assumes that the probability of excitation of any level is small and that higher order processes are negligible. This is true, in general, for excitation by p, d, and α's but not for higher Z projectiles nor for target nuclei with large transition probabilities between excited states and the ground or final states. For those cases, multiple Coulomb excitation becomes important. The nuclear system then interacts strongly with the time-dependent electromagnetic fields produced by the

*Note, in the definition of X, equation (12) of [68De34], $(\lambda+1)!$ should be replaced with $(\lambda-1)!$

projectile and many levels are excited simultaneously. Some higher levels can even be more strongly excited than lower lying ones. If multiple excitation effects are important, the final state amplitudes for the individual levels can be obtained by solving a set of coupled Schrödinger equations. The calculation of the reorientation effect must be carried out for the particular nucleus and for the actual bombarding conditions. All of the available information on the energies and spins of the individual nuclear levels which can contribute and on the matrix elements connecting them (experimentally determined or calculated from some model) must be used as input data in order to determine the quadrupole moments from the reorientation measurements. A representation of the types of virtual transitions which must be considered in such calculations is given in figure 3. Many Q-values have been determined using the deBoer-Winther computer code for the differential cross sections for multiple Coulomb excitation [65Wil4 or 66Al22]. This code can handle up to 10 nuclear levels with a total of 90 substates, for $\lambda = 2$. One of the major sources of uncertainty in the determination of Q's from such calculations is the relative phases of the matrix elements for excitation via different levels. In many cases, several values of Q are quoted, one for each of the different combinations of signs possible.

A code is also available to compute the angular

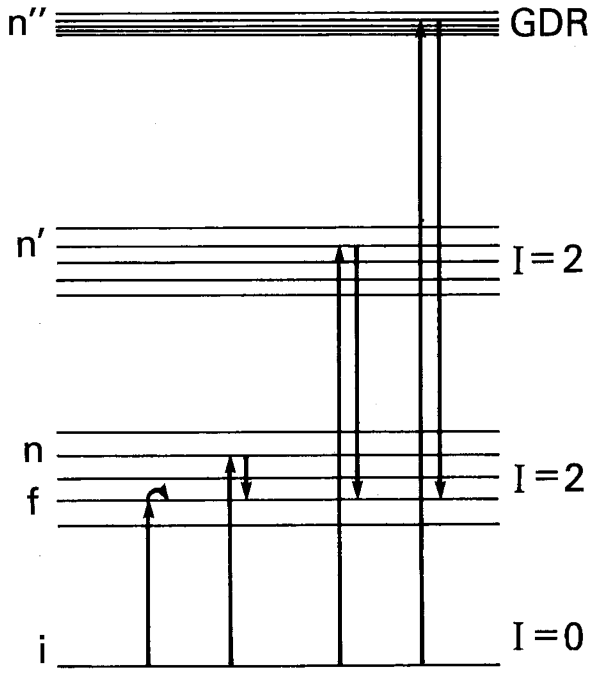

FIGURE 3. A representation of some of the kinds of transitions which must be included in the multiple Coulomb excitation of level 'f' from level 'i'. The first two represent the reorientation transitions: the third, a competing excitation of the level through a higher, $I=2$ level: and the fourth, an excitation of the level through the giant dipole resonance.

distribution of the deexcitation γ-rays. When observing only the γ-ray angular distribution from a particular level, the situation is more complicated than when the scattered particles are observed. The level is not only populated by Coulomb excitation directly to that level but also by Coulomb excitation to higher levels with subsequent unobserved cascades of conversion electrons or γ-rays to the level. The contribution of these additional real transitions must be subtracted. It is therefore necessary to know the L-pole γ-transition rates and internal conversion coefficients for all transitions which could occur as well as the angular correlations between them if the reorientation effect is measured via the dexcitation γ-ray angular distributions.

Several graphs are presented in deBoer and Eichler's article, [68De34], which are useful in establishing the values of some experimental variables. The bombarding energy must be kept small enough to insure that nuclear interactions, other than Coulomb, are not important. Such interactions are not well enough understood, generally, to be accounted for with sufficient accuracy. Two arbitrary limits were chosen by the authors to define a "maximum safe bombarding energy" for their plot of E_{max} as a function of the target mass, A_2, for values of the projectile mass, A_1, from 2 to 64 [68De34, figure 7]. The minimum distance between the two nuclear surfaces in a head-on collision must be 1) greater than 3 Fermi and 2) larger than the deBroglie wavelength of the projectile at infinity. The "safe bombarding energy" increases slowly with A_1 and A_2. In figure 8, [68De34], a similar plot of the corresponding values of η is given. A third useful graph, figure 9 in the same article, shows the interaction strength, $X_{i\to f}$, as a function of A_1 and A_2 for the excitation of the first 2^+-level by a projectile at the "maximum safe bombarding energy." The plot assumes a $B(E2,\ 0^+\to 2^+)$-value of 1.0 e^2b^2. For values of $X<0.1$, the use of second order perturbation theory yields excitation probabilities which are accurate to about 1%. The interaction strengths increase rapidly with A_1 so that second order perturbation theory may not be justified and a multiple-excitation calculation be required for heavy projectiles.

For the case of ^{114}Cd, on which the earliest reorientation experiments were performed and on which there has been very much activity, the "maximum safe bombarding energies," corresponding values of η, and the interaction strengths, $X_{i\to f}$, for a $B(E2,\ 0^+\to 2^+) = 1.0e^2b^2$ obtained from the graphs in [68De34] are presented in table 1. For the 558keV level, the actual $B(E2) = 0.51e^2b^2$. From the table it is seen that second order perturbation calculations would be applicable for ^{2}H-projectiles under 3MeV and possibly also for ^{4}He under 11MeV, but not for the heavier projectiles. For these, multiple Coulomb excitation must be considered. In the paper by

TABLE 1. Maximum safe bombarding energies, corresponding η's, and interactions strengths, $X_{i\rightarrow f}$, for projectiles on ^{114}Cd, as taken from the graphs in [68De34]

Projectile	Maximum safe bombarding energy (MeV)	η	$X_{i\rightarrow f}$†
^{2}H	3	5	0.07
^{4}He	11	9	0.22
^{8}C	23	17	0.50
^{16}O	50	33	0.85
^{32}S	100	65	1.5

†Assumed $B(E2,0\rightarrow2) = 1.0\ e^2b^2$

Berant et al., [71Be36], there is a discussion of the many papers on ^{114}Cd with an attempt to establish a best value for the static quadrupole moment of the 558keV level, which they give as -0.32 ± 8b. In the same paper they mention that with a precision level of 1%, they observe no deviations from pure Coulomb excitation for ^{4}He–projectiles up to 10MeV, but that deviations do occur for ^{16}O above about 46MeV. These are not consistent with the values in table 1. These "safe bombarding energies" should, therefore, be considered merely as a guide. It has been suggested that the lack of nuclear interactions should always be checked out experimentally by performing the reorientation experiments at at least two different bombarding energies.

Quadrupole moments can be obtained either by making high precision absolute cross section measurements or by studying the relative excitation of a level under different bombarding conditions. For example, eq (11) can be written as $d\sigma \cong P^{(11)}(1+r)d\sigma_R$ where, for the most frequently encountered case, one with $I_i=0$, $I_f=2$, $\lambda=2$, no other states excited and for low excitation energies, ΔE:

$$r \equiv P^{(12)}/P^{(11)} \approx A_1 \Delta E\ \langle f\|ME2\|f\rangle\ K(\xi,\theta) \times [Z_2(1+A_1/A_2)]^{-1}. \quad (12)$$

Here the A are in amu, ΔE in MeV, and $\langle f\|ME\|f\rangle$ in eb. K is a function of the projectile parameters: $Y_{2,\mu}$, $I_{2,\mu}$, $\beta_{2,-\mu}$. A plot of K as a function of ξ for different scattering angles can be found in deBoer and Eichler, [68De34], p33. For a given angle, K is a slowly varying function of ξ. It is a maximum for $\theta = \pi$. At backward angles, K is a maximum for small values of ξ. r is seen to be proportional to the excitation energy of the level and to the mass of the projectile used. However, the ratio $\Delta E/E$ must be kept small ($\xi<1$) if the projectile is to be treated semiclassically. The $P^{(11)}$ can be calculated from measurements of the lifetimes of the excited states. Since typical values of r are of the order of 0.10, the $B(E2)$'s and absolute cross sections must be known to a few percent or better in order to determine the quadrupole moment.

For relative excitation measurements, the ratio of the cross sections for two different bombarding conditions, a and b, can be expressed as:

$$d\sigma_a/d\sigma_b \approx (P_a^{(11)}/P_b^{(11)})\ (1 + r_a - r_b) \quad (13)$$

with

$$r_a - r_b \cong \Delta E\ \langle 2+\|ME2\|2+\rangle \times [A_{1a}K(\xi_a,\theta_a) - A_{1b}K(\xi_b,\theta_b)]/Z_2 \quad (14)$$

for $A_1 << A_2$, $P_a^{(11)}/P_b^{(11)}$ is independent of the nuclear transition matrix element and is easily calculated. The ratio of the cross sections can be made more sensitive to the quadrupole moment by choosing the projectile parameters, A_1, ξ, and/or θ, to make the term in the square brackets in (14) as large as possible.

The excitation cross sections are measured either by detecting the elastically and inelastically scattered projectiles or by observing the deexcitation of the nucleus, usually in coincidence with the scattered projectile. In the first type of experiment, the major difficulties are those associated with trying to separate the elastic and inelastic peaks. At high excitation energy, the excitation probabilities are small and it is difficult to observe the small inelastic peak in the tail of the elastic peak. At low excitation energies, the excitation probabilities are larger but the resolution of the two peaks frequently presents problems.

In the second type of experiment, the deexcitation γ's are measured in coincidence with the scattered projectile. A schematic diagram of a possible arrangement is shown in figure 4. The p'γ coincidence rate is given by:

$$\text{C.R.} = \epsilon_\gamma \sum_{n=1}^{\infty} f_n (d\sigma_n/d\Omega)_{lab} \Big/ \sum_{n=0}^{\infty} (d\sigma_n/d\Omega)_{lab} \quad (15)$$

where ϵ_γ is the counting efficiency for $\gamma_{f\rightarrow i}$; f_n, the fraction of decays of state n which give rise to a $\gamma_{f\rightarrow i}$;

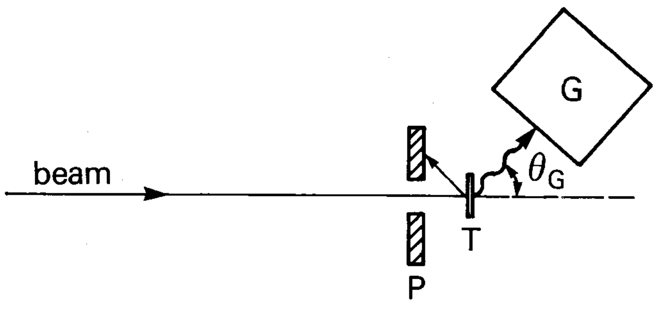

FIGURE 4. A schematic view of an experimental arrangement for the detection of γ-rays in coincidence with back-scattered projectiles. T represents the target: P, an annular particle detector: and G, the γ-ray detector at an angle θ_G to the beam.

$(d\sigma_n/d\Omega)_{lab}$, the differential excitation cross section for the state n, in the laboratory system. When only one level is excited and if that level decays solely by γ-emission, the coincidence rate is approximately $\epsilon_\gamma P_{i\to f}$. The counting efficiency, ϵ_γ, must be corrected for the anisotropic distribution of the deexcitation γ. The effect of the anisotropy can be reduced by the proper choice of θ_C and the distance of the γ-counter from the target.

The measurement of the scattering cross section as a function of energy is made difficult by the small dependence of K on ξ. These experiments require great accuracy if Q is to be determined from the measurements.

Several moments have been determined by the measurement of the reorientation effect in the projectile. This is an important mode of excitation for heavy projectiles on light nuclei. An approximate expression for this effect can be found by replacing Z_2 by Z_1 in equation (12).

There are several possible sources of errors which may need to be considered in the determination of Q-values from Coulomb excitation reorientation measurements in addition to those already mentioned. Among these are: deorientation caused by the atomic electrons, relativistic corrections to the motion of the projectile, the attenuation of the angular distributions by the interaction of the excited state moments with the electronic fields, and the recoil of the nucleus which could give rise to Doppler-shifted energies as well as additional γ-distribution attenuations.

This simplified discussion of the Coulomb excitation reorientation relies heavily on the material presented in [68De34, 65Bi14, 60Al23, 59Br23, and 56Al54], which should be referred to for more detailed descriptions of the actual measurements and calculations of the quadrupole moments therefrom. A collection of reprints of the important papers on Coulomb Excitation, including the deBoer–Winther computer code for multiple Coulomb excitation which is used in many reorientation calculations, is found in [66Al22]. Biedenharn and Brussard, [65Bi14], also discuss some of the features of Coulomb excitation using electrons.

Recently, Lightbody and Penner, see [72Li12], proposed the calculation of static quadrupole moments from high-resolution inelastic electron-scattering measurements. To date, the quadrupole moments derived from these measurements depend on the use of an oversimplified nuclear model for the states involved. The deduced Q-values for eight nuclei in the Cr and Cd regions, are in reasonably good agreement with the Coulomb excitation reorientation measurements on the same nuclei. The physical basis for the success of this model in giving the moments is not understood at this time. The electron-scattering experiments yield the sign of the quadrupole moments and are not plagued with the uncertainties connected with the relative signs of the matrix elements which are present in the reorientation calculations.

The last systematic literature search for data included in the table was done in early 1972.

Explanation of Table K

Nucl.	Chemical symbol with Z− and A−number
Level	Energy, in keV, of the level for which information is given Ground state levels are indicated by gs.
$T_{1/2}$	Half−life of the level The value quoted is taken from Table of Nuclear Half−Lives (68Ma49), Nuclear Data Sheets (through Volume B5), Table of Isotopes (67LeHo), or it is the value used in the referenced article.
I	Nuclear spin, in units of $h/2\pi$ Values enclosed in ( )'s have been determined by resonance or spectroscopic techniques. Values enclosed in [ ]'s have been inferred from decay characteristics.
μ	Nuclear magnetic dipole moment, in nuclear magnetons Nuclear magnetic octupole moments, Ω, in nuclear magneton−barns, have also been tabulated in this column. These have been obtained from elastic and inelastic electron−scattering cross sections. The values, which are model−dependent, have been enclosed in [ ]'s.
Q	Nuclear electric quadrupole moment, in barns, as given by the experimenter Those values marked by an asterisk, *, indicate that the experimenter has made some polarization or Sternheimer correction in computing the moment. Values which are enclosed in [ ]'s, have been derived from elastic and inelastic electron−scattering cross sections and are model−dependent. When two values of Q are given, for CExRO measurements, the first represents the value obtained assuming constructive interference; the second, destructive interference of the matrix elements. Values of the hexadecapole moment, in barns^2, are also tabulated in this column.
Refer.	Reference key number
Method	Codes used to designate the specific techniques are: CExRO Coulomb excitation reorientation eSc electron scattering
Measured Quantity	Measured quantities from which moments are derived
Environment and Comments	Nature of materials used, assumptions made, and comments

Table K: Nuclear Moments by Coulomb Excitation Reorientation and Inelastic Electron–Scattering

Nucleus	Level (keV)	$T_{1/2}$	I	μ	Q	Refer.	Method	Measured Quantity	Environment and Comments
$^{7}_{3}$Li	gs	–	(3/2)	[Ω = +0.091 16]		66Ra29	eSc	Ω/μ = 0.028 5b	
$^{7}_{3}$Li	gs	–	(3/2)		[−0.0302^{c}]	69Vi02	eSc		
$^{9}_{4}$Be	gs	–	(3/2)	[Ω = −0.035]		65Gr18	eSc		
$^{9}_{4}$Be	gs	–	(3/2)	[Ω = −0.041 6]		66Ra29	eSc	Ω/μ = 0.035 5b	
$^{9}_{4}$Be	gs	–	(3/2)		[+0.0476^{c}]	69Vi02	eSc		
$^{9}_{4}$Be	gs	–	(3/2)		[±0.0578^{c}]	69Be50	eSc		
$^{10}_{5}$B	gs	–	(3)	[$\Omega \leq$ 0.029]		66Ra29	eSc	$\Omega/\mu \leq$ 0.016 b	
$^{10}_{5}$B	gs	–	(3)		[±0.0675^{c}]	69Vi02	eSc		
$^{11}_{5}$B	gs	–	(3/2)	[Ω = +0.081]		65Gr18	eSc		
$^{11}_{5}$B	gs	–	(3/2)	[Ω = +0.078 5]		66Ra29	eSc	Ω/μ = 0.029 5b	
$^{11}_{5}$B	gs	–	(3/2)		[±0.032^{c}]	69Vi02	eSc		
$^{12}_{6}$C	14100	?	[4]		[^{i}−0.201] {Q_4^{i} = +0.00215b^2]	71Na14	eSc		Used $<r^2>^{1/2}$ = 2.42F and $<r^4>^{1/4}$ = 2.68F
$^{20}_{10}$Ne	1630	0.7ps	[2]		−0.27 11	69Sc08	CExRO		Ne gas(^{32}S,S′)
$^{20}_{10}$Ne	1630	0.7ps	[2]		−0.24 3	70Na07	CExRO		CEx with Ne on ^{120}Sn; ^{130}Te; ^{148}Sm
$^{22}_{10}$Ne	1275	3ps	[2]		−0.21 6	69Sc08	CExRO		^{22}Ne gas(^{32}S,S′)
$^{22}_{10}$Ne	1275	3ps	[2]		−0.21 4	70Na07	CExRO		CEx with Ne on ^{130}Te; ^{148}Sm
$^{24}_{12}$Mg	1368	1ps	[2]		−0.26 8	68Ba44	CExRO		Mg(^{32}S,S′)
$^{24}_{12}$Mg	1368	1ps	[2]		−0.243 35	70Ha04	CExRO		Mg(^{35}Cl,Cl′)
$^{24}_{12}$Mg	1368	1ps	[2]		−0.305 64	71Vi01	CExRO		Mg(^{16}O,O′)
$^{27}_{13}$Al	gs	–	(5/2)		[±0.146]	67St01	eSc		
$^{27}_{13}$Al	gs	–	(5/2)	[Ω = ±0.34^{p} 9]		71de55	eSc		
$^{28}_{14}$Si	1779	0.5ps	[2]		+0.17 5	69Ha31	CExRO		^{62}Ni(^{28}Si,Si′)
$^{28}_{14}$Si	1779	0.5ps	[2]		+0.22 9	69Pe08	CExRO		Si(^{32}S^{6+},S′)
$^{28}_{14}$Si	1779	0.5ps	[2]		+0.11‡ 5	70Na05	CExRO		Si(^{206}Pb,Pb′)
								‡Assumed Q_{2+}(^{206}Pb) = (0.0 5)×$\lvert Q_{rot}\rvert$	
$^{32}_{16}$S	2237	0.25ps	[2]		−0.05 to +0.25	70Ha24	CExRO		^{50}Ti(^{32}S,S′)
$^{32}_{16}$S	2237	0.25ps	[2]		−0.20‡ 6	70Na05	CExRO		S(^{206}Pb,Pb′)
								‡Assumed Q_{2+}(^{206}Pb) = (0.0 5)×$\lvert Q_{rot}\rvert$	
$^{36}_{18}$Ar	1980	?	[2]		+0.11‡ 6	71Na06	CExRO		^{206}Pb(150MeV ^{36}Ar,Ar′)
								‡Assumed Q_{2+}(^{206}Pb) = (0.0 5)×$\lvert 2\ Q_o/7\rvert$	
$^{40}_{18}$Ar	1460	0.8ps	[2]		+0.01‡ 4	70Na05	CExRO		CEx with ^{206}Pb, ^{130}Te, ^{120}Sn on Ar
								‡Assumed Q_2+(^{206}Pb) = (0.0 5)×$\lvert Q_{rot}\rvert$	
$^{46}_{22}$Ti	889	7ps	[2]		−0.19 10	70Ha24	CExRO		^{46}Ti(^{35}Cl^{7+},Cl′)
$^{46}_{22}$Ti	889	7ps	[2]		−0.28 14	71De29	CExRO		^{46}Ti(^{16}O,O′)
$^{48}_{22}$Ti	983	3.6ps	[2]		−0.22 8	70Ha24	CExRO		^{48}Ti(^{35}Cl^{7+},Cl′)
$^{48}_{22}$Ti	983	3.6ps	[2]		−0.38 13	71De29	CExRO		^{48}Ti(^{16}O,O′)
$^{48}_{22}$Ti	983	3.6ps	[2]		−0.05^{p} 7	71Le17	CExRO		Ti(^{32}S,S′)
$^{48}_{22}$Ti	983	3.6ps	[2]		[−0.177 8]	72Li12	eSc		
$^{50}_{22}$Ti	1550	1ps	[2]		−0.02 9	70Ha24	CExRO		^{50}Ti(^{32}S^{6+},S′)
$^{50}_{24}$Cr	783	8.4ps	[2]		±0.30^{p} 9	72To12	CExRO		CEx with 62MeV ^{32}S on thin target

Table K: Nuclear Moments by Coulomb Excitation Reorientation and Inelastic Electron–Scattering – Continued

Nucleus	Level (keV)	$T_{1/2}$	I	μ or Ω	Q	Refer.	Method	Measured Quantity	Environment and Comments
$^{52}_{24}$Cr	1434	0.90ps	[2]		[−0.082 *16*]	72Pe22	eSc		
$^{52}_{24}$Cr	1434	0.90ps	[2]		−0.09^{P} *13*	72To12	CExRO		CEx with ^{12}C, ^{16}O, ^{32}S; used Q^{50}_{2+} = 0.304 *91*b
$^{53}_{24}$Cr	gs	–	(3/2)		+0.04 *6*	71Th19	CExRO		CEx with 55; 59MeV ^{32}S
$^{54}_{24}$Cr	834	8.9ps	[2]		−0.12^{P} *10*	72To12	CExRO		CEx with ^{12}C, ^{16}O, ^{32}S; used Q^{50}_{2+} = 0.304 *91* b
$^{56}_{26}$Fe	847	7.4ps	[2]		−0.345 *54*	70Sc15	CExRO		CEx with 25; 30MeV ^{16}O
$^{56}_{26}$Fe	847	7.4ps	[2]		−0.22^{P} *6*	71Le17	CExRO		Fe(^{32}S,S′)
$^{56}_{26}$Fe	847	7.4ps	[2]		−0.23 *3*	71Th14	CExRO	$(M_{22})_{av}$ = 0.306 *37*	CEx with 25; 27.5MeV ^{16}O and 56.0MeV ^{32}S on Fe metal. For E_0>28 MeV, M_{22}affected by nuclear interactions.
$^{57}_{26}$Fe	gs	–	1/2			55Tr21			Fe(polarized thermal n,γ). Observed left circular polarization of 7640γ to g.s.
$^{58}_{28}$Ni	1450	0.67ps	[2]		−0.12^{P} *13*	70Le17	CExRO		CEx with ^{12}C, ^{16}O,
					−0.16^{P} *10*	71Le17			^{32}S on thick target
$^{58}_{28}$Ni	1450	0.67ps	[2]		−0.14^{P} *10*	71Ch25	CExRO		^{58}Ni(^{16}O,O′)
$^{60}_{28}$Ni	1330	0.80ps	[2]		±0.00 *13*	69Cl05	CExRO		CEx with ^{16}O, ^{32}S
					+0.07^{P} *9*	71Le17			
$^{60}_{28}$Ni	1330	0.80ps	[2]		+0.01^{P} *10*	71Ch25	CExRO		^{60}Ni(^{16}O,O′)
$^{60}_{28}$Ni	1330	0.80ps	[2]		[−0.104 *18*]	72Li12	eSc		
$^{62}_{28}$Ni	1170	1.57ns	[2]		±0.08 *12*	69Ha31	CExRO		CEx with ^{28}Si on ^{62}Ni
$^{62}_{28}$Ni	1170	1.57ns	[2]		−0.08^{P} *17*	70Le17	CExRO		CEx with ^{32}S, ^{16}O, ^{12}C on thick target
$^{62}_{28}$Ni	1170	1.57ps	[2]		+0.37^{P} *20*	71Ch25	CExRO		^{62}Ni(^{16}O,O′)
$^{64}_{28}$Ni	1350	0.78ps	[2]		+0.35^{P} *20*	71Ch25	CExRO		^{64}Ni(^{16}O,O′)
$^{64}_{30}$Zn	992	2.7ps	[2]		[−0.135 *16*]	72Li12	eSc		
$^{70}_{30}$Zn	884	3ps	[2]		[−0.21 *3*]	72Li12	eSc		
$^{70}_{32}$Ge	1040	1.3ps	[2]		+0.02 *11*	69Si15	CExRO		CEx with ^{16}O, ^{4}He on
					+0.003 *100*				^{70}Ge on C foil
$^{74}_{32}$Ge	596	12ps	[2]		−0.12 *16*	69Sc32	CExRO		^{74}Ge(^{16}O,O′)
$^{76}_{32}$Ge	563	17.6ps	[2]		−0.03 *17*	69Sc32	CExRO		^{76}Ge(^{16}O,O′)
$^{76}_{32}$Ge	563	17.6ps	[2]		−0.18 *14*	69Si15	CExRO		CEx with ^{16}O, ^{4}He on
					or +0.055 *140*				^{76}Ge on C foil
$^{104}_{44}$Ru	358	58ps	[2]		‡		CExRO	‡value attributed to Stelson deleted at request of author	
$^{104}_{46}$Pd	556	9.7ps	[2]		−0.28 *12*	70Ch01,	CExRO		CEx with ^{4}He, ^{16}O on
					or +0.01 *10*	71Ha08			^{104}Pd
$^{106}_{46}$Pd	512	12.0ps	[2]		−0.46 *6*	70Be45	CExRO		CEx with ^{16}O, ^{32}S on
					or −0.28 *6*				^{106}Pd
$^{106}_{46}$Pd	512	12.0ps	[2]		−0.52 *11*	70Ch01	CExRO		CEx with ^{4}He, ^{16}O on
					or −0.25 *12*	71Ha08			^{106}Pd
$^{108}_{46}$Pd	434	23.8ps	[2]		−0.58 *13*	71Ha08	CExRO		CEx with ^{4}He on ^{108}Pd
					or −0.37 *12*				on C foil; CEx with ^{16}O on ^{108}Pd on Ni or Al; included 4 excited states in analysis

Table K: Nuclear Moments by Coulomb Excitation Reorientation and Inelastic Electron–Scattering – Continued

Nucleus	Level (keV)	$T_{1/2}$	I	μ or Ω	Q	Refer.	Method	Measured Quantity	Environment and Comments
$^{108}_{46}$Pd	434	23.8ps	[2]		-0.57^{P} *5* or -0.35 *5*	71Sc30	CExRO		^{108}Pd metal foils(^{32}S, S′)
$^{110}_{46}$Pd	374	45.8ps	[2]		-0.83^{P} *19*	68St28	CExRO		CEx with ^{4}He,^{16}O
$^{110}_{46}$Pd	374	45.8ps	[2]		-0.48 *5* or -0.27 *5*	70Be45	CExRO		CEx with ^{16}O,^{32}S on ^{110}Pd
$^{110}_{46}$Pd	374	45.8ps	[2]		-0.72 *12* or -0.45 *12*	71Ha08	CExRO		CEx with ^{4}He on ^{110}Pd on C; CEx with ^{16}O on ^{110}Pd on Ni; included 5 excited states in analysis
$^{110}_{46}$Pd	374	45.8ps	[2]			71Wa07	CExRO	$Q^{110}_{2^+}-Q^{108}_{2^+}=-0.11^{P}$ *4* $Q^{110}_{2^+}-Q^{104}_{2^+}=-0.34^{P}$ *7*	CEx with ^{4}He,^{12}C,^{16}O, ^{35}Cl; assumed constructive interference.
$^{110}_{46}$Pd	374	45.8ps	[2]		[-0.28 *3*]	72Pe22	eSc		
$^{106}_{48}$Cd	633	6ps	[2]		-0.84‡ *28*	70St17	CExRO		CEx with ^{4}He,^{16}O, ^{32}S,^{40}Ar
								‡Could not separate γ's of ^{106}Cd and ^{108}Cd Based on Q(^{114}Cd 2^{+}state) = -0.38	
$^{106}_{48}$Cd	633	6ps	[2]		-0.61‡ to -0.97‡	70Kl12	CExRO		CEx with ^{4}He,^{16}O, ^{32}S on ^{106}Cd
								‡Corrected for $\gamma\gamma$ attenuation	
$^{108}_{48}$Cd	633	5ps	[2]		-0.84‡ *28*	70St17	CExRO		CEx with ^{4}He,^{16}O, ^{32}S,^{40}Ar
								‡Could not separate γ's of ^{106}Cd and ^{108}Cd Based on Q(^{114}Cd 2^{+}state) = -0.38	
$^{110}_{48}$Cd	656	4.6ps	[2]		-0.40^{P} *10*	70Gr29	CExRO		CEx with ^{4}He,^{16}O
$^{110}_{48}$Cd	656	4.6ps	[2]		-0.24‡ *10*	70St17	CExRO		CEx with ^{4}He,^{16}O, ^{32}S,^{40}Ar
								‡Based on Q(^{114}Cd 2^{+}state) = -0.38	
$^{110}_{48}$Cd	656	4.6ps	[2]		-0.42 *10* or -0.21 *10*	71Be36	CExRO		CEx with 8–16MeV ^{4}He, 37–48MeV ^{16}O
$^{110}_{48}$Cd	656	4.6ps	[2]		-0.55 *8* or -0.31 *7*	71Ha08	CExRO		CEx with ^{4}He on ^{110}Cd on C; CEx with ^{16}O on ^{110}Cd on Ni; included 5 excited states in analysis
$^{112}_{48}$Cd	617	6.2ps	[2]		‡		CExRO	‡value attributed to Stelson deleted at request of author	
$^{112}_{48}$Cd	617	6.2ps	[2]		-0.15‡ *7*	70St17	CExRO		CEx with ^{4}He,^{16}O, ^{32}S,^{40}Ar
								‡Based on Q(^{114}Cd 2^{+}state) = -0.38	
$^{114}_{48}$Cd	558	9ps	[2]		-0.49 *25*	67Si03	CExRO		CEx with ^{16}O,^{32}S on ^{114}Cd; 7 states included in fit
$^{114}_{48}$Cd	558	9ps	[2]		-0.90 to -0.54 -0.58‡ to -0.35‡	67St03	CExRO		CEx with ^{4}He,^{12}C,^{16}O on ^{114}CdO$_2$, measured at ~ 180°; 7 states included in fit
								‡Corrected for perturbation of angular correlations by deBoer, quoted in 69Sa27	
$^{114}_{48}$Cd	558	9ps	[2]		$+0.05$ *27* or -0.21 *28*	68Si05	CExRO		CEx with ^{4}He,^{16}O on ^{114}Cd
$^{114}_{48}$Cd	558	9ps	[2]		-0.68 *10* to -0.43 *10*	69Sa27	CExRO		CEx with ^{4}He,^{16}O on ^{114}Cd
$^{114}_{48}$Cd	558	9ps	[2]		-0.53^{P} *17*	70An09	CExRO		CEx with He^{1+},C^{3+}

Table K: Nuclear Moments by Coulomb Excitation Reorientation and Inelastic Electron–Scattering – Continued

Nucleus	Level (keV)	$T_{1/2}$	I	μ or Ω	Q	Refer.	Method	Measured Quantity	Environment and Comments
$^{114}_{48}$Cd	558	9ps	[2]		−0.28‡ *11* to −0.40‡ *12*	70Kl12	CExRO		CEx with ^{4}He,^{16}O,^{32}S on ^{114}Cd on thin C foil or thick Ni foil
								‡Corrected for attenuation of angular correlation	
$^{114}_{48}$Cd	558	9ps	[2]		−0.64 *19*	70Sc15	CExRO		CEx with 25; 30MeV ^{16}O on ^{114}Cd in Cu sandwich
$^{114}_{48}$Cd	558	9ps	[2]		−0.28 *9* or −0.03 *9* −0.32‡ *8*	71Be36	CExRO		CEx with 8–16MeV ^{4}He, 37–48MeV ^{16}O. Deviations from Coulomb interactions observed for $E_\alpha > 10$ MeV and E_O>46MeV
								‡Average of Q–values of 70Kl12 and 71Be36.	
$^{114}_{48}$Cd	558	9.2ps	[2]		−0.29 *3*	72Pe22	eSc		
$^{116}_{48}$Cd	513	13.7ps	[2]		−1.16 to −0.70	67St03	CExRO		CEx with ^{4}He,^{12}C,^{16}O on ^{116}CdO$_2$; included 5 levels in fit
$^{116}_{48}$Cd	513	13.7ps	[2]		−0.88‡ *25*	70St17	CExRO		CEx with ^{4}He,^{16}O,^{32}S, ^{40}Ar
								‡Based on Q(^{114}Cd 2$^+$state) = −0.38	
$^{112}_{50}$Sn	1257	3ps	[2]		−0.15‡ *18*	70St20	CExRO		CEx with ^{4}He,^{16}O
								‡Based on Q(^{120}Sn 2$^+$state) = +0.09 *10*	
$^{116}_{50}$Sn	1290	0.4ps	[2]		+0.09 *13*	70Kl06	CExRO		CEx with ^{4}He,^{16}O,^{32}S; included 4 levels in fit
$^{116}_{50}$Sn	1290	0.4ps	[2]		+0.07‡ *16*	70St20	CExRO		CEx with ^{4}He,^{16}O
								‡Based on Q(^{120}Sn 2$^+$state) = +0.09 *10*	
$^{116}_{50}$Sn	1290	0.4ps	[2]		[−0.14 *3*]	72Pe22	eSc		
$^{118}_{50}$Sn	1230	0.5ps	[2]		−0.23‡ *16*	70St20	CExRO		CEx with ^{4}He,^{16}O
								‡Based on Q(^{120}Sn 2$^+$state) = +0.09 *10*	
$^{120}_{50}$Sn	1170	0.5ps	[2]		+0.09 *10*	70St20	CExRO		CEx with ^{4}He, ^{16}O
$^{122}_{50}$Sn	1140	0.6ps	[2]		−0.28‡ *17*	70St20	CExRO		CEx with ^{4}He, ^{16}O
								‡Based on Q(^{120}Sn 2$^+$state) = +0.09 *10*	
$^{124}_{50}$Sn	1130	0.8ps	[2]		−0.24 *15*	70Kl06	CExRO		CEx with ^{4}He,^{16}O,^{32}S on ^{124}Sn; 4 levels included in fit
$^{124}_{50}$Sn	1130	0.8ps	[2]		+0.07‡ *17*	70St20	CExRO		CEx with ^{4}He,^{16}O
								‡Based on Q(^{120}Sn 2$^+$state) = +0.09 *10*	
^{122}Te	564	7.6ps	[2]		‡		CExRO	‡Value attributed to Stelson deleted at request of author	
$^{124}_{52}$Te	603	4.3ps	[2]		−0.50^P *10* or −0.27^P *10*	72Kl02, 71Kl06	CExRO		CEx with ^{4}He,^{16}O on ^{124}Te
$^{126}_{52}$Te	667	4.4ps	[2]		−0.50 to −0.16	67St16	CExRO		CEx with ^{4}He,^{16}O
$^{126}_{52}$Te	667	4.4ps	[2]		−0.20^P *9* or −0.00^P *9*	72Kl02, 71Kl06	CExRO		CEx with ^{4}He,^{16}O on ^{126}Te
$^{128}_{52}$Te	743	3.2ps	[2]		−0.40 to −0.01	67St16	CExRO		CEx with ^{4}He,^{16}O on ^{128}Te
$^{128}_{52}$Te	743	3.2ps	[2]		−0.07^P *9* +0.12^P *9*	72Kl02, 71Kl06	CExRO		CEx with ^{4}He, 160 on ^{128}Te
$^{130}_{52}$Te	840	2.0ps	[2]		−0.19 *15* or −0.12 *15*	70Ch01	CExRO		CEx with ^{4}He,^{16}O on ^{130}Te

Table K: Nuclear Moments by Coulomb Excitation Reorientation and Inelastic Electron–Scattering – Continued

Nucleus	Level (keV)	$T_{1/2}$	I	μ or Ω	Q	Refer.	Method	Measured Quantity	Environment and Comments
$^{130}_{56}$Ba	356	63ps	[2]		−1.13 *29*; −1.10 *34*	67Si03	CExRO	perturbation calc.; 2 level calc.	CEx with ^{16}O,^{32}S on ^{130}Ba
$^{130}_{56}$Ba	356	63ps	[2]		+0.31^{P} *22* or +0.43^{P‡} *22*	72To13	CExRO		CEx with ^{32}S,^{40}Ca
								‡For asymmetric rotor	
$^{134}_{56}$Ba	605	7ps	[2]		−0.46^{P} *11* or −0.70^{P} *11*	69Ke16	CExRO		CEx with ^{16}O
$^{134}_{56}$Ba	605	7ps	[2]		+0.16^{P} *28* or +0.21^{P‡} *22*	72To13	CExRO		CEx with ^{32}S,^{40}Ca
								‡For asymmetric rotor	
$^{136}_{56}$Ba	818	1.5ps	[2]		negative, small^{P}	69Ke16	CExRO		CEx with ^{16}O
$^{136}_{56}$Ba	818	1.5ps	[2]		+0.34^{P} *52* or +0.43^{P‡} *52*	72To13	CExRO		CEx with ^{40}Ca
								‡For asymmetric rotor	
$^{142}_{58}$Ce	650	6.2ps	[2]		−0.12 *9*	70En01	CExRO		CEx with ^{16}O
$^{144}_{60}$Nd	695	4.2ps	[2]		+0.03‡ *21* or −0.07‡ *15*	70Ge08	CExRO		CEx with He,O,S on thick Nd metal targets
								‡Used $Q_{2+}(^{150}\mathrm{Nd})$ = −1.48 or −2.00 *51*	
$^{144}_{60}$Nd	695	4.2ps	[2]		−0.17 or −0.61	71Cr01	CExRO		^{144}Nd$_2$O$_3$ on C(42MeV ^{16}O,O′)
$^{146}_{60}$Nd	454	21ps	[2]		−0.63‡ *10*, −0.78‡ *9*	70Ge08	CExRO		CEx with He,O,S
								‡Used $Q_{2+}(^{150}\mathrm{Nd})$ = −1.48, −2.00 *51*	
$^{146}_{60}$Nd	454	21ps	[2]		−0.72 *20*	71Cr01	CExRO		^{146}Nd$_2$O$_3$ on C(42MeV ^{16}O,O′)
$^{148}_{60}$Nd	300	116ps	[2]		−1.24‡ *14*, −1.46‡ *13*	70Ge08	CExRO		CEx with He,O,S on Nd metal
								‡For $Q_{2+}(^{150}\mathrm{Nd})$ = −148, −2.00 *51*	
$^{148}_{60}$Nd	300	116ps	[2]		−1.36 *30*	71Cr01	CExRO		^{148}Nd$_2$O$_3$ on C(42MeV ^{16}O,O′)
$^{150}_{60}$Nd	132	1.52ns	[2]		−1.34^{P} *54*	69Ke17	CExRO		CEx with ^{4}He,^{16}O
$^{150}_{60}$Nd	132	1.52ns	[2]		−2.00‡ *51*	70Ge08	CExRO		CEx with He,O,S on Nd
								‡For best fit to Nd data of Crowley and this paper	
$^{148}_{62}$Sm	551	7ps	[2]		−0.77 *34*; −0.73 *38*	67Si03	CExRO	perturbation calc.; 4 level calc.	CEx with ^{16}O,^{32}S on ^{148}Sm
$^{148}_{62}$Sm	551	7ps	[2]		−0.24 *28* or +0.28 *28*	70Ge07	CExRO		CEx with He,O
$^{148}_{62}$Sm	551	7ps	[2]		−0.97^{P} *27*	72Cl12, 71Cl13	CExRO		CEx with ^{4}He,^{16}O, or ^{32}S on thick Sm target; used Q^{152}_{2+} = −1.653b
$^{150}_{62}$Sm	334	48ps	[2]		−1.28 *20*; −1.22 *22*	67Si03	CExRO	perturbation calc.; 4 level calc.	CEx with ^{16}O,^{32}S on ^{150}Sm
$^{150}_{62}$Sm	334	48ps	[2]		−1.21^{c‡}	68Gr03	CExRO	‡Corrections to reorientation by β and γ bands reduce Q ~ 10%.	
$^{150}_{62}$Sm	334	48ps	[2]		−1.31^{P} *19*	72Cl12, 71Cl13	CExRO		CEx with ^{4}He,^{16}O,^{32}S; used Q^{152}_{2+} = −1.653b
$^{152}_{62}$Sm	122	1.4ns	[2]		−1.8 *6*	65Go06	CExRO		CEx with ^{16}O
$^{152}_{62}$Sm	122	1.4ns	[2]		−1.65 *19*	70Ka45	CExRO		CEx with ~ 23MeV ^{16}O
$^{152}_{62}$Sm	122	1.4ns	[2]		−1.82^{P} *12*	71Cl13	CExRO		CEx with ^{4}He,^{16}O,^{32}S
$^{166}_{68}$Er	80.6	1.82ns	[2]		−2.87 *95*	70Ka45	CExRO		CEx with ~ 35MeV ^{16}O
$^{166}_{68}$Er	265	120ps	[4]		−2.67^{P}‡ *90*	69Mc20	CExRO		CEx with ^{4}He,^{16}O
$^{166}_{68}$Er	787	?	[2]		+2.00^{P} *32*	69Mc20	CExRO		CEx with ^{4}He,^{16}O
$^{168}_{68}$Er	264	120ps	[4]		−2.2^{P} *10*	70Mc27	CExRO		CEx with ^{4}He,^{16}O on ^{168}Er

Table K: Nuclear Moments by Coulomb Excitation Reorientation and Inelastic Electron–Scattering – Continued

Nucleus	Level (keV)	$T_{1/2}$	I	μ or Ω	Q	Refer.	Method	Measured Quantity	Environment and Comments
$^{170}_{68}$Er	79	2.0ns	[2]		-1.95^{p}‡ *26*	72Ke22	CExRO	‡No appreciable higher–state corrections needed	CEx with ^{81}Br
$^{170}_{68}$Er	261	135ps	[4]		-2.2^{p} *10*	70Mc27	CExRO		CEx with ^{4}He, ^{16}O on ^{170}Er
$^{172}_{70}$Yb	260	132ps	[4]		-2.3^{p} *12*	70Mc27	CExRO		CEx with ^{4}He, ^{16}O on ^{172}Yb
$^{174}_{70}$Yb	252	?	[4]		-1.8^{p} *12*	70Mc27	CExRO		CEx with ^{4}He, ^{16}O on ^{174}Yb
$^{176}_{70}$Yb	270	?	[4]		-0.93^{p} *120*	70Mc27	CExRO		CEx with ^{4}He, ^{16}O on ^{176}Yb
$^{186}_{74}$W	399	25ps	[4]		-2.6^{p} *13*	70Mc27	CExRO		CEx with ^{4}He, ^{16}O on ^{186}W
$^{186}_{74}$W	730	4.2ps	[2]		+0.74 *42*	69Mc20	CExRO		CEx with ^{4}He, ^{16}O
$^{184}_{76}$Os	?	?	[2]		-2.4^{p} *11*	71La24	CExRO		Relative to $Q_{2+}^{188,190,192}$(70Pr09)
$^{186}_{76}$Os	137	840ps	[2]		$\pm1.47^{p}$ *54*	71La24	CExRO		Relative to $Q_{2+}^{188,190,192}$(70Pr09)
$^{188}_{76}$Os	155	710ps	[2]		−0.39 *38* or −1.31 *34*	70Pr09	CExRO		CEx with ^{4}He, ^{16}O
$^{190}_{76}$Os	187	350ps	[2]		+0.27 *12* or −0.99 *13*	70Pr09	CExRO		CEx with ^{4}He, ^{16}O
$^{192}_{76}$Os	206	280ps	[2]		+1.22 *19* or −0.41 *20*	70Pr09	CExRO		CEx with ^{4}He, ^{16}O
$^{194}_{78}$Pt	328	35ps	[2]		+0.64 *16* or +0.87 *18*	69Gl08	CExRO		CEx with ^{16}O, ^{1}H on ^{194}Pt
$^{196}_{78}$Pt	356	35ps	[2]		+0.51 *18* or +0.58 *18*	69Gl08	CExRO		CEx with ^{16}O, ^{1}H on ^{196}Pt
$^{198}_{78}$Pt	408	19ps	[2]		+1.22 *50*	69Gl08	CExRO		CEx with ^{16}O, ^{1}H on ^{198}Pt
$^{208}_{82}$Pb	2615	15ps	[3]		−1.3 *6*	69Ba51	CExRO		CEx with ^{4}He, ^{16}O
$^{208}_{82}$Pb	2615	15ps	[3]		$-1.1^{p‡}$ *4* or -0.9^{p}‡ *4*	72Ba88	CExRO	‡For Q_{2+}^{206}= 0 or −0.36 b	CEx with ^{12}C, ^{20}Ne, ^{32}S, ^{40}Ar on Pb; measured relative γ–yields

* Polarization or Sternheimer correction included

^{c} Recalculation of earlier data

^{i} Intrinsic quadrupole moment

^{p} Preliminary value from meeting abstract, report, thesis, or private communication

6. References

The references are listed here according to their alphanumeric code number. The first two digits represent the year of publication. The two letters that follow are the first two letters of the first surname. Compound surnames, such as those beginning with de, Van, von, zu, are alphabetized by the first two letters of the compound name, e.g. De, Va, Vo, Zu. The digits that follow are merely ordering numbers.

The references before 1960 had originally been given single letter codes, as they appear in the tables. The Nuclear Data Project reference numbers have all been converted to two letter (six alphanumeric) codes, which keep the same ordering number for numbers below 100. For those above 100, the hundreds digit has been dropped, while 100 becomes 10. Since there are less than 10 references with the same letter for any year before 1960 in our table, it will not be difficult to find the correct reference.

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