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Higher Order Effects in β-γ Correlations Involving Allowed β Transitions*

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Higher order effects in allowed β transitions may be generated by the interference of the allowed Gamow-Teller components with second-forbidden components. In strongly hindered β transitions, this interference effect is expected to give rise to β-γ directional correlations with measurable anisotropies. The β-γ directional correlations of the hindered allowed β transition ($\log ft>8$) in the deformed nuclei Eu^{152}, Eu^{154}, and Tb^{160} were studied. The β-correlation factor $A_2{}^\beta$, which characterizes the β transition in the expression for the β-γ directional correlation $W(\theta)=1+A_2{}^\beta A_2{}^\gamma P_2(\cos\theta)$, was found to be vanishingly small in all cases, except that of Tb^{160}. The results are: $A_2{}^\beta=-0.017\pm0.012$ for the 0.70-MeV β transition of $Eu^{152}(\log ft=10.6)$; $A_2{}^\beta=+0.016\pm0.020$ for the 0.20-MeV β transition of $Eu^{152}(\log ft=9.6)$; $A_2{}^\beta=0.007\pm0.006$ for the 0.58-MeV β transition of $Eu^{154}(\log ft=10.0)$; and $A_2{}^\beta=+0.041\pm0.015$ for the 0.566-MeV β transition of $Tb^{160}(\log ft=8.1)$. A summary of β-γ directional correlation measurements on allowed β transitions is presented and the implications of the results are discussed. In most cases the experimental results suggest that the effects that cause the reduction of the allowed matrix elements are also operative in reducing the second-forbidden matrix elements.

I. INTRODUCTION

THE work reported in this paper completes the systematic study of possible higher order effects in hindered allowed β transitions by β-γ directional correlation methods.[1,2] The β-γ directional correlation involving allowed beta transitions is, in general, isotropic, because only s-wave leptons are emitted. If, however, the allowed matrix elements ($\int 1$ and/or $\int \boldsymbol{\sigma}$) are strongly reduced (hindered transition), the contributions from p- and d-wave leptons, whose amplitudes are characterized by second-forbidden β-decay matrix elements, may cause an anisotropic β-γ directional correlation.

The β-γ directional correlation is of the form[3]

$$W(\theta)=1+A_{22}P_2(\cos\theta). \quad (1)$$

The anisotropy factor $A_{22}(W)$ is a product of the β factor $A_2{}^\beta(W)$ and the γ factor $A_2{}^\gamma$

$$A_{22}(W)=A_2{}^\beta(W)A_2{}^\gamma. \quad (2)$$

The β factor $A_2{}^\beta(W)$ depends on the energy of the β particle and on the relative contributions of certain second-order forbidden matrix elements. These contributions may be characterized by a parameter η which is defined in Ref. 2, where also an approximate expression for $A_2{}^\beta(W)$ is given [Eq. (9) of Ref. 2]. In view of the fact that the η values of the β transition investigated in this work are very large, the theoretical expression for $A_2{}^\beta(W)$ has only qualitative character.

Beta transitions with $\log ft$ values in excess of $\sim$7.0 may be expected to display slightly anisotropic β-γ correlations. In this paper, results of β-γ directional correlation measurements on several allowed beta transitions in the region of deformed nuclei will be reported.

The ground states of the β emitters investigated (Eu^{152},Eu^{154},Tb^{160}) have all spin and parity $I^\pi=3^-$ and their magnetic moments are consistent with the assignment of the configuration $[411\uparrow]+[521\uparrow]$.[4] In addition, the β transitions of the three nuclei are very similar. The three nuclei decay by first-forbidden β transitions with larger than usual ft values leading to the lower excited states of the daughter nuclei and by allowed β transitions with unusually large ft values ($\log ft>8$) feeding the higher excited states of the daughter nuclei. The level schemes of the daughter nuclei are also very similar. However, only one of the hindered allowed β transitions (Tb^{160}) has an anisotropic β-γ directional correlation.

II. EXPERIMENTAL METHODS

The multichannel β-γ directional correlation equipment used in the present investigation has been described before.[5] Since the expected anisotropy effects in allowed β transitions are very small, even small numbers of spurious counts due to external pickup introduce considerable errors. For this reason, the four β channels were used at the same energy setting to check on the consistency of the results.

In addition, the Tb^{160} β-γ directional correlation was also measured with a different apparatus, employing a magnetic lens spectrometer.

The usual corrections for chance coincidences, the corrections owing to competing β-γ and γ-γ cascades and to the Compton background of higher energy γ radiation under the γ photopeaks, were carefully taken into account. In all cases, these corrections were small,

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but not negligible. All data were corrected for the finite geometry of the source-counter arrangement.

The sources were backed by 1-mg/cm^2 Mylar foils and were about 0.1 mg/cm^2 thick. Because of the low energy of the β particles, the Eu^{152} sources used for the measurement of the β(0.2 MeV)–γ(1.298 MeV) directional correlation were vacuum evaporated onto a 0.0001-in. aluminum foil. The Eu sources were prepared by high flux neutron irradiations of the enriched isotopes Eu^{151}($\geq$99%) and Eu^{153}($\geq$95%). The Tb^{160} source was obtained by an (n,γ) reaction on Tb^{159} (purity 99.9%).

III. EXPERIMENTAL RESULTS

Eu^{152}

The spin $I=3^-$ assignment for the Eu^{152} ground state is based on a direct measurement using the paramagnetic resonance method.[6,7] The odd parity is required to account for the 1.484–0.344-MeV beta-gamma directional correlation measurement (see, e.g., Ref. 8). It was reported by Takahashi, McKeown, and Scharff-Goldhaber[9] that the levels of Eu^{152} could be understood in terms of a coupling of Nilsson orbitals. The most plausible configuration for the 3^- ground state seems to be $\frac{3}{2}^+[411\uparrow]$ for the proton and $\frac{3}{2}^-[521\uparrow]$ for the neutron orbital. The quadrupole moment, as measured by Judd, Lovejoy, and Shirley, is $Q=(2.61\pm0.20)$b,[10] indicating a deformation of the Eu^{152} ground state.

The $I=3^-$ assignment for the 1.124-MeV excited level in Gd^{152} (see Fig. 1) is based on gamma-gamma directional correlation experiments and conversion

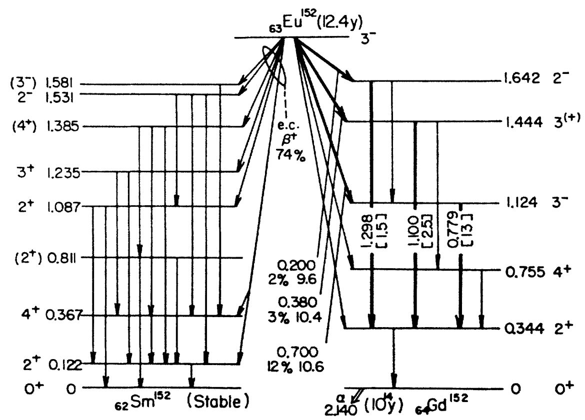

FIG. 1. Decay of Eu^{152}. (Energies in MeV.)

coefficient measurements which reveal the $E1$ character of the 0.779-MeV transition.[11]

The β transition of 0.70-MeV endpoint energy is thus allowed, although it is strongly hindered as indicated by its very large ft value ($\log ft=10.6$). The β-γ directional correlation of the 0.70-MeV β group, followed by the 0.779-MeV γ radiation, was measured accepting β energies from 0.40 to 0.65 MeV in the β channels. In this measurement, no competing β-γ or γ-γ cascades interfere. The experimental result

$$A_{22}(0.70\beta-0.779\gamma)=-0.006\pm0.005$$

indicates a vanishing anisotropy in agreement with a previous measurement.[8]

The 0.779γ transition is an $E1$ transition. The γ-correlation factor is thus $A_2{}^\gamma(0.779\text{ MeV})=F_2(1123)=0.346$ and the experimental β-correlation factor has the value

$$A_2{}^\beta(W>0.88)=-0.017\pm0.012. \quad (3)$$

Formula (9) of Ref. 2 also predicts a vanishing anisotropy (see Table I).

The 2^- spin-parity assignment for the 1.642-MeV level in Gd^{152} is based on gamma-gamma directional correlation measurements and internal conversion measurements on the 1.298-MeV transition (see discussion in Refs. 11 and 12). From such evidence, it appears that the 0.20-MeV β transition is allowed, although its ft value is large ($\log ft=9.6$).

The experimental result of the β-γ directional correlation of the 0.20-MeV β transition and the 1.298-MeV γ transition is, after introducing a small correction for the γ-γ contribution,

$$A_{22}(0.20\beta-1.298\gamma)=-0.008\pm0.010. \quad (4)$$

The 1.298-MeV γ radiation is followed by the 0.344-MeV γ transition, and the γ factor of the 1.298-MeV γ transition can be computed from the experimental results of the 1.298–0.344-MeV γ-γ directional correlation.[11] Taking into account the sign reversal of the $E1$-$M2$ mixing ratio, due to the fact that the 1.298-MeV γ radiation is the second radiation in the β-γ cascade,

$$A_2{}^\gamma(1.298\text{ MeV})=-0.49\pm0.02.$$

Therefore, the β-correlation factor of the 0.20-MeV β transition is

$$A_2{}^\beta(W>1.31)=+0.016\pm0.020. \quad (5)$$

The vanishing $A_2{}^\beta$ for the 0.200-MeV β transition is in agreement with the prediction of formula (9) of Ref. 2.

The spin-3 assignment for the 1.444-MeV level is consistent with gamma-gamma directional correlation results.[11,12] There is, however, no conclusive evidence concerning the parity of this level.

In order to determine the parity of the 1.444-MeV

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[12] W. Schick and L. Grodzins, Nucl. Phys. **62**, 254 (1965).

excited state in Gd[152], the 0.38–1.100-MeV beta-gamma directional correlation has been measured. The result obtained for this cascade in terms of the A_{22} coefficient is

$$A_{22}(0.38\beta-1.100\gamma)=-0.05\pm0.01. \qquad (6)$$

The beta channel setting in this measurement was chosen to avoid the contribution from the 0.20-MeV β–1.298-MeV γ cascade. This result disagrees with the vanishing anisotropy factor, $A_{22}=0.00\pm0.017$, reported by Schick and Grodzins for this cascade.[12] The comparatively low energy selected in the β channel by Schick and Grodzins ($E_\beta=0.20$ MeV) may be partly responsible for this small value of A_{22}, since the 0.20-MeV β–1.298-MeV γ cascade gives a small contribution. It is very unlikely, however, that this small contribution can account completely for the discrepancy in these two measurements. The nonvanishing anisotropy for the 0.38 β–1.100 γ cascade (as compared with practically zero anisotropy shown by allowed transitions in this isotope) indicates that the 0.38-MeV β transition is first-forbidden and thus supports a positive parity assignment for the 1.444-MeV level. Hence, the 1.100-MeV gamma transition should be a $M1+E2$ multipole transition. A rather large $E2$ component admixture in the 1.100-MeV transition is required to explain the 1.100 e_K^-—344 γ directional correlation observed by Burde *et al.*[13] The large $E2$ contribution is in agreement with the K-conversion coefficient reported by Nathan and Waggoner for the 1.100-MeV transition[14] and implies a collective character of the 1.444-MeV excited state.

Eu[154]

The spin ($I=3$) of the Eu[154] ground state (Fig. 2) has been determined by the paramagnetic resonance method.[7] The negative parity is assigned on the basis of β-γ directional correlation experiments on the 1.855-MeV β transition to the 2^+ excited state of Gd[154].[15] Since the absence of a $P_4(\cos\theta)$ term makes it very unlikely that this β transition is second-forbidden, it must be first-forbidden involving a parity change. The high ft value of this 1.855-MeV β transition can be explained by K-forbiddeness. The Eu[154] ground state is deformed [$Q=(3.24\pm0.38)$b][10] with $K=3^-$; the ground state and the first two excited states of Gd[154] are $K=0^+$ rotational states.

The 2^- spin-parity assignment for the 1.399-MeV level of Gd[154] follows from nuclear alignment studies,[10] directional correlation experiments,[16] and linear-polarization directional correlation measurements[17] on the 1.276-MeV–0.123-MeV gamma-gamma cascade. The

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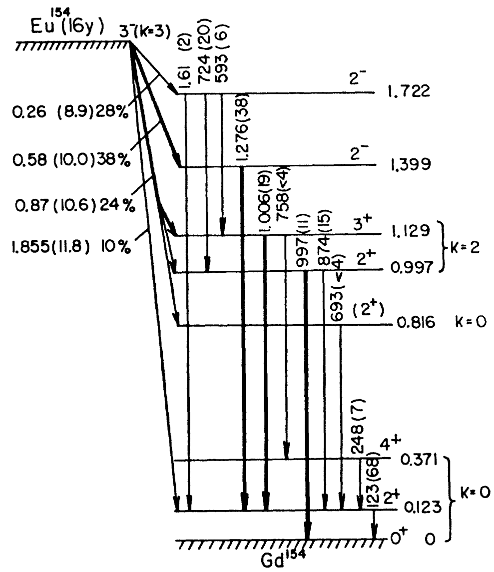

FIG. 2. Decay of Eu[154].

β transition of 0.58-MeV end-point energy feeding the 1.399-MeV level must therefore be allowed. The large ft value of this β transition ($\log ft=10.0$) has not been explained satisfactorily.

The measurement of the 0.58-MeV β–1.276-MeV γ directional correlation yielded a vanishing anisotropy

$$A_{22}(0.58\beta-1.276\gamma)=-0.004\pm0.003.$$

This result is in agreement with the isotropic correlation reported by Sunier *et al.*[8] The γ-correlation factor of the 1.276-MeV $E1$ transition is $A_2^\gamma(1.276)=F_2(1122)=-0.418$ and the experimental value of the β-correlation factor of the 0.58-MeV β transition becomes thus

$$A_2^\beta(W>1.7)=+0.007\pm0.006. \qquad (7)$$

The nuclear structure dependent factor η for this β transition ($\log ft=10.0$) is very large, $\eta=560$. The expression for A_2^β [Eq. (9) of Ref. 2] provides only a very qualitative estimate for such large η values yielding $A_2(W=1.76)\simeq\pm0.003$. This theoretical estimate shows, however, that no sizable anisotropy is expected in this β-γ directional correlation, despite the strong hindrance.

Tb[160]

The decay scheme of Tb[160] (Fig. 3) is well established.[18,19] The spin of Tb[160] ($I=3$) has been measured directly.[20] The odd parity of the Tb[160] ground state follows from nuclear systematics.

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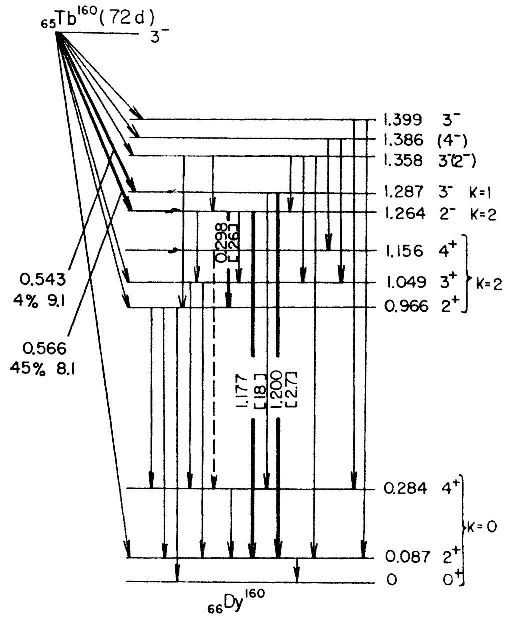

FIG. 3. Decay of Tb^{160}.

The spin ($I=2$) of the 1.264-MeV excited state of Dy^{160} has been established by gamma-gamma directional correlation[21–23] and nuclear orientation[24] experiments. The odd parity of this state is assigned on the basis of the $E1$ multipole character of the 1.180-, 0.298-, and 0.216-MeV gamma transitions.[25]

The beta transition of 0.566-MeV endpoint energy ($\log ft=8.1$) is thus allowed.

Previous measurements on this β transition showed evidence of higher order effects.[2] The results, however, were not consistent with other decay data. Thus the β-γ directional correlation measurements involving the 0.566-MeV β transition were repeated with improved experimental techniques. Particular attention was devoted to corrections for competing β-γ and γ-γ cascades.

The corrections for the γ-γ background are particularly difficult to evaluate precisely for the 0.566-MeV β-0.298-MeV γ correlation measurement. To eliminate the γ-γ contribution, a thin-lens magnetic spectrometer was used to measure this correlation. The energy resolution of the spectrometer was 3% and the spectrometer current was set to accept electrons with energy of 0.490 MeV. The result obtained, after correcting for coincidences between the beta particles and Compton background under the 0.298-MeV gamma peak in the scintillation counter, was

$$A_{22}=-0.018\pm0.005. \tag{8}$$

This result is lower than the previously reported value.[2] The discrepancy between these two results is most probably due to the uncertainties in the relatively large correction for the γ-γ background in the previous measurement.

The 0.298-MeV gamma-transition is a pure or almost pure $E1$ transition. On the basis of gamma-gamma directional correlation measurement,[22,23] the possible $M2$ admixture is less than 0.2%. The γ-correlation factor is thus

$$A_2^{\gamma}(0.298\text{ MeV})=-0.42\pm0.06. \tag{9}$$

The β-correlation factor for the 0.566-MeV β transition is therefore

$$A_2^{\beta}(W>1.92)=0.043\pm0.018. \tag{10}$$

The β-correlation factor of the same β transition can also be determined by observing the 0.566-MeV β–1.177-MeV γ directional correlation. This measurement is more difficult, because the contributions from the competing 0.543-MeV β–1.200-MeV γ cascade must be taken into account. This cascade contributes about 12% to the β-γ coincidence rate. Accepting β particles of energies between 0.45 and 0.55 MeV, four independent measurements yielded the following result after applying the correction for the competing cascade:

$$A_{22}=-0.019\pm0.008. \tag{11}$$

The error is caused mainly by uncertainties in the correction. This result is somewhat different from the previously reported anisotropy factor

$$A_{22}=+0.013\pm0.007.$$

The γ factor of the 1.177-MeV gamma radiation can be computed from the γ-γ directional correlation measurements.

Arns *et al.*[22] report a γ-γ anisotropy factor of $A_{22}'(1.177\gamma-0.087\gamma)=+0.133\pm0.041$ for this directional correlation. This value must be corrected for the presence of extranuclear perturbations in the liquid sources that were used by these authors. Günther *et al.*[26] determined the attenuation factor for liquid Tb^{160} sources $G_{22}=0.74\pm0.02$ in agreement with an earlier measurement of Broude and Kaplan.[27] Thus, the true correlation coefficient for this γ-γ cascade is

$$A_{22}(1.177\gamma-0.087\gamma)=0.180\pm0.06. \tag{12}$$

The γ factor $A_2^{\gamma}(1.177)$ of the 1.177-MeV γ transition

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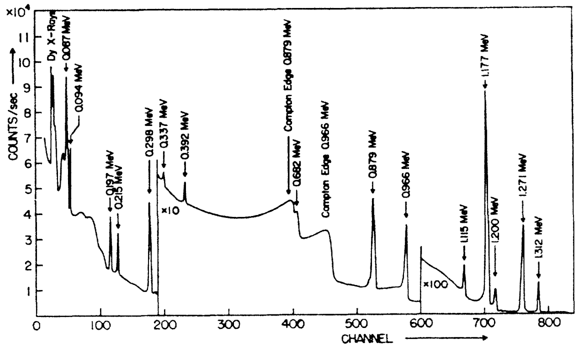

FIG. 4. Gamma-spectrum of Tb^{160} measured with a lithium-drifted germanium detector of 2-mm depletion depth.

is, therefore,

$$A_2^{\gamma}(1.177\text{ MeV})=0.180\pm0.06/F_2(2202)$$
$$=-0.30\pm0.10, \quad (13)$$

corresponding to a $M2$-$E1$ mixing ratio of $\delta=-0.096$ or 0.9% $M2$ admixture. This is in good agreement with the value of 0.7% for $M2$ admixture obtained from the orientation experiment.[24]

Taking into account the sign reversal of δ, if the 1.177-MeV γ transition is the second transition of the cascade, one obtains for the γ factor relevant to the β-γ correlation function

$$A_2^{\gamma}(1.177\text{ MeV})=-0.53\pm0.11. \quad (14)$$

Hence, the β-correlation factor of the 0.566-MeV β transition computed from the experimental result of Eq. (11) is

$$A_2^{\beta}(W>1.92)=+0.04\pm0.02. \quad (15)$$

The two results (10) and (15) show conclusively that the allowed 0.566-MeV β transition has a small yet nonvanishing β anisotropy factor.

The weighted average of the two independent measurements is

$$A_2^{\beta}(0.566\text{ MeV})=+0.041\pm0.015. \quad (16)$$

In order to ascertain that there is no level adjacent to the 1.264-MeV level that could be fed by a forbidden β transition, the gamma spectrum was investigated with a high-resolution Ge-Li detector. The spectrum (see Fig. 4) does not show any evidence of an unknown level in the neighborhood of the 1.264-MeV level of interest.

From the ft value of the 0.566β transition ($\log ft=8.1$), the nuclear structure factor η is computed as $\eta\simeq\pm63$. Using Eq. (9) of Ref. 2, this results in an estimate of the β factor $A_2(\beta)$ of

$$\begin{aligned} A_2(\beta)&=+0.16 \quad \text{for} \quad \eta<0,\\ A_2(\beta)&=\ 0.001 \quad \text{for} \quad \eta>0. \end{aligned} \quad (17)$$

IV. SUMMARY AND CONCLUSIONS

Table I summarizes β-γ directional correlation measurements involving allowed β transitions. The nuclear structure parameters η which are listed in column 5 have been calculated from the ft values of the β transitions. Estimates of the β-anisotropy factors A_2^{β} expected from the η values are indicated in column 6. The A_2^{β} values have been computed for the β energies W at which the various measurements were made.

In all but three cases (F^{20},Na^{22},Tb^{160}), the β-γ correlations are isotropic. (We disregard the results of older measurements, if newer and more reliable values are available.) The anisotropy factors expected in Na^{24}, Sc^{46}, Co^{60}, Eu^{152}, and Eu^{154} are so small [$|A_2^{(\beta)}(\text{theory})|\leq10^{-3}$] that it is extremely difficult to observe them experimentally. In some cases, however, e.g., Co^{56}, Mn^{56}, Sb^{124}, Cs^{134}, the large hindrance of the allowed component should result in a measurable anisotropy. The fact that isotropic correlations were observed indicates that in these nuclei the nuclear structure effects which are responsible for the hindrance of the allowed β component are also effective in reducing the second-forbidden matrix elements.

The small anisotropy factor observed in the β-γ directional correlation of F^{20} may be due to weak magnetism effects caused by the conserved vector current. The weak magnetism effect is measurably large in F^{20} because of the large β energy.

The very small anisotropy in the Na^{22} β-γ correlation may also be caused by weak magnetism. The anisotropy, as observed in Ref. 1, is of the correct order of magnitude. On the other hand, the anisotropy may be due to interference with second-forbidden β components that cannot be predicted by the conserved-vector-current theory.

The rather large anisotropy factor observed in the β-γ directional correlation of the 0.566-MeV β transition of Tb^{160} is interesting. Both Tb^{160} and Dy^{160} are strongly deformed nuclei and one is tempted to invoke $\Delta K\geq-2$ selection rules which forbid allowed β transitions without affecting the second-forbidden β components. All experimental evidence from γ transitions, however, indicates that the 1.264-MeV excited state of Dy belongs to a $K=2$ band, and certainly not to a $K=0$ band. The $K=2$ assignment would make the 0.566-MeV β decay from the $K=3^-$ ground state of Tb^{160} a K-allowed transition. According to a survey by Gallagher and Soloviev, the 1.264-MeV state of Dy^{160} can be interpreted on the basis of the Nilsson model as a $[411\uparrow]-[523\uparrow]$ proton configuration. The β decay from Tb^{160} would thus be associated with a $[521\uparrow](n)\rightarrow[523\uparrow](p)$ transition, implying $\Delta N=0$, $\Delta n_z=0$, $\Delta\Lambda=-2$, where Λ is the component of orbital angular momentum along the nuclear symmetry axis, N is the total number of nodes in the harmonic-oscillator wave function, and n_z is the number of nodal planes perpen-

TABLE I. β-γ directional correlations involving allowed β transitions.

β emitter	Transition	W_0	$\log ft$	η	A_2^β(theory)	A_2^β(experiment)	Ref.
F^{20}	$2^+ \xrightarrow{\beta^-} 2^+$	11.6	5.0	± 1.8	-0.005[a]	-0.010 ± 0.003	b
Na^{22}	$3^+ \xrightarrow{\beta^+} 2^+$	1.69	7.4	± 28	∓ 0.001	$+0.0030 \pm 0.0005$ $+0.025 \pm 0.005$ $< +0.04$ $+0.0017 \pm 0.008$	c d e f
Na^{24}	$4^+ \xrightarrow{\beta^-} 4^+$	3.15	6.1	± 6	∓ 0.001	-0.03 ± 0.03 -0.0004 ± 0.0008	g c
Sc^{46}	$4^+ \xrightarrow{\beta^-} 4^+$	1.4	6.2	± 7	∓ 0.0002	-0.0004 ± 0.0008	c
Mn^{56}	$3^+ \xrightarrow{\beta^-} 2^+$	6.6	7.2	± 22	± 0.008	$+0.06 \pm 0.01$ -0.000 ± 0.002	h i
Co^{56}	$4^+ \xrightarrow{\beta^+} 4^+$	3.9	8.7	± 120	$-0.10^{+0.08}$	-0.033 ± 0.009 -0.012 ± 0.003 -0.007 ± 0.006 $+0.002 \pm 0.007$	j k l f
Co^{60}	$5^+ \xrightarrow{\beta^-} 4^+$	1.4	7.4	± 28	± 0.001	$+0.03 \pm 0.03$ $+0.0004 \pm 0.0007$ $+0.0004 \pm 0.0003$	g c e
Sb^{124}	$3^- \xrightarrow{\beta^-} 3^-$	2.2	7.7	± 40	$+0.06^{-0.01}$	0.006 ± 0.007	f
Cs^{134}	$4^+ \xrightarrow{\beta^-} 4^+$	2.3	8.9	± 160	$+0.11^{-0.01}$	-0.0025 ± 0.009 -0.02 ± 0.04 -0.002 ± 0.006 $(A_4^\beta = -0.003 \pm 0.018)$	m g f f
Eu^{152}	$3^- \xrightarrow{\beta^-} 3^-$	2.37	10.6	± 1100	$+0.004^{-0.0003}$	$+0.03 \pm 0.05$ -0.017 ± 0.012	n o
Eu^{152}	$3^- \xrightarrow{\beta^-} 2^-$	1.39	9.6	± 355	± 0.00001	$+0.016 \pm 0.020$	o
Eu^{154}	$3^- \xrightarrow{\beta^-} 2^-$	2.13	10.0	± 560	$+0.0004^{-0.0003}$	$+0.007 \pm 0.006$	o
Tb^{160}	$3^- \xrightarrow{\beta^-} 3^-$	2.11	8.1	± 63	$+0.16^{-0.001}$	$+0.17 \pm 0.03$ $+0.09 \pm 0.03$ $+0.04 \pm 0.02$	f o o

[a] Predicted on the basis of the conserved-vector-current theory; see footnote b of this table.
[b] F. Boehm, V. Soergel, and B. Stech, Phys. Rev. Letters **1**, 77 (1958).
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dicular to the nuclear symmetry axis. The selection rule for allowed β transition is $\Delta\Lambda = 0$. Thus, the allowed component of the 0.566-MeV β transition is hindered by the $\Delta\Lambda$ selection rule, whereas any second-forbidden component is not slowed down by $\Delta\Lambda = -2$. This Λ-forbiddenness may explain the observed anisotropy in the Tb^{160} β-γ cascade.

[*Note added in proof.* Recently H. Müller [Nucl. Phys. **74**, 449 (1965)] has reported a small, but nonvanishing anisotropy for the 1.5-MeV β–1.24-MeV γ correlation in Co^{56} ($A_{22} = +0.007 \pm 0.002$). His analysis of the result in terms of contributions from second-forbidden matrix elements is in agreement with the conclusions drawn in this paper.]