Revisiting Grodzins Systematics of B(E2) values

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Abstract

Using Grodzins formalism as modified by S. Raman et *al.*, PHYS. REV. C **37** (1988) 805, and D. Habs et *al.*, CERN Proposal INTC-P-156 (2002), we analyze systematics of our latest evaluated B(E2) data for all the even-even nuclei in Z=2-104 range published in At. Data Nucl. Data Tables 107 (2016) 1. The analysis indicates a low predictive power of systematics for a large number of cases, and a strong correlation between B(E2) fit values and nuclear structure effects. These findings provide a strong rationale for introduction of individual or elemental (grouped by Z) fit parameters. The current estimates of quadrupole collectivities for systematics of even-even nuclei yield complementary values for comparison with experimental results and theoretical calculations. The lists of fit parameters and predicted B(E2) values are given and possible implications are discussed.

Keywords: Reduced Transition Probabilities, Nuclear Data Analysis, Systematics

PACS: 23.20.-g, 29.85.-c, 25.70.De

1. Introduction

Nuclear properties of the first excited 2^+ states in even-even nuclei have been an important topic in nuclear physics for the last 65 years. The scientific value of large collections of E2 transition probabilities (B(E2) values) for even-even nuclei first was demonstrated by Grodzins in 1962 [1] with

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an introduction of nuclear systematic trends, and the first compilation of $B(E2)$ values for 2_1^+ states was prepared by Stelson and Grodzins a few years later [2]. A high demand for these data motivated Raman *et al.* [3, 4] to continue the $B(E2)$ compilation and evaluation work at Oak Ridge National Laboratory in 80s and 90s. Recently, the new re-evaluation of $B(E2)\uparrow$ values has been performed by a Brookhaven - McMaster - Central Michigan Universities collaboration [5]. Our latest evaluation [5] had been triggered by a large volume of new data; indeed the number of evaluated nuclei has increased from 328 to 447 in the last 15 years. Using the database in our evaluation work, we published an investigation of equivalence between the different methods employed in determining the experimental $B(E2)$ values [6]. Here we present a detailed analysis of Grodzins systematics using the evaluated data and empirical formalism connecting $B(E2)$, level energy, atomic number Z and mass number A .

2. $B(E2)\uparrow$ Systematics

Historically, there have been many attempts to investigate quadrupole collectivities of atomic nuclei in a systematic way [7]. Initially, Grodzins analyzed the γ -ray transition probabilities and energies (T_γ in sec^{-1} and E in MeV) in 126 even-even nuclei. The analysis showed that 80% of cases, except those near doubly closed shells, could be described within a factor of 2 using a simple formula [1]

$$T_\gamma(2_1^+ \rightarrow 0_1^+) = \frac{1}{\tau_\gamma} = (3 \pm 1) \times 10^{10} E^4 Z^2 A^{-1}, \quad (1)$$

which is equivalent to (τ_γ in psec and $E(2_1^+)$ in keV) [7]

$$\tau_\gamma = \tau(1 + \alpha) = (3.3 \pm 1.1) \times 10^{13} E^{-4} Z^{-2} A^1, \quad (2)$$

where τ and α are lifetime and internal conversion coefficient, respectively. Later, the Grodzins' formula has been modified for the prediction of $B(E2; 0_1^+ \rightarrow 2_1^+)$ values by Raman *et al.* [4, 7]

$$B(E2) \uparrow = (2.57 \pm 0.45) \times E^{-1} Z^2 A^{-2/3}, \quad (3)$$

where the (2.57 ± 0.45) multiplier, Z - and A -dependence has been taken from the best global fit. In the current paper, hereafter we would assign credit

Figure 1: The energy ratio $R_{4/2} = E(4_1^+)/E(2_1^+)$ for 581 even-even nuclei listed in Ref. [5].

for the last formula to Raman because it is substantially different from the original Grodzins formula for transition probabilities. Both formulas have been compared and analyzed over the years. The calculated/experimental ratios, in Raman's case, fall in between 0.5 and 2.0 for up to 91% of nuclei outside the closed shells [7].

Raman's formula is consistent with hydrodynamic estimates of $B(E2) \uparrow$ values [7, 8], where the $B(E2) \uparrow$ and energy of the 2_1^+ state are inversely proportional. For vibrational nuclei we deduce

$$B(E2) \uparrow = \frac{45\hbar^2 e^2 r_0^4}{32\pi^2} \frac{Z^2 A^{4/3}}{EB_2}, \quad (4)$$

where B_2 is an inertial parameter measuring the mass transport [9, 10], and r_0 is usually taken to be 1.2 fm. For rotational nuclei we obtain

$$B(E2) \uparrow = \frac{9\hbar^2 e^2 r_0^4}{16\pi^2} \frac{Z^2 A^{4/3}}{EB_2}. \quad (5)$$

The formulae (Eq. 4-5) imply that Grodzins systematics should work well for vibrational and rotational cases, and these nuclei could be identified using a $R_{4/2}$ formalism [11]. The excitation energy ratio $R_{4/2} = E(4_1^+)/E(2_1^+)$ gives information on the structure of the nucleus: “shell configurations” for

$E_4/E_2 < 2$, “vibrational” for $E_4/E_2 \sim 2$ -2.2, “transitional” for $E_4/E_2 \sim 2.7$ and “rotational” for $E_4/E_2 \sim 3.33$. The $R_{4/2}$ values for 585 even-even nuclei listed in our evaluation [5] are shown in Fig. 1 where the energies of the first 4^+ states are taken from the ENSDF database [12]. This Figure is consistent with the findings of Refs. [11, 13] and it demonstrates two sharp peaks at $R_{4/2} \sim 2.2$ -2.4 and ~ 3.3 that correspond to vibrational/ γ -unstable rotor and rotational nuclei, respectively. The data shown in Fig. 1 indicate that there are different regions of collectivity and a variety of nuclear structure effects across the nuclear chart. Therefore, it is naive to assume that all these nuclei will be precisely described by the simple formula of Raman.

There have been multiple attempts in the past to describe $B(E2)$ values systematics [7]. In this work we will concentrate on the recent improvements. The insufficient accuracy of formula of Raman *et al.* motivated the work of Habs *et al.* [14], who have suggested a $B(E2)\uparrow$ formula modification for nuclei with $50 \leq Z \leq 82$ where Raman’s predicted values for proton-rich nuclei are too small and are too large for neutron-rich nuclei. To accommodate these deficiencies they introduced a linear term $N - \bar{N}$, where $N=A - Z$ is the neutron number and $\bar{N}$ denotes the neutron number for which nuclear mass within an isobaric chain reaches its maximum

$$B(E2)\uparrow = (H1 - H2 \cdot ((A - Z) - \bar{N})) \times E^{-1} Z^2 A^{-2/3}, \quad (6)$$

where

$$\bar{N} = \frac{A}{2} \cdot \frac{1.0070 + 0.0128A^{2/3}}{1 + 0.0064A^{2/3}}, \quad (7)$$

and the Habs fit values are $H1 = 3.242$ and $H2 = 0.197$. The analysis of Eq. 6 shows that this formula could be fully adjusted to the latest data using two numerical multipliers $H1$ and $H2$. Habs *et al.* formalism has improved the accuracy of $B(E2)$ values in $50 \leq Z \leq 82$ region from a factor of 2 to $\pm 20\%$. These developments have demonstrated that regional (local) rather than global fitting is preferential. Consequently, it makes sense to reduce the data sets and fit data by isotopes of a single element in order to get a better picture of the systematics.

The latest recommended $B(E2)\uparrow$ values [5] have been fitted for the elemental data sets using Raman’s and Habs’ formulas. The fitting process was similar to the previously-described by Raman *et al.* [7] and was based on a weighted least squares method employing the Frontline Systems Solver application [15, 16]. To investigate the limitations of Grodzins systematics

Figure 2: The current elemental and original Raman global values fitted to Grodzins formalism are shown in green and red, respectively.

across the nuclear chart [1, 4] we have included closed-shell nuclei into the fitting procedures. This approach is acceptable for local (elemental) fits because, for example, an elemental fit for oxygen isotopes is independent of one for the magnesium isotopes so closed shell outliers do not compound as they do for global fits. The elemental fit numerical values are shown in Fig. 2 and Table 1. The displayed elemental fit multipliers demonstrate a strong dependence of Raman's formalism on nuclear structure effects near the closed nuclear shells. These results indicate that there is no single multiplier that can successfully describe $B(E2)\uparrow$ values across the nuclear chart accurately, and that there is a strong preference for local fits.

Table 1: Raman and Habs elemental fit values. Only non-zero fitting values and uncertainties are listed.

Element	Z	Raman Fit Value	H1 Fit Value	H2 Fit Value
C	6	1.06(30)	1.52(34)	0.25(22)
O	8	0.80(19)	1.21(41)	0.35(34)
Ne	10	2.68(39)	2.95(38)	0.39(16)

Element	Z	Raman Fit Value	H1 Fit Value	H2 Fit Value
Mg	12	2.84(15)	2.88(48)	0.02(16)
Si	14	1.88(30)	1.88(41)	
S	16	1.61(15)	1.61(34)	
Ar	18	1.62(8)	1.63(9)	0.013(27)
Ca	20	0.97(40)	1.15(40)	0.25(30)
Ti	22	2.01(15)	2.03(18)	0.13(13)
Cr	24	1.64(17)	2.01(9)	0.01(2)
Fe	26	2.18(13)	2.18(13)	
Ni	28	1.88(12)	1.89(16)	0.02(6)
Zn	30	2.13(16)	2.38(24)	0.13(10)
Ge	32	2.63(19)	2.71(25)	0.09(13)
Se	34	2.95(25)	2.94(26)	0.035(93)
Kr	36	3.49(30)	3.48(27)	0.19(13)
Sr	38	2.81(29)	3.13(15)	0.13(8)
Zr	40	3.25(25)	3.25(24)	
Mo	42	3.32(10)	3.32(37)	
Ru	44	3.04(14)	3.04(16)	
Pd	46	2.92(21)	2.92(21)	
Cd	48	2.64(14)	2.64(14)	
Sn	50	1.81(30)	2.03(16)	0.19(7)
Te	52	2.70(24)	2.71(31)	0.10(15)
Xe	54	3.03(33)	3.21(16)	0.22(3)
Ba	56	2.88(33)	2.97(14)	0.19(4)
Ce	58	3.49(36)	3.59(37)	0.05(10)
Nd	60	2.47(63)	3.38(38)	0.35(11)
Sm	62	3.22(54)	3.35(12)	0.24(3)
Gd	64	2.91(5)	3.05(12)	0.05(4)
Dy	66	3.00(8)	3.22(13)	0.20(10)
Er	68	3.18(8)	3.32(6)	0.16(6)
Yb	70	3.05(8)	3.13(2)	0.14(1)
Hf	72	2.93(8)	2.92(7)	0.05(5)
W	74	2.79(13)	2.74(7)	0.18(5)
Os	76	2.71(17)	2.48(11)	0.19(9)
Pt	78	3.32(15)	3.04(11)	0.11(4)
Hg	80	2.53(25)	2.12(14)	0.23(4)
Pb	82	0.63(12)	0.57(15)	0.03(4)

Element	Z	Raman Fit Value	H1 Fit Value	H2 Fit Value
Po	84	3.94(55)	1.51(89)	0.69(26)
Rn	86	2.32(17)	2.57(44)	0.12(15)
Ra	88	1.80(10)	2.06(51)	0.10(21)
Th	90	1.99(6)	2.08(17)	0.05(7)
U	92	2.20(9)	2.20(9)	
Pu	94	2.55(9)	2.55(9)	
Cm	96	2.56(13)	2.52(13)	

Accurate calculations of $B(E2)\uparrow$ values represent a challenge for nuclear theory. Therefore, it is warranted to explore nuclear systematics for realistic estimates of collectivities in even-even nuclei. The quadrupole collectivities for all presently-known even-even nuclei have been calculated in the present work using the Raman and Habs fits, and these results are shown in Table A1. The present work provides $B(E2)\uparrow$ estimates for 556 even-even nuclei; this calculated data set exceeds the presently-available collection of evaluated reduced transition probabilities of 447 nuclei based on experimental data. The calculated to evaluated (C/E) $B(E2)\uparrow$ values and $E(4_1^+)/E(2_1^+)$ ratios for selected nuclei are shown in Fig. 3. These data show that the quality of fits improves with rising $R_{4/2}$ ratio, i.e. when we move from shell ordering (light and medium) to vibrational and rotational (heavy and actinides) nuclides. In fact, the current elemental fitting approach produces the best results where nuclei with a particular nuclear shape are grouped together, e.g. large numbers of rotators among heavy and actinide nuclides or vibrators in cadmium and tellurium.

In several cases, the elemental Habs *et al.* fits often perform better than the Raman's fits. However, Habs' fits are not ideal for several nuclei where the $(H1 - H2 \cdot ((A - Z) - \bar{N}))$ multiplier, occasionally, may predict the negative $B(E2)\uparrow$ values with large uncertainties for neutron-rich nuclei such as in ^{26}O and $^{214,216,218}\text{Po}$ nuclei. These non-physical predictions demonstrate general limitations of Habs' formalism outside the $50 \leq Z \leq 82$ region, while the more robust and less accurate Raman's formalism could be safely adopted across the nuclear chart.

Figure 3: Calculated vs. Evaluated (C/E) $B(E2)^\dagger$ values and experimental $E(4_1^+)/E(2_1^+)$ ratios for shell and rotational nuclei. The 20% bands for $B(E2)^\dagger$ and $R_{4/2}$ ratios are shown as dashed and solid lines, respectively.

Figure 4: $B(E2)_{\uparrow}$ data and fits for C, O, Ne, Mg and Si. The evaluated, Raman and Habs fitted values are shown as green solid circles with error bars, red rhombs and blue rectangles, respectively.

Figure 5: $B(E2)\uparrow$ data and fits for S, Ar, Ca, Ti, Cr, Fe and Ni. The evaluated, Raman and Habs fitted values are shown as green solid circles with error bars, red rhombs and blue rectangles, respectively.

Figure 6: $B(E2)\uparrow$ data and fits for Zn, Ge, Se, Kr, Sr, Zr and Mo. The evaluated, Raman and Habs fitted values are shown as green solid circles with error bars, red rhombs and blue rectangles, respectively.

Figure 7: $B(E2)_{\uparrow}$ data and fits for Ru, Pd, Cd, Sn, Te, Xe and Ba. The evaluated, Raman and Habs fitted values are shown as green solid circles with error bars, red rhombs and blue rectangles, respectively.

Figure 8: $B(E2)_{\uparrow}$ data and fits for Ce, Nd, Sm, Gd, Dy, Er and Yb. The evaluated, Raman and Habs fitted values are shown as green solid circles with error bars, red rhombs and blue rectangles, respectively.

Figure 9: $B(E2)_{\uparrow}$ data and fits for Hf, W, Os, Pt, Hg, Pb and Po. The evaluated, Raman and Habs fitted values are shown as green solid circles with error bars, red rhombs and blue rectangles, respectively.

3. $B(E2)\uparrow$ Systematics Analysis

Systematic trends, which are based on the comprehensive analyses of available experimental data in conjunction with nuclear theory, play an important role in nuclear physics. In this paper we consider the elemental data fits shown in Fig. 4-10 and assess the quality of fits across the nuclear chart, in addition to extrapolating the $B(E2)$ trends to nuclei where no experimental data are yet available.

Both Raman and Habs fits for $Z=6, 8, 10, 20, 46, 50, 82, 92, 94$ and 96 isotopes deviate markedly from the trend of the experimental values, as expected from the closed shell nature of many of the isotopes. Thus extrapolations of $B(E2)$ values across the whole nuclear chart cannot be made. The fits for $Z=12, 14, 18, 22, 24, 26, 28, 30, 32, 34, 36, 48, 52, 54, 74, 76, 80, 84$ and 86 isotopes are marginal, which can probably be understood as varying degrees of collectivity in these nuclides. It is surprising that fits for $Z=28$ isotopes are remarkably good, even though it is a closed shell. The extrapolations to the unknown regions can be made but the uncertainties in these values are expected to be large. Excellent fits are obtained for $Z=38, 40, 42, 44, 56, 58, 60, 62, 64, 66, 68, 70, 72, 78, 88$ and 90 isotopes, many of which are deformed and highly collective nuclei. For nuclei in these Z regions, extrapolations for the unknown cases can be made reliably.

Such fits could serve as a testing ground for new experimental measurements. One such example is shown in Fig. 11 for $Z=44$, Ru isotopes where both the fits agree well with the experimental values evaluated in our work. However, a recent remeasurement by T. Konstantinopoulos *et al.* [17] of the mean lifetime of the first 2^+ state in ^{100}Ru using RDM method is $31.7(25)$ ps, which gives $B(E2)\uparrow = 0.28(2)$ plotted in Fig. 11. Surprisingly, the new measurement deviates significantly from the trend of $B(E2)$ values for other Ru isotopes as well as Habs fits. It is difficult to explain this rather large deviation, except that the new measurement may suffer from some experimental deficiencies. Another example demonstrating the predictive power of Raman and Habs fits for osmium isotopes is shown in Fig. 12. The recent measurement by T. Daniel *et al.* [18] indicates $T_{1/2}=302(50)$ ps for the first 2^+ state at 218.51 keV in ^{194}Os . This value gives $B(E2)\uparrow = 1.5^{(+3)}_{(-2)} e^2b^2$ which is in a perfect agreement with the Habs fit predicted value of $1.45(25) e^2b^2$ listed in the Appendix.

Systematic trends may indicate cases where more measurements are necessary. The recent result of J.M. Allmond *et al.* [19] suggests approxi-

Figure 11: $B(E2)\uparrow$ data, fits and experimental result of T. Konstantinopoulos et al. [17] for Ru.

Figure 12: $B(E2)\uparrow$ data, fits and experimental result of T. Daniel et al. [18] for Os.

Figure 13: $B(E2)\uparrow$ data, fits and experimental result of J.M. Allmond et al. [19] for Te.

mately 50% higher quadrupole collectivity than previous measurements and agrees better with predicted trends. The latest experimental, previously evaluated [5] and fitted $B(E2)\uparrow$ values for tellurium nuclei are shown in Fig. 13. Moreover, the data in Fig. 6 show that the quadrupole collectivities in $^{90,92,94}\text{Sr}$ vibrational nuclei are lower than predicted by the systematics $B(E2)\uparrow$ values. These values have been extracted from half-life measurements of the first 2^+ states in strontium isotopes by Mach et al. [20]. The $^{90,92,94}\text{Sr}$ half-lives from this experiment are unique, while ^{96}Sr result is consistent with other measurements [5]. Therefore, it is advisable to repeat the strontium nuclei measurements. The visual inspection of Fig. 7 indicates a typo in our evaluation for ^{128}Ba [5], and the corrected $B(E2)\uparrow$ value is $1.441(53) e^2b^2$. Further analysis of shown in Fig. 14 $B(E2)\uparrow$ barium ratios for the evaluated and calculated values supports this conclusion. The barium ratios plot could be compared with the shown in Fig. 15 ratios for ytterbium nuclides where the good agreement between calculated and evaluated values has been found. Besides, the visual analysis helped to identify and correct deficiencies in $^{100,104}\text{Cd}$ evaluations. The corrected values for $B(E2)\uparrow$ in $^{100,104}\text{Cd}$ are <0.28 and $0.337(19) e^2b^2$, respectively. The cerium isotopes data shown in Fig. 8 imply that the older measurement of ^{126}Ce [21] lifetime of $949(53)$ psec is more consistent with the systematics than the recent value of $560(110)$ psec [22], and an additional measurement of ^{126}Ce would be desirable. The last

Figure 14: $B(E2)_{\uparrow}$ ratios between the evaluated and calculated values for Ba.

Figure 15: $B(E2)_{\uparrow}$ ratios between the evaluated and calculated values for Yb.

Figure 16: $B(E2)\uparrow$ data, fits and experimental result of J. Pakarinen et *al.* [23] for Pb.

finding demonstrates that systematics help in the evaluation of potentially discrepant measurements as in the case of ^{100}Ru discussed above.

Further analysis of the Figs. 8-10 data suggests that collectivities in ^{146}Sm , ^{202}Po and ^{222}Ra are based on single measurements and inconsistent with the systematics. These conflicting, single-measurement values are prime candidates for further experimental verifications. Recently $B(E2)$ values in $^{196,198}\text{Pb}$ nuclei have been measured at CERN using Coulomb excitation. The depicted in Fig. 16 experimental results of J. Pakarinen et *al.* [23] for $^{196,198}\text{Pb}$ illustrate that the current Raman and Habs fits strongly disagree with experimental trends in magic Pb nuclei, as is the case for Sn nuclei. Finally, the data points in Figs. 7 and 9 for anomalous $B(E2)\uparrow$ values in ^{132}Sn and ^{208}Pb , respectively, further illustrate the difficulties with description of closed shell nuclei in the current approach. More complex modes of excitation are required for better interpretation of these cases. Data for the rest of nuclei in our evaluation are compatible with the Grodzins systematics. Furthermore, a good agreement between evaluated and nuclear systematics values for Yb and Th nuclei clearly demonstrates a successful application of the current fits for prediction of unknown $B(E2)\uparrow$ values.

4. Conclusions

The recently evaluated $B(E2)\uparrow$ data have been analyzed using a nuclear systematics approach. All even-even nuclei were fitted using the Raman's and Habs' interpretations of Grodzins formalism. The data analysis shows a strong correlation between calculated and evaluated $B(E2)\uparrow$ values for nuclei with $R_{4/2} \geq 2$ and preference for local (elemental) rather than global fits. The elemental data fit parameters and corresponding $B(E2)$ values for 556 collective even-even nuclei are presented. These results may serve as a complementary benchmark for the presently-available *ab initio*, shell model and interacting boson approximation calculations.

Further analysis indicates a pivotal role of systematic trends for understanding of collectivities in even-even nuclei. A general consistency between the fitted and evaluated values validates the current approach. In a few cases, the potentially deficient measurements have been identified, and new measurements have been suggested for validation purposes. The present semi-empirical study provides guidance for future research and yields $B(E2)\uparrow$ values for all the even-even nuclei where energies of the first excited 2^+ states are known. These results demonstrate an important role of nuclear systematics in experimental and theoretical nuclear physics and nuclear data evaluation process.

5. Acknowledgments

The authors gratefully acknowledge Dr. A. Sonzogni and Dr. E. McCutchan (Brookhaven National Laboratory) and Prof. V. Zelevinsky (Michigan State University) for useful comments and valuable suggestions. Work at Brookhaven was funded by the Office of Nuclear Physics, Office of Science of the U.S. Department of Energy, under Contract No. DE-AC02-98CH10886 with Brookhaven Science Associates, LLC. Work at McMaster University was partially supported by the Office of Science of the U.S. Department of Energy.

Appendix A. Tables of Data

$R_{4/2}$ ratios, evaluated and nuclear systematics $B(E2)\uparrow$ values in even-even nuclei are given below.

Table A1: $R_{4/2}$ and $B(E2)\uparrow$ values in $Z=6-96$ nuclei. Energy ratios $R_{4/2}=E(4_1^+)/E(2_1^+)$ [12] and evaluated model-independent, combined (*) and model-dependent (**) $B(E2)\uparrow$ values [5] are shown together with systematics predictions. In cases, where the ENSDF spin and parity assignments for one of the levels are tentative, $R_{4/2}$ values are marked with a $\star$ character. Those marked with a $\dagger$ symbol are lower and upper limits on evaluated $B(E2)\uparrow$ values which do not go to zero or infinity, respectively. The recently-corrected recommended values for $^{100,104}\text{Cd}$ and ^{128}Ba are marked with a C footnote and uncorrected values are marked with a UNC footnote.

Nuclide	$R_{4/2}$	Evaluated $B(E2)\uparrow$ (e^2b^2)	Raman Fit $B(E2)\uparrow$ (e^2b^2)	Habs Fit $B(E2)\uparrow$ (e^2b^2)
^{10}C		0.00450(42)	0.0025(7)	0.00419(99)
^{12}C	3.173(3)	0.00397(20)	0.00165(47)	0.00244(53)
^{14}C	1.531(1)	0.00187(25)*	0.00094(27)	0.00118(33)
^{16}C	2.345(14)	0.00179(20)	0.00342(97)	0.0036(16)
^{18}C		0.00168($^{+23}_{-15}$)	0.00344(98)	0.0028(22)
^{20}C		0.0038($^{+17}_{-8}$)	0.00321(91)	0.0019(26)
^{12}O			0.0055(13)	0.0135(58)
^{14}O	1.505(4)		0.00134(32)	0.0028(10)
^{16}O	1.497(1)	0.00371(39)	0.00117(28)	0.00195(62)
^{18}O	1.794(1)	0.00430(38)	0.00378(90)	0.0048(21)
^{20}O	2.133(4)	0.00298(26)	0.0042(10)	0.0036(34)
^{22}O	2.169(6)*	0.0021(8)	0.00205(49)	0.00096(230)
^{24}O		0.00118(63)**	0.00131(31)	0.000092(1900)
^{26}O			0.00325(78)	-0.0011(60)
^{16}Ne			0.0250(37)	0.0360(49)
^{18}Ne	1.789(1)	0.0243(16)	0.0207(30)	0.0270(34)
^{20}Ne	2.600(1)	0.0333(16)	0.0223(33)	0.0261(32)
^{22}Ne	2.634(1)	0.0230(4)	0.0268(39)	0.0279(38)
^{24}Ne	2.004(1)	0.0143($^{+57}_{-24}$)	0.0163(24)	0.0148(26)
^{26}Ne		0.0155(32)	0.0151(22)	0.0118(29)
^{28}Ne	2.308(7)*	0.0136(23)	0.0223(33)	0.0145(51)
^{30}Ne	2.822(21)*	0.0226(35)**	0.0351(51)	0.0182(96)
^{32}Ne			0.0368(54)	0.014(12)
^{20}Mg		0.0179(33)**	0.0347(18)	0.0359(75)
^{22}Mg	2.653(1)	0.034($^{+16}_{-11}$)	0.0418(22)	0.0429(79)
^{24}Mg	3.012(1)	0.0437(9)	0.0359(19)	0.0366(62)
^{26}Mg	2.388(1)	0.0314(7)	0.0258(13)	0.0261(43)
^{28}Mg	2.729(1)	0.0366(46)	0.0301(16)	0.0302(54)
^{30}Mg	2.280(1)*	0.0273(26)	0.0286(15)	0.0285(57)

Table A1: $R_{4/2}$ and $B(E2)\uparrow$ values in $Z=6-96$ nuclei (continued)

Nuclide	$R_{4/2}$	Evaluated $B(E2)\uparrow$ (e^2b^2)	Raman Fit $B(E2)\uparrow$ (e^2b^2)	Habs Fit $B(E2)\uparrow$ (e^2b^2)
^{32}Mg	2.623(1)	0.0434(52)	0.0458(24)	0.045(11)
^{34}Mg	3.210(50)*	0.0573(79)	0.0598(31)	0.059(16)
^{36}Mg		0.051($^{+13}_{-11}$)**	0.0567(29)	0.055(17)
^{38}Mg			0.0552(29)	0.053(19)
^{24}Si		0.0096(30)	0.0235(38)	0.0235(67)
^{26}Si	2.138(1)*	0.0344(25)	0.0233(38)	0.0233(58)
^{28}Si	2.596(1)	0.0327($^{+6}_{-5}$)	0.0224(36)	0.0224(51)
^{30}Si	2.362(1)	0.0208(6)	0.0170(27)	0.0170(37)
^{32}Si		0.0122($^{+36}_{-21}$)	0.0188(30)	0.0188(43)
^{34}Si		0.0085(33)	0.0105(17)	0.0105(26)
^{36}Si	2.024(3)*	0.0193(59)	0.0241(39)	0.0241(69)
^{38}Si		0.0193(71)	0.0300(48)	0.0300(98)
^{40}Si		0.043(12)	0.0319(51)	0.032(12)
^{42}Si			0.0410(66)	0.041(17)
^{28}S		0.0181(31)	0.0296(28)	0.0296(86)
^{30}S	2.338(3)*	0.0324(22)	0.0193(18)	0.0193(49)
^{32}S	1.999(1)	0.0296($^{+9}_{-4}$)	0.0183(17)	0.0183(41)
^{34}S	2.204(1)	0.0208(12)	0.0185(17)	0.0185(40)
^{36}S	1.980(1)	0.00886($^{+87}_{-52}$)	0.0115(11)	0.0115(25)
^{38}S	2.187(1)	0.0235(30)	0.0282(27)	0.0282(68)
^{40}S	2.121(3)*	0.0334(36)	0.0390(37)	0.039(11)
^{42}S		0.0397(63)	0.0383(36)	0.038(12)
^{44}S	1.849(5)*	0.0314(88)	0.0249(23)	0.0249(90)
^{46}S			0.0337(32)	0.034(14)
^{32}Ar		0.0266(68)	0.0278(14)	0.0288(22)
^{34}Ar		0.0232(29)	0.0239(12)	0.0245(6)
^{36}Ar	2.240(1)	0.0301($^{+20}_{-11}$)	0.0244(12)	0.0249(15)
^{38}Ar	2.468(1)	0.0125(4)	0.0214(10)	0.0216(13)
^{40}Ar	1.980(1)	0.0332(17)	0.0307(15)	0.0308(18)
^{42}Ar	1.998(1)	0.042($^{+11}_{-9}$)	0.0359(17)	0.0358(22)
^{44}Ar	2.372(1)*	0.0358($^{+36}_{-22}$)	0.0363(18)	0.0359(25)
^{46}Ar		0.0243(22)	0.0259(13)	0.0254(20)
^{48}Ar	2.652(20)*	0.0346(55)	0.0382(19)	0.0373(34)
^{50}Ar	2.340(50)*		0.0328(16)	0.0317(33)
^{36}Ca			0.0117(48)	0.024(13)
^{38}Ca	2.625(2)*	0.0097(27)	0.0155(64)	0.028(13)
^{40}Ca	1.352(1)	0.00924(68)	0.0085(35)	0.0135(53)
^{42}Ca	1.805(1)	0.0369(20)	0.0210(86)	0.0285(96)
^{44}Ca	1.973(1)	0.0467(21)	0.027(11)	0.030(11)
^{46}Ca	1.913(1)	0.0168(13)	0.0224(92)	0.020(12)
^{48}Ca	1.175(1)	0.0092($^{+12}_{-5}$)	0.0077(32)	0.0052(56)

Table A1: $R_{4/2}$ and $B(E2)\uparrow$ values in $Z=6-96$ nuclei (continued)

Nuclide	$R_{4/2}$	Evaluated $B(E2)\uparrow$ (e^2b^2)	Raman Fit $B(E2)\uparrow$ (e^2b^2)	Habs Fit $B(E2)\uparrow$ (e^2b^2)
^{50}Ca	4.398(1)*	0.00373($^{+20}_{-18}$)	0.028(11)	0.013(27)
^{52}Ca			0.0109(45)	0.0025(130)
^{54}Ca			0.0133(55)	0.00010(2000)
^{42}Ti	1.722(1)	0.086(16)	0.0518(39)	0.0613(99)
^{44}Ti	2.266(1)	0.0680($^{+59}_{-28}$)	0.0721(54)	0.081(10)
^{46}Ti	2.260(1)	0.0951(25)	0.0852(64)	0.0910(89)
^{48}Ti	2.334(1)	0.0662(29)	0.0749(56)	0.0756(65)
^{50}Ti	1.722(1)	0.0275(16)	0.0462(35)	0.0439(47)
^{52}Ti	2.208(1)	0.0603($^{+29}_{-24}$)	0.0666(50)	0.0595(93)
^{54}Ti	1.670(1)*	0.0357(63)	0.0456(34)	0.0381(85)
^{56}Ti	2.028(1)*	0.060(20)	0.0589(44)	0.046(14)
^{58}Ti	1.947(9)*	0.042($^{+26}_{-23}$)**	0.0620(47)	0.045(18)
^{60}Ti	2.019(14)*		0.0733(55)	0.049(25)
^{46}Cr	2.227(1)*	0.093(20)	0.0826(85)	0.103(6)
^{48}Cr	2.471(1)	0.137(15)	0.0953(98)	0.118(6)
^{50}Cr	2.402(1)	0.105(3)	0.0890(92)	0.110(5)
^{52}Cr	1.652(1)	0.0622(24)	0.0474(49)	0.0581(26)
^{54}Cr	2.185(1)	0.0853(42)	0.0794(82)	0.0969(44)
^{56}Cr	2.664(1)	0.055(19)	0.0642(66)	0.0781(37)
^{58}Cr	2.201(1)	0.097(13)	0.0717(74)	0.0868(45)
^{60}Cr	2.269(1)*	0.121(15)	0.0956(99)	0.115(7)
^{62}Cr	2.635(21)*	0.173(17)	0.135(14)	0.162(10)
^{64}Cr	2.653(24)*	0.156(40)	0.138(14)	0.164(12)
^{48}Fe			0.115(7)	0.115(7)
^{50}Fe	2.421(1)*	0.140(30)*	0.142(9)	0.142(9)
^{52}Fe	2.807(1)	0.082(10)*	0.125(8)	0.0125(8)
^{54}Fe	1.802(1)	0.0608(31)	0.0734(45)	0.0734(45)
^{56}Fe	2.462(1)	0.0981(20)	0.119(7)	0.119(7)
^{58}Fe	2.561(1)	0.122(6)	0.122(8)	0.122(8)
^{60}Fe	2.567(1)	0.0938(88)	0.117(7)	0.117(7)
^{62}Fe	2.481(1)*	0.102($^{+10}_{-8}$)	0.108(7)	0.108(7)
^{64}Fe	2.362(1)	0.173($^{+21}_{-10}$)	0.124(8)	0.124(8)
^{66}Fe	2.450(11)*	0.152(10)	0.157(10)	0.157(10)
^{68}Fe	2.661(6)*	0.178(22)	0.170(10)	0.170(10)
^{52}Ni	1.707(10)		0.0756(50)	0.080(12)
^{54}Ni	1.882(1)	0.061(12)	0.0740(49)	0.078(10)
^{56}Ni	1.453(1)	0.0453(86)	0.0372(25)	0.0387(44)
^{58}Ni	1.691(1)	0.0650(12)	0.0676(45)	0.0695(68)
^{60}Ni	1.880(1)	0.0916(16)	0.0721(48)	0.0734(64)
^{62}Ni	1.992(1)	0.0889(30)	0.0801(53)	0.0808(68)
^{64}Ni	1.940(1)	0.0674(32)	0.0684(45)	0.0682(61)

Table A1: $R_{4/2}$ and $B(E2)\uparrow$ values in $Z=6-96$ nuclei (continued)

Nuclide	$R_{4/2}$	Evaluated $B(E2)\uparrow$ (e^2b^2)	Raman Fit $B(E2)\uparrow$ (e^2b^2)	Habs Fit $B(E2)\uparrow$ (e^2b^2)
^{66}Ni	2.236(2)*	0.06(1)	0.0633(42)	0.0625(63)
^{68}Ni	1.548(1)*	0.0261(60)	0.0434(29)	0.0425(51)
^{70}Ni	1.770(1)	0.086(14)	0.0688(45)	0.0665(94)
^{72}Ni	1.771(4)*		0.0776(51)	0.074(12)
^{74}Ni	1.722(2)*	0.064(22)	0.0816(54)	0.077(15)
^{76}Ni	1.938(5)*		0.0827(55)	0.077(17)
^{58}Zn	1.843(5)*		0.0945(71)	0.126(19)
^{60}Zn	2.185(1)		0.125(9)	0.160(21)
^{62}Zn	2.292(1)	0.122(6)	0.129(10)	0.159(18)
^{64}Zn	2.326(1)	0.149(4)	0.121(9)	0.144(15)
^{66}Zn	2.358(1)	0.137(3)	0.113(9)	0.129(13)
^{68}Zn	2.244(1)	0.120(2)	0.107(8)	0.116(12)
^{70}Zn	2.019(1)	0.151(8)	0.128(10)	0.133(16)
^{72}Zn		0.188(17)	0.170(13)	0.168(25)
^{74}Zn		0.195(15)	0.180(14)	0.169(31)
^{76}Zn	2.166(1)*	0.145(18)	0.179(14)	0.159(36)
^{78}Zn	2.220(1)*	0.077(19)	0.144(11)	0.122(34)
^{80}Zn		0.073(9)	0.0693(52)	0.055(19)
^{62}Ge			0.178(13)	0.209(38)
^{64}Ge	2.276(1)	0.208($^{+37}_{-27}$)	0.149(11)	0.170(27)
^{66}Ge	2.271(1)	0.134(11)	0.172(13)	0.192(25)
^{68}Ge	2.233(1)	0.124($^{+8}_{-3}$)	0.159(12)	0.172(19)
^{70}Ge	2.071(1)	0.179(3)	0.152(11)	0.161(15)
^{72}Ge	2.072(1)	0.209(3)	0.186(14)	0.191(18)
^{74}Ge	2.457(1)	0.306(15)	0.256(19)	0.256(27)
^{76}Ge	2.505(1)	0.274(3)	0.266(19)	0.258(34)
^{78}Ge	2.535(1)	0.222(14)	0.238(17)	0.224(38)
^{80}Ge	2.644(1)*	0.139(27)	0.220(16)	0.201(42)
^{82}Ge	1.505(1)*	0.121(15)	0.106(8)	0.094(24)
^{84}Ge	2.676(3)*		0.225(16)	0.192(59)
^{86}Ge			0.262(19)	0.217(78)
^{66}Se			0.225(19)	0.236(37)
^{68}Se	2.275(1)	0.211(29)	0.240(21)	0.249(34)
^{70}Se	2.159(1)	0.169(11)	0.213(18)	0.219(26)
^{72}Se	1.899(1)	0.190(8)	0.228(20)	0.233(24)
^{74}Se	2.148(1)	0.357(20)	0.305(26)	0.307(29)
^{76}Se	2.380(1)	0.432($^{+15}_{-6}$)	0.340(29)	0.340(30)
^{78}Se	2.449(1)	0.343(12)	0.304(26)	0.301(28)
^{80}Se	2.554(1)	0.252(8)	0.276(24)	0.270(28)
^{82}Se	2.650(1)	0.183(10)	0.276(24)	0.268(32)
^{84}Se	1.459(1)	0.105(15)	0.122(10)	0.117(16)

Table A1: $R_{4/2}$ and $B(E2)\uparrow$ values in $Z=6-96$ nuclei (continued)

Nuclide	$R_{4/2}$	Evaluated $B(E2)\uparrow$ (e^2b^2)	Raman Fit $B(E2)\uparrow$ (e^2b^2)	Habs Fit $B(E2)\uparrow$ (e^2b^2)
^{86}Se	2.226(1)*		0.248(21)	0.236(38)
^{72}Kr	1.862(1)	0.466(65)	0.368(32)	0.445(58)
^{74}Kr	2.224(1)	0.627(31)	0.563(49)	0.655(75)
^{76}Kr	2.440(1)	0.758(26)	0.594(52)	0.664(65)
^{78}Kr	2.460(1)	0.634(16)	0.544(47)	0.583(50)
^{80}Kr	2.329(1)	0.381(12)	0.395(34)	0.405(32)
^{82}Kr	2.344(1)	0.225($^{+7}_{-6}$)	0.308(27)	0.302(24)
^{84}Kr	2.376(1)	0.127($^{+5}_{-3}$)	0.267(23)	0.249(24)
^{86}Kr	1.438(1)	0.106(10)	0.148(13)	0.132(16)
^{88}Kr	2.120(1)	0.0895(93)	0.295(26)	0.248(37)
^{90}Kr		0.154($^{+307}_{-61}$)	0.318(28)	0.254(48)
^{92}Kr	2.346(1)	0.207(7)	0.288(25)	0.217(51)
^{94}Kr	2.280(1)*	0.247(28)	0.328(29)	0.232(67)
^{96}Kr		0.436(93)	0.389(34)	0.257(90)
^{74}Sr	2.214(6)*		0.489(50)	0.659(72)
^{76}Sr	2.847(3)*	1.08($^{+15}_{-12}$)	0.862(89)	1.13(11)
^{78}Sr	2.813(1)	0.97(10)	0.800(82)	1.020(84)
^{80}Sr	2.541(1)	0.909(40)	0.566(58)	0.697(49)
^{82}Sr	2.316(1)	0.505($^{+29}_{-20}$)	0.375(39)	0.447(26)
^{84}Sr	2.229(1)	0.292(23)	0.267(27)	0.308(15)
^{86}Sr	2.071(1)	0.134(8)	0.193(20)	0.216(10)
^{88}Sr	2.305(5)	0.0903($^{+32}_{-23}$)	0.112(12)	0.120(6)
^{90}Sr	1.991(1)	0.102($^{+44}_{-24}$)	0.243(25)	0.252(17)
^{92}Sr	2.053(1)*	0.095($^{+68}_{-28}$)	0.244(25)	0.245(21)
^{94}Sr	2.564(1)	0.099($^{+66}_{-28}$)	0.234(24)	0.226(24)
^{96}Sr	2.200(1)	0.231($^{+16}_{-5}$)	0.237(24)	0.220(29)
^{98}Sr	3.006(1)	1.24(6)	1.32(14)	1.17(19)
^{100}Sr	3.236(3)*	1.22(17)	1.46(15)	1.24(24)
^{102}Sr			1.47(15)	1.20(27)
^{80}Zr	2.858(1)*		0.970(75)	0.970(71)
^{82}Zr	2.557(1)	0.91($^{+12}_{-5}$)	0.677(53)	0.677(49)
^{84}Zr	2.339(1)	0.437($^{+25}_{-22}$)	0.502(39)	0.502(36)
^{86}Zr	2.217(1)	0.157($^{+36}_{-24}$)	0.355(28)	0.355(26)
^{88}Zr	2.024(1)	0.086($^{+11}_{-9}$)	0.249(19)	0.249(18)
^{90}Zr	1.407(1)	0.0627(34)	0.118(9)	0.118(9)
^{92}Zr	1.600(1)	0.0800(39)	0.273(21)	0.273(20)
^{94}Zr	1.600(1)	0.0629(45)	0.274(21)	0.274(20)
^{96}Zr	1.571(9)	0.0314(33)	0.142(11)	0.142(10)
^{98}Zr	1.507(1)*	$>0.0093^\dagger$	0.200(16)	0.200(15)
^{100}Zr	2.656(1)*	1.11($^{+5}_{-4}$)	1.14(9)	1.14(8)
^{102}Zr	3.151(3)	1.35(12)	1.57(12)	1.57(11)

Table A1: $R_{4/2}$ and $B(E2)\uparrow$ values in $Z=6-96$ nuclei (continued)

Nuclide	$R_{4/2}$	Evaluated $B(E2)\uparrow$ (e^2b^2)	Raman Fit $B(E2)\uparrow$ (e^2b^2)	Habs Fit $B(E2)\uparrow$ (e^2b^2)
^{104}Zr	3.246(8)*	1.96(10)	1.69(13)	1.69(12)
^{106}Zr	3.133(11)*	1.55(5)	1.53(12)	1.53(11)
^{108}Zr	2.992(9)*		1.32(10)	1.32(10)
^{84}Mo	2.517(1)*		0.69(21)	0.689(78)
^{86}Mo	2.343(1)*		0.53(16)	0.531(60)
^{88}Mo	2.235(1)*		0.40(12)	0.400(45)
^{90}Mo	2.112(1)		0.308(92)	0.308(35)
^{92}Mo	1.512(1)	0.0975(43)	0.191(57)	0.191(21)
^{94}Mo	1.807(1)	0.207(7)	0.326(98)	0.326(37)
^{96}Mo	2.092(1)	0.278(6)	0.36(11)	0.359(40)
^{98}Mo	1.918(1)	0.270(6)	0.35(11)	0.350(39)
^{100}Mo	2.121(1)	0.530(22)	0.51(15)	0.508(57)
^{102}Mo	2.507(1)	$0.976(^{+49}_{-40})$	0.91(27)	0.91(10)
^{104}Mo	2.917(2)	1.28(11)	1.38(41)	1.38(16)
^{106}Mo	3.045(1)	1.29(7)	1.53(46)	1.53(17)
^{108}Mo	2.924(3)	1.74(46)	1.34(40)	1.34(15)
^{110}Mo	2.805(2)*		1.20(36)	1.20(13)
^{88}Ru	2.298(2)*		0.483(22)	0.483(36)
^{90}Ru	2.220(1)*		0.397(18)	0.397(27)
^{92}Ru	2.143(2)*		0.334(15)	0.334(21)
^{94}Ru	1.528(1)		0.199(9)	0.199(12)
^{96}Ru	1.823(1)	0.238(7)	0.337(16)	0.337(19)
^{98}Ru	2.142(1)	0.401(13)	0.425(20)	0.425(23)
^{100}Ru	2.273(1)	0.493(4)	0.507(23)	0.507(27)
^{102}Ru	2.329(1)	0.632(12)	0.568(26)	0.568(30)
^{104}Ru	2.482(1)	0.826(17)	0.744(34)	0.744(40)
^{106}Ru	2.646(1)*	1.07(10)	0.973(45)	0.973(55)
^{108}Ru	2.746(1)	$0.894(^{+80}_{-58})$	1.07(5)	1.07(6)
^{110}Ru	2.756(1)	1.07(6)	1.07(5)	1.07(7)
^{112}Ru	2.725(1)	1.11(10)	1.07(5)	1.07(7)
^{114}Ru	2.671(2)*		0.944(43)	0.944(70)
^{116}Ru	2.599(2)*		0.846(39)	0.846(67)
^{118}Ru	2.472(3)*		0.747(34)	0.747(64)
^{92}Pd	2.044(1)*		0.347(24)	0.347(24)
^{94}Pd	2.112(1)*		0.367(26)	0.367(26)
^{96}Pd	1.483(1)*		0.208(15)	0.208(15)
^{98}Pd	1.786(1)	$>0.0523^\dagger$	0.337(24)	0.337(24)
^{100}Pd	2.128(1)	$0.347(^{+16}_{-15})$	0.431(30)	0.431(30)
^{102}Pd	2.293(1)	0.460(23)	0.508(36)	0.508(36)
^{104}Pd	2.381(1)	0.529(15)	0.502(35)	0.502(35)
^{106}Pd	2.402(1)	0.660(17)	0.539(38)	0.539(38)

Table A1: $R_{4/2}$ and $B(E2)\uparrow$ values in $Z=6-96$ nuclei (continued)

Nuclide	$R_{4/2}$	Evaluated $B(E2)\uparrow$ (e^2b^2)	Raman Fit $B(E2)\uparrow$ (e^2b^2)	Habs Fit $B(E2)\uparrow$ (e^2b^2)
^{108}Pd	2.416(1)	0.764(20)	0.628(44)	0.628(44)
^{110}Pd	2.463(1)	0.865(23)	0.720(51)	0.720(51)
^{112}Pd	2.532(1)	$0.64^{(+13)}_{(-9)}$	0.762(54)	0.762(54)
^{114}Pd	2.563(1)	$0.83^{(+17)}_{(-12)}$	0.790(56)	0.790(56)
^{116}Pd	2.579(1)	$0.57^{(+22)}_{(-13)}$	0.763(54)	0.763(54)
^{118}Pd	2.518(1)*		0.678(48)	0.678(48)
^{120}Pd	2.412(6)*		0.580(41)	0.580(41)
^{122}Pd	2.330(60)*		0.503(35)	0.503(35)
^{124}Pd	2.200(60)*		0.421(30)	0.421(30)
^{126}Pd	2.136(2)*		0.358(25)	0.358(25)
^{128}Pd	1.385(1)*		0.185(13)	0.185(13)
^{98}Cd	1.493(1)*		0.205(9)	0.207(12)
^{100}Cd	1.792(1)*	$<0.28^C$	0.281(12)	0.283(16)
^{102}Cd	2.109(1)	0.257(23)	0.358(15)	0.361(20)
^{104}Cd	2.268(1)	$0.337(19)^C$	0.418(18)	0.420(23)
^{106}Cd	2.361(1)	0.407(12)	0.429(18)	0.430(23)
^{108}Cd	2.383(1)	0.419(14)	0.423(18)	0.424(22)
^{110}Cd	2.345(1)	0.426(21)	0.402(17)	0.403(21)
^{112}Cd	2.292(1)	0.501(22)	0.424(18)	0.423(22)
^{114}Cd	2.299(1)	0.536(25)	0.462(20)	0.462(25)
^{116}Cd	2.375(1)	0.580(26)	0.498(21)	0.496(27)
^{118}Cd	2.388(1)	0.578(44)	0.518(22)	0.515(29)
^{120}Cd	2.379(1)*	0.473(55)	0.493(21)	0.491(28)
^{122}Cd	2.334(1)*	0.44(20)	0.434(19)	0.431(25)
^{124}Cd	2.260(2)*	0.35(19)	0.399(17)	0.395(24)
^{126}Cd	2.250(4)*	0.263(60)	0.371(16)	0.367(23)
^{128}Cd	2.215(1)*		0.371(16)	0.366(24)
^{130}Cd	1.407(2)*		0.179(8)	0.176(12)
^{102}Sn	1.330(1)*		0.141(23)	0.238(31)
^{104}Sn	1.542(1)	0.176(28)	0.162(27)	0.261(32)
^{106}Sn	1.672(1)	0.209(33)	0.167(28)	0.255(29)
^{108}Sn	1.750(1)	0.224(16)	0.165(27)	0.239(24)
^{110}Sn	1.813(1)	0.231(18)	0.162(27)	0.222(20)
^{112}Sn	1.788(1)	0.232(11)	0.155(25)	0.199(17)
^{114}Sn	1.683(1)	0.215(13)	0.148(24)	0.178(14)
^{116}Sn	1.848(1)	0.206(5)	0.147(24)	0.165(13)
^{118}Sn	1.854(1)	0.207(4)	0.153(25)	0.159(15)
^{120}Sn	1.873(1)	0.198(3)	0.159(26)	0.153(17)
^{122}Sn	1.878(1)	0.189(5)	0.161(27)	0.142(20)
^{124}Sn	1.857(1)	0.162(4)	0.160(26)	0.129(23)
^{126}Sn	1.796(1)	0.127(7)	0.157(26)	0.114(27)

Table A1: $R_{4/2}$ and $B(E2)\uparrow$ values in $Z=6-96$ nuclei (continued)

Nuclide	$R_{4/2}$	Evaluated $B(E2)\uparrow$ (e^2b^2)	Raman Fit $B(E2)\uparrow$ (e^2b^2)	Habs Fit $B(E2)\uparrow$ (e^2b^2)
^{128}Sn	1.711(1)*	0.0771(38)	0.152(25)	0.098(30)
^{130}Sn	1.634(1)*	0.023(5)	0.144(24)	0.081(32)
^{132}Sn	1.093(1)*	0.118(26)	0.0431(71)	0.021(11)
^{134}Sn	1.470(1)	0.029(5)	0.238(39)	0.097(65)
^{136}Sn	1.568(4)*		0.248(41)	0.081(74)
^{138}Sn	1.645(4)*		0.237(39)	0.059(77)
^{106}Te	2.036(1)*		0.491(44)	0.61(17)
^{108}Te	2.062(1)	$0.387^{(+52)}_{(-41)}$	0.515(46)	0.62(16)
^{110}Te	2.133(1)		0.484(43)	0.57(13)
^{112}Te	2.142(1)	0.46(4)	0.456(41)	0.52(11)
^{114}Te	2.094(1)	$0.556^{(+49)}_{(-41)}$	0.439(39)	0.487(84)
^{116}Te	2.002(1)		0.453(40)	0.489(72)
^{118}Te	1.992(1)	$0.57^{(+11)}_{(-8)}$	0.501(45)	0.527(66)
^{120}Te	2.073(1)	0.685(33)	0.536(48)	0.547(62)
^{122}Te	2.094(1)	0.650(30)	0.527(47)	0.521(60)
^{124}Te	2.072(1)	0.560(28)	0.488(43)	0.468(63)
^{126}Te	2.043(1)	0.474(9)	0.436(39)	0.406(67)
^{128}Te	2.014(1)	0.380(7)	0.387(35)	0.349(72)
^{130}Te	1.945(1)	0.296(10)	0.339(30)	0.295(75)
^{132}Te	1.716(1)	0.207(17)	0.289(26)	0.243(75)
^{134}Te	1.232(1)	0.103(4)	0.218(19)	0.177(65)
^{136}Te	1.698(1)	0.122(18)	0.455(41)	0.36(15)
^{138}Te	2.040(6)*		0.618(55)	0.47(23)
^{110}Xe	2.370(1)*		0.821(90)	1.26(7)
^{112}Xe	2.408(1)		0.817(90)	1.20(6)
^{114}Xe	2.375(1)	0.971(58)	0.836(92)	1.18(6)
^{116}Xe	2.332(1)	1.21(6)	0.95(10)	1.28(6)
^{118}Xe	2.402(1)	$1.38^{(+5)}_{(-4)}$	1.09(12)	1.42(7)
^{120}Xe	2.468(1)	1.74(11)	1.09(12)	1.36(6)
^{122}Xe	2.501(1)	1.35(7)	1.09(12)	1.28(6)
^{124}Xe	2.483(1)	1.07(4)	1.01(11)	1.13(5)
^{126}Xe	2.424(1)	0.826(60)	0.906(99)	0.966(48)
^{128}Xe	2.333(1)	0.790(38)	0.787(86)	0.794(42)
^{130}Xe	2.247(1)	0.634(29)	0.643(71)	0.612(35)
^{132}Xe	2.157(1)	0.468(24)	0.511(56)	0.458(29)
^{134}Xe	2.044(1)	0.317(18)	0.399(44)	0.334(24)
^{136}Xe	1.290(1)	0.217(33)	0.255(28)	0.199(17)
^{138}Xe	1.821(1)	0.38(10)	0.563(62)	0.408(39)
^{140}Xe	2.215(1)	0.522(40)	0.871(96)	0.582(65)
^{142}Xe	2.405(1)*	0.69(10)	1.13(12)	0.692(91)
^{144}Xe	2.550(1)*	0.73(17)	1.28(14)	0.71(11)

Table A1: $R_{4/2}$ and $B(E2)\uparrow$ values in $Z=6-96$ nuclei (continued)

Nuclide	$R_{4/2}$	Evaluated $B(E2)\uparrow$ (e^2b^2)	Raman Fit $B(E2)\uparrow$ (e^2b^2)	Habs Fit $B(E2)\uparrow$ (e^2b^2)
^{118}Ba	2.850(1)*		1.93(22)	2.66(17)
^{120}Ba	2.925(18)*		1.99(23)	2.64(16)
^{122}Ba	2.903(3)*	2.34(22)	1.87(22)	2.38(13)
^{124}Ba	2.834(1)	2.10(8)	1.58(18)	1.93(10)
^{126}Ba	2.778(1)	1.74(8)	1.40(16)	1.64(8)
^{128}Ba	2.688(1)	$0.983^{(+52)}_{(-35)}{}^{UNC}$	1.25(14)	1.40(7)
^{128}Ba	2.688(1)	$1.441(53)^C$		
^{130}Ba	2.524(1)	1.14(5)	0.98(11)	1.05(5)
^{132}Ba	2.428(1)	0.847(57)	0.749(86)	0.763(37)
^{134}Ba	2.316(1)	0.665(19)	0.570(65)	0.552(29)
^{136}Ba	2.280(1)	0.413(11)	0.417(48)	0.383(23)
^{138}Ba	1.322(1)	0.230(11)	0.235(27)	0.204(14)
^{140}Ba	1.877(1)	0.484(38)	0.555(64)	0.455(37)
^{142}Ba	2.322(1)	0.676(35)	0.92(11)	0.709(69)
^{144}Ba	2.660(1)	1.01(6)	1.65(19)	1.19(14)
^{146}Ba	2.837(1)	1.35(7)	1.80(21)	1.20(16)
^{148}Ba	2.984(1)		2.27(26)	1.41(23)
^{122}Ce	3.187(13)*		3.50(36)	3.89(71)
^{124}Ce	3.156(5)	$3.50^{(+100)}_{(-63)}$	3.33(35)	3.66(61)
^{126}Ce	3.061(1)	3.65(46)	2.75(29)	3.00(45)
^{128}Ce	2.930(3)	2.27(13)	2.23(23)	2.40(33)
^{130}Ce	2.798(2)	1.76(8)	1.80(19)	1.92(24)
^{132}Ce	2.640(1)	1.69(11)	1.39(15)	1.47(17)
^{134}Ce	2.563(1)	1.06(9)	1.10(11)	1.14(12)
^{136}Ce	2.380(1)	0.81(9)	0.803(84)	0.830(85)
^{138}Ce	2.316(1)	0.467(10)	0.557(58)	0.569(60)
^{140}Ce	1.305(1)	0.300(15)	0.273(28)	0.275(31)
^{142}Ce	1.901(1)	0.457(5)	0.672(70)	0.672(83)
^{144}Ce	2.362(1)	$0.96^{(+30)}_{(-18)}$	1.08(11)	1.06(15)
^{146}Ce	2.586(1)	0.97(11)	1.64(17)	1.60(25)
^{148}Ce	2.862(1)	2.02(11)	2.65(28)	2.56(45)
^{150}Ce	3.152(4)	3.18(48)	4.28(45)	4.09(81)
^{152}Ce	3.251(22)	$5.9^{(+15)}_{(-10)}$	5.04(53)	4.76(110)
^{128}Nd	3.176(2)		2.62(66)	5.58(73)
^{130}Nd	3.052(3)	3.9(16)	2.18(55)	4.40(55)
^{132}Nd	2.866(2)	3.58(59)	1.61(41)	3.07(36)
^{134}Nd	2.682(2)	$1.88^{(+6)}_{(-5)}$	1.15(29)	2.08(23)
^{136}Nd	2.613(1)	1.66(23)	0.90(23)	1.52(16)
^{138}Nd	2.400(1)		0.64(16)	1.01(11)
^{140}Nd	2.329(1)	0.72(5)	0.43(11)	0.627(67)
^{142}Nd	1.333(1)	0.265(13)	0.207(53)	0.283(32)

Table A1: $R_{4/2}$ and $B(E2)\uparrow$ values in $Z=6-96$ nuclei (continued)

Nuclide	$R_{4/2}$	Evaluated $B(E2)\uparrow$ (e^2b^2)	Raman Fit $B(E2)\uparrow$ (e^2b^2)	Habs Fit $B(E2)\uparrow$ (e^2b^2)
^{144}Nd	1.887(1)	0.504(15)	0.46(12)	0.583(74)
^{146}Nd	2.299(1)	0.748(22)	0.71(18)	0.81(12)
^{148}Nd	2.494(1)	1.34(3)	1.05(27)	1.09(19)
^{150}Nd	2.927(2)	2.71(3)	2.42(61)	2.25(49)
^{152}Nd	3.267(3)	4.10(22)	4.3(11)	3.54(98)
^{154}Nd	3.294(5)	$2.35^{(+82)}_{(-49)}$	4.4(11)	3.1(11)
^{156}Nd	3.307(11)		4.6(12)	2.8(13)
^{130}Sm			3.95(66)	6.04(31)
^{132}Sm	3.180(30)*		3.64(61)	5.36(26)
^{134}Sm	2.930(10)	4.14(34)	2.90(49)	4.10(19)
^{136}Sm	2.693(2)	$2.71^{(+28)}_{(-23)}$	1.84(31)	2.49(11)
^{138}Sm	2.571(2)	1.30(19)	1.34(22)	1.74(7)
^{140}Sm	2.348(1)	$1.05^{(+8)}_{(-7)}$	0.87(15)	1.07(4)
^{142}Sm	2.332(1)	0.70(9)	0.592(99)	0.702(26)
^{144}Sm	1.320(1)	0.259(19)	0.271(45)	0.306(11)
^{146}Sm	1.849(1)	$0.24_{(-7)}$	0.60(10)	0.640(23)
^{148}Sm	2.145(1)	0.713(35)	0.80(14)	0.816(31)
^{150}Sm	2.316(1)	1.35(3)	1.31(22)	1.26(5)
^{152}Sm	3.009(1)	3.460(2)	3.57(60)	3.22(15)
^{154}Sm	3.255(1)	4.35(4)	5.25(88)	4.45(25)
^{156}Sm	3.290(2)	$<7.2^\dagger$	5.63(94)	4.46(29)
^{158}Sm	3.300(10)*		5.81(97)	4.28(34)
^{160}Sm	3.290(10)		5.92(99)	4.03(38)
^{138}Gd	2.741(3)	2.18(13)	2.02(3)	2.33(16)
^{140}Gd	2.545(3)		1.35(2)	1.53(9)
^{142}Gd	2.346(1)		0.851(14)	0.954(53)
^{144}Gd	2.348(1)*		0.585(10)	0.647(32)
^{146}Gd	1.324(1)	$>0.014^\dagger$	0.218(4)	0.238(11)
^{148}Gd	1.806(1)	$0.228^{(+114)}_{(-55)}$	0.544(9)	0.586(24)
^{150}Gd	2.019(1)		0.663(11)	0.705(27)
^{152}Gd	2.194(1)	1.66(7)	1.22(2)	1.28(5)
^{154}Gd	3.015(1)	3.87(2)	3.38(6)	3.50(14)
^{156}Gd	3.239(1)	4.70(11)	4.63(8)	4.73(20)
^{158}Gd	3.288(1)	5.09(11)	5.14(8)	5.18(24)
^{160}Gd	3.302(1)	5.18(1)	5.38(9)	5.35(28)
^{162}Gd	3.300(10)	5.50(11)	5.61(9)	5.50(33)
^{164}Gd	3.300(10)*	$5.29^{(+28)}_{(-25)}$	5.43(9)	5.25(36)
^{166}Gd	3.300(50)*		5.64(9)	5.38(41)
^{140}Dy	2.800(3)*		2.39(7)	3.66(55)
^{142}Dy	2.529(4)*		1.52(4)	2.24(31)
^{144}Dy	2.366(2)*		0.965(28)	1.37(17)

Table A1: $R_{4/2}$ and $B(E2)\uparrow$ values in $Z=6-96$ nuclei (continued)

Nuclide	$R_{4/2}$	Evaluated $B(E2)\uparrow$ (e^2b^2)	Raman Fit $B(E2)\uparrow$ (e^2b^2)	Habs Fit $B(E2)\uparrow$ (e^2b^2)
^{146}Dy	2.355(1)		0.689(20)	0.95(11)
^{148}Dy	1.440(10)		0.278(8)	0.368(36)
^{150}Dy	1.813(1)		0.576(17)	0.732(62)
^{152}Dy	2.055(1)	0.43(23)	0.746(21)	0.912(63)
^{154}Dy	2.234(1)	2.42(12)	1.36(4)	1.59(9)
^{156}Dy	2.934(2)	3.72(12)	3.27(9)	3.66(16)
^{158}Dy	3.206(1)	4.66(11)	4.51(13)	4.83(20)
^{160}Dy	3.270(1)	5.05(4)	5.10(15)	5.21(26)
^{162}Dy	3.294(1)	5.23(8)	5.44(16)	5.28(37)
^{164}Dy	3.300(1)	5.62(7)	5.93(17)	5.46(53)
^{166}Dy	3.310(1)		5.64(16)	4.91(63)
^{168}Dy	3.313(3)*		5.72(16)	4.69(77)
^{170}Dy	3.300(500)*		5.91(17)	4.55(94)
^{144}Er			1.63(4)	2.27(22)
^{148}Er	2.358(1)*		0.813(20)	1.07(9)
^{150}Er	1.453(1)		0.330(8)	0.423(30)
^{152}Er	1.832(1)		0.639(16)	0.795(50)
^{154}Er	2.072(1)		0.913(22)	1.10(6)
^{156}Er	2.314(1)	1.65(8)	1.47(4)	1.73(8)
^{158}Er	2.744(1)	3.41(13)	2.62(6)	2.97(11)
^{160}Er	3.099(3)	4.34(15)	3.97(10)	4.36(12)
^{162}Er	3.230(1)	5.04(25)	4.85(12)	5.16(10)
^{164}Er	3.277(1)	5.50(12)	5.37(13)	5.52(11)
^{166}Er	3.289(1)	5.75(9)	6.05(15)	5.99(17)
^{168}Er	3.309(1)	5.72(45)	6.06(15)	5.78(23)
^{170}Er	3.310(1)	5.84(7)	6.10(15)	5.60(31)
^{172}Er	3.314(9)*		6.18(15)	5.45(39)
^{174}Er			5.79(14)	4.90(44)
^{152}Yb			0.342(9)	0.447(8)
^{154}Yb	1.846(1)*		0.633(16)	0.805(12)
^{156}Yb	2.130(10)		0.960(24)	1.19(2)
^{158}Yb	2.332(1)	1.84(22)	1.43(4)	1.72(2)
^{160}Yb	2.626(1)	2.44(16)	2.08(5)	2.44(3)
^{162}Yb	2.923(1)	3.47(11)	3.01(8)	3.43(3)
^{164}Yb	3.127(1)	4.33(14)	4.04(10)	4.46(4)
^{166}Yb	3.228(1)	5.20(20)	4.83(12)	5.16(4)
^{168}Yb	3.266(1)	5.75(12)	5.59(14)	5.79(4)
^{170}Yb	3.293(1)	5.72(7)	5.77(14)	5.79(4)
^{172}Yb	3.305(1)	6.09(15)	6.13(15)	5.94(5)
^{174}Yb	3.310(1)	5.85(16)	6.26(16)	5.86(6)
^{176}Yb	3.310(1)	5.19(9)	5.79(14)	5.22(7)
^{178}Yb	3.310(14)		5.62(14)	4.88(8)

Table A1: $R_{4/2}$ and $B(E2)\uparrow$ values in $Z=6-96$ nuclei (continued)

Nuclide	$R_{4/2}$	Evaluated $B(E2)\uparrow$ (e^2b^2)	Raman Fit $B(E2)\uparrow$ (e^2b^2)	Habs Fit $B(E2)\uparrow$ (e^2b^2)
^{154}Hf			0.349(10)	0.391(49)
^{156}Hf	1.840(10)		0.610(17)	0.677(77)
^{158}Hf	2.169(1)*		1.09(3)	1.20(12)
^{160}Hf	2.307(1)		1.32(4)	1.43(13)
^{162}Hf	2.550(10)	1.34(10)	1.79(5)	1.92(15)
^{164}Hf	2.786(4)	1.82(17)	2.40(7)	2.54(17)
^{166}Hf	2.966(1)	$3.46^{(+17)}_{(-15)}$	3.17(9)	3.31(19)
^{168}Hf	3.110(1)	4.39(4)	4.01(11)	4.15(19)
^{170}Hf	3.194(6)*	5.11(18)	4.90(14)	5.01(18)
^{172}Hf	3.248(2)	5.77(10)	5.15(15)	5.20(14)
^{174}Hf	3.269(1)	5.38(20)	5.35(15)	5.33(13)
^{176}Hf	3.285(1)	5.42(17)	5.47(16)	5.38(16)
^{178}Hf	3.291(1)	4.74(6)	5.14(15)	5.00(19)
^{180}Hf	3.307(1)	4.647(3)	5.10(14)	4.89(25)
^{182}Hf	3.295(3)*		4.83(14)	4.58(29)
^{184}Hf	3.264(4)*		4.38(12)	4.09(32)
^{160}W	2.074(1)		0.850(39)	1.22(10)
^{162}W	2.253(1)*		1.14(5)	1.58(12)
^{164}W	2.470(10)*		1.53(7)	2.05(15)
^{166}W	2.681(4)		2.01(9)	2.59(17)
^{168}W	2.821(3)	3.22(16)	2.52(12)	3.13(19)
^{170}W	2.950(3)	3.50(17)	3.18(15)	3.81(20)
^{172}W	3.061(3)	5.36(2)	4.01(19)	4.62(21)
^{174}W	3.154(3)	4.38(35)	4.34(20)	4.80(18)
^{176}W	3.215(2)	4.95(3)	4.49(21)	4.76(15)
^{178}W	3.236(3)	4.55(6)	4.56(21)	4.62(13)
^{180}W	3.260(1)	4.15(14)	4.63(21)	4.48(13)
^{182}W	3.291(1)	4.12(4)	4.75(22)	4.38(15)
^{184}W	3.274(1)	3.71(4)	4.25(20)	3.72(16)
^{186}W	3.234(1)	3.50(4)	3.82(18)	3.17(18)
^{188}W	3.070(2)*	$2.71^{(+42)}_{(-33)}$	3.25(15)	2.55(19)
^{190}W	2.720(10)*		2.23(10)	1.65(15)
^{192}W			2.10(10)	1.45(17)
^{162}Os	1.990(1)*		0.746(46)	1.13(21)
^{164}Os	2.201(1)*		0.955(58)	1.40(24)
^{166}Os	2.363(2)		1.20(7)	1.69(27)
^{168}Os	2.513(1)		1.51(9)	2.05(31)
^{170}Os	2.616(2)		1.78(11)	2.32(32)
^{172}Os	2.661(1)	$3.28^{(+21)}_{(-19)}$	2.23(14)	2.78(35)
^{174}Os	2.743(2)	$4.55^{(+18)}_{(-15)}$	3.17(19)	3.80(43)
^{176}Os	2.927(2)	3.20(48)	3.69(23)	4.23(41)

Table A1: $R_{4/2}$ and $B(E2)\uparrow$ values in $Z=6-96$ nuclei (continued)

Nuclide	$R_{4/2}$	Evaluated $B(E2)\uparrow$ (e^2b^2)	Raman Fit $B(E2)\uparrow$ (e^2b^2)	Habs Fit $B(E2)\uparrow$ (e^2b^2)
^{178}Os	3.017(4)	$4.12^{(+31)}_{(-25)}$	3.75(23)	4.09(34)
^{180}Os	3.093(3)	4.07(38)	3.72(23)	3.87(26)
^{182}Os	3.155(2)	3.90(9)	3.85(24)	3.80(21)
^{184}Os	3.203(3)	3.21(8)	4.05(25)	3.79(17)
^{186}Os	3.165(1)	3.06(7)	3.51(21)	3.10(15)
^{188}Os	3.083(1)	2.50(4)	3.08(19)	2.57(17)
^{190}Os	2.934(1)	2.35(9)	2.54(16)	1.98(19)
^{192}Os	2.820(1)	2.03(10)	2.29(14)	1.67(21)
^{194}Os	2.750(23)*		2.14(13)	1.45(25)
^{196}Os			1.43(9)	0.90(20)
^{198}Os	2.307(3)*		0.992(61)	0.57(16)
^{168}Pt	2.249(2)*		1.14(5)	1.36(12)
^{170}Pt	2.301(5)*		1.29(6)	1.51(13)
^{172}Pt	2.338(1)*		1.43(6)	1.63(13)
^{174}Pt	2.262(7)		1.64(7)	1.84(13)
^{176}Pt	2.137(3)	2.55(23)	2.43(11)	2.66(18)
^{178}Pt	2.510(2)	$4.24^{(+33)}_{(-29)}$	3.75(17)	4.00(24)
^{180}Pt	2.680(1)	4.66(43)	4.13(19)	4.32(24)
^{182}Pt	2.708(2)	$3.46^{(+23)}_{(-17)}$	4.06(18)	4.14(21)
^{184}Pt	2.675(1)	3.79(20)	3.83(17)	3.81(17)
^{186}Pt	2.560(1)	3.04(12)	3.23(15)	3.14(13)
^{188}Pt	2.526(1)	2.60(47)	2.32(10)	2.19(8)
^{190}Pt	2.492(1)	1.85(9)	2.06(9)	1.90(7)
^{192}Pt	2.479(1)	1.94(7)	1.92(9)	1.72(7)
^{194}Pt	2.470(1)	1.63(7)	1.83(8)	1.60(7)
^{196}Pt	2.465(1)	1.40(7)	1.68(8)	1.43(7)
^{198}Pt	2.419(1)	1.07(5)	1.46(7)	1.20(7)
^{200}Pt	2.347(1)		1.26(6)	1.00(7)
^{202}Pt	2.344(1)*		1.10(5)	0.850(68)
^{204}Pt			0.668(30)	0.502(46)
^{172}Hg	2.257(2)*		0.779(77)	1.26(11)
^{174}Hg			0.804(79)	1.25(11)
^{176}Hg	2.233(4)		0.841(83)	1.25(10)
^{178}Hg	1.814(1)		0.918(90)	1.30(11)
^{180}Hg	1.627(1)	1.45(21)	1.17(12)	1.59(12)
^{182}Hg	1.744(2)	1.68(9)	1.44(14)	1.85(14)
^{184}Hg	1.783(1)	1.62(7)	1.37(13)	1.67(12)
^{186}Hg	1.993(1)	1.47(21)	1.23(12)	1.42(10)
^{188}Hg	2.434(1)	$1.72^{(+27)}_{(-26)}$	1.20(12)	1.31(8)
^{190}Hg	2.502(1)		1.18(12)	1.21(8)
^{192}Hg	2.501(1)		1.15(11)	1.11(7)

Table A1: $R_{4/2}$ and $B(E2)\uparrow$ values in $Z=6-96$ nuclei (continued)

Nuclide	$R_{4/2}$	Evaluated $B(E2)\uparrow$ (e^2b^2)	Raman Fit $B(E2)\uparrow$ (e^2b^2)	Habs Fit $B(E2)\uparrow$ (e^2b^2)
^{194}Hg	2.487(1)		1.13(11)	1.02(6)
^{196}Hg	2.492(1)	1.14(8)	1.13(11)	0.945(61)
^{198}Hg	2.546(1)	0.961(7)	1.16(11)	0.896(64)
^{200}Hg	2.574(1)	0.855(28)	1.29(13)	0.914(76)
^{202}Hg	2.548(1)	0.615(21)	1.07(11)	0.692(68)
^{204}Hg	2.584(1)	0.424(21)	1.07(11)	0.624(75)
^{206}Hg		$>0.0000097^\dagger$	0.435(43)	0.226(34)
^{208}Hg	1.635(2)*		0.690(68)	0.314(59)
^{210}Hg	1.860(10)*		0.713(70)	0.280(68)
^{180}Pb	1.238(1)*		0.114(22)	0.151(65)
^{182}Pb	1.260(1)*		0.149(28)	0.191(79)
^{184}Pb	1.330(10)*		0.187(36)	0.232(91)
^{186}Pb	1.393(1)*	0.190(53)	0.197(38)	0.237(87)
^{188}Pb	1.471(1)*	0.255(85)	0.179(34)	0.208(72)
^{190}Pb	1.588(1)*		0.166(32)	0.187(61)
^{192}Pb	1.588(1)		0.150(29)	0.162(49)
^{194}Pb	1.596(1)		0.131(25)	0.138(39)
^{196}Pb	1.657(1)		0.120(23)	0.121(33)
^{198}Pb	1.529(1)		0.118(22)	0.114(30)
^{200}Pb	1.450(1)		0.121(23)	0.113(29)
^{202}Pb	1.439(1)	$>0.0034^\dagger$	0.129(25)	0.115(31)
^{204}Pb	1.417(1)	0.159(7)	0.136(26)	0.117(33)
^{206}Pb	2.097(1)	0.0989(28)	0.152(29)	0.124(40)
^{208}Pb	1.058(1)	0.287(18)	0.0296(57)	0.0231(84)
^{210}Pb	1.373(1)	0.0510(15)**	0.150(29)	0.111(47)
^{212}Pb	1.388(1)*		0.149(28)	0.104(51)
^{214}Pb	1.412(3)*		0.142(27)	0.094(54)
^{190}Po	2.274(10)*		3.61(51)	5.3(17)
^{192}Po	2.310(3)*		3.19(45)	4.2(14)
^{194}Po	2.147(2)*	$2.99^{(+70)}_{(-48)}$	2.60(36)	3.1(10)
^{196}Po	1.924(1)	1.59(21)	1.78(25)	1.92(62)
^{198}Po	1.915(1)	$1.30^{(+29)}_{(-24)}$ **	1.35(19)	1.29(43)
^{200}Po	1.918(1)	$1.06(6)$ **	1.22(17)	1.01(35)
^{202}Po	1.844(1)	$1.12^{(+34)}_{(-26)}$ **	1.19(17)	0.84(31)
^{204}Po	1.754(1)		1.17(16)	0.67(28)
^{206}Po	1.681(1)		1.14(16)	0.51(26)
^{208}Po	1.961(1)		1.15(16)	0.38(26)
^{210}Po	1.208(1)	0.0200(40)	0.666(93)	0.13(16)
^{212}Po	1.557(1)		1.08(15)	0.082(270)
^{214}Po	1.666(1)*	$>0.794^\dagger$	1.28(18)	-0.060(360)
^{216}Po	1.762(1)*		1.41(20)	-0.24(44)

Table A1: $R_{4/2}$ and $B(E2)\uparrow$ values in $Z=6-96$ nuclei (continued)

Nuclide	$R_{4/2}$	Evaluated $B(E2)\uparrow$ (e^2b^2)	Raman Fit $B(E2)\uparrow$ (e^2b^2)	Habs Fit $B(E2)\uparrow$ (e^2b^2)
^{218}Po	1.835(1)*		1.51(21)	-0.44(52)
^{198}Rn	2.211(2)*		1.49(11)	2.05(57)
^{200}Rn	2.164(1)*		1.16(9)	1.56(40)
^{202}Rn	2.129(1)	$1.00(^{+32}_{-26})$	0.990(73)	1.29(31)
^{204}Rn	2.084(1)	$1.51(^{+59}_{-45})$	0.913(67)	1.16(25)
^{206}Rn	1.972(1)		0.856(63)	1.05(21)
^{208}Rn	1.870(1)		0.770(57)	0.92(17)
^{210}Rn	2.270(1)*		0.755(56)	0.87(15)
^{212}Rn	1.179(1)		0.379(28)	0.424(73)
^{214}Rn	1.640(10)	$>0.0012^\dagger$	0.691(51)	0.75(13)
^{216}Rn	1.822(1)		1.03(8)	1.08(21)
^{218}Rn	2.014(1)*	$>0.89^\dagger$	1.46(11)	1.47(33)
^{220}Rn	2.215(1)	1.87(6)	1.96(14)	1.90(49)
^{222}Rn	2.408(1)	2.36(15)	2.52(19)	2.35(71)
^{206}Ra	2.218(3)*		0.844(47)	1.17(49)
^{208}Ra	2.102(1)*		0.764(43)	1.03(39)
^{210}Ra	1.996(1)		0.655(36)	0.86(29)
^{212}Ra	2.311(2)		0.624(35)	0.79(24)
^{214}Ra	1.180(10)		0.282(16)	0.348(95)
^{216}Ra	1.692(1)		0.563(31)	0.67(17)
^{218}Ra	1.906(1)	$1.00(^{+10}_{-9})$	0.991(55)	1.14(28)
^{220}Ra	2.298(2)		2.15(12)	2.39(62)
^{222}Ra	2.712(1)	4.51(36)	3.43(19)	3.7(11)
^{224}Ra	2.972(1)	3.99(5)	4.49(25)	4.6(16)
^{226}Ra	3.126(1)	5.16(13)	5.56(31)	5.5(23)
^{228}Ra	3.207(1)	5.98(20)	5.86(33)	5.6(28)
^{230}Ra	3.252(6)*		6.48(36)	5.9(36)
^{232}Ra	3.290(70)*		6.78(38)	5.9(42)
^{214}Th	2.332(4)*		0.721(22)	0.81(11)
^{216}Th	1.227(1)		0.302(9)	0.336(42)
^{218}Th	1.732(2)		0.644(20)	0.705(76)
^{220}Th	1.966(1)		1.14(4)	1.23(12)
^{222}Th	2.390(10)	2.98(25)	2.39(7)	2.55(22)
^{224}Th	2.896(1)	$3.96(^{+29}_{-25})$	4.44(14)	4.66(39)
^{226}Th	3.136(2)	6.82(35)	6.00(18)	6.19(55)
^{228}Th	3.234(1)	7.05(12)	7.46(23)	7.58(76)
^{230}Th	3.271(1)	8.14(21)	8.05(25)	8.05(94)
^{232}Th	3.284(1)	9.02(38)	8.62(26)	8.5(12)
^{234}Th	3.291(5)	7.92(64)	8.54(26)	8.3(13)
^{236}Th	3.306(2)*		8.70(27)	8.3(16)
^{226}U	3.080(30)*		6.17(25)	6.17(25)

Table A1: $R_{4/2}$ and $B(E2)\uparrow$ values in $Z=6-96$ nuclei (continued)

Nuclide	$R_{4/2}$	Evaluated $B(E2)\uparrow$ (e^2b^2)	Raman Fit $B(E2)\uparrow$ (e^2b^2)	Habs Fit $B(E2)\uparrow$ (e^2b^2)
^{228}U			8.45(34)	8.45(34)
^{230}U	3.274(2)	9.5(11)	9.58(39)	9.58(39)
^{232}U	3.291(1)	9.91(79)	10.4(4)	10.4(4)
^{234}U	3.296(1)	10.2(5)	11.3(5)	11.3(5)
^{236}U	3.304(1)	11.0(3)	10.8(4)	10.8(4)
^{238}U	3.304(1)	12.2(6)	10.8(4)	10.8(4)
^{240}U	3.350(70)*		10.7(4)	10.7(4)
^{242}U	3.310(30)*		10.0(4)	10.0(4)
^{236}Pu	3.304(8)		13.2(5)	13.2(5)
^{238}Pu	3.312(1)	12.3(3)	13.3(5)	13.3(5)
^{240}Pu	3.309(1)	13.1(4)	13.6(5)	13.6(5)
^{242}Pu	3.307(5)	14.0(8)	13.0(5)	13.0(5)
^{244}Pu	3.510(30)	13.6(7)	13.0(5)	13.0(5)
^{246}Pu	3.308(2)		12.3(4)	12.3(4)
^{238}Cm			17.6(9)	17.3(9)
^{240}Cm		14.3(10)	16.1(8)	15.9(8)
^{242}Cm	3.250(50)		14.4(7)	14.2(7)
^{244}Cm	3.313(1)	14.6(7)	14.1(7)	13.9(7)
^{246}Cm	3.314(1)	14.9(8)	14.0(7)	13.8(7)
^{248}Cm	3.313(5)	14.4(8)	13.8(7)	13.6(7)
^{250}Cm			12.4(6)	12.3(6)

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