PHYSICAL REVIEW C VOLUME 54, NUMBER 2 AUGUST 1996

Is there experimental evidence for an interpretation of the lowest $K=0$ collective excitation of deformed nuclei as a phonon excitation of the γ band?

C. Günther, S. Boehmsdorff, K. Freitag, J. Manns, and U. Müller
Institut für Strahlen- und Kernphysik, Universität Bonn, Nussallee 14, D-53115 Bonn, Germany
(Received 21 August 1995)

The experimental evidence presented recently by Casten and von Brentano, to support their suggestion that the lowest excited $K^\pi=0^+$ states in deformed nuclei should be given a new interpretation as a phonon built on the γ vibration, is critically examined. It is argued that in the determination of $B(E2,0_\beta^+\rightarrow 2_\gamma^+)$ values from the higher-spin members of the β band to the γ band the rotational transitions caused by the mutual coupling of the β and γ bands have to be taken into account. An intensity limit is obtained for the $0_\beta^+\rightarrow 2_\gamma^+$ γ transition in ^{160}Dy yielding $B(E2,0_\beta^+\rightarrow 2_\gamma^+)/B(E2,0_\beta^+\rightarrow 2_g^+)\leqslant 25$. We conclude that there is no experimental evidence supporting the new interpretation of the β vibrations in the deformed rare-earth nuclei. [S0556-2813(96)03208-6]

PACS number(s): 21.10.Re, 21.60.Ev, 23.20.Lv, 27.70.+q

The lowest excited $K^\pi=0^+$ levels in the even-even deformed rare-earth nuclei have traditionally been interpreted as β vibrations. However, recently this interpretation has been contested by Casten and von Brentano [1]: they claim that the properties of these bands suggest an interpretation as phonon excitations on the γ band. In response to this paper two comments were published [2,3] together with the reply of Casten and von Brentano [4]. In their reply these authors claim that experimental data ''*show a preference of decay of the $K=0_2^+$ band to the γ band over the ground band by two orders of magnitude*'' which they interpret as ''*evidence for a significant two-phonon amplitude in the $K=0_2^+$ excitation.*'' In the present work we want to present our objections against this interpretation.

Casten and von Brentano were led to their new interpretation of the lowest $K^\pi=0^+$ mode (which we will denote as the 0_β^+ states, with 0_g^+ referring to the ground state and 2_γ^+ referring to the bandhead of the lowest $K^\pi=2^+$ excitation) by interacting-boson approximation (IBA) predictions [5].

(i) The excitation energies $E(0_\beta^+)$ are predicted to lie between $\sim$1.4 and $\sim$1.7 times that of the γ band [or, more precisely, of $E(2_\gamma^+)-E(2_g^+)$].

The empirical systematics of the $K^\pi=0^+$ and 2^+ excitation energies is shown in Fig. 1. Except for a few nuclei in the first half of the region of quadrupole deformation around $N=98$ (^{162}Gd,^{164}Dy,^{166}Er) the experimental ratios of E_β/E_γ are not in agreement with the IBA prediction. In fact, for half of the nuclei shown in Fig. 1 the 0_β^+ levels lie below the 2_γ^+ levels. It is difficult to understand how this could be consistent with the interpretation of the 0_β^+ levels as phonons built on the 2_γ^+ levels as claimed in Ref. [4].

(ii) The $B(E2)$ values for the $0_\beta^+\rightarrow 0_g^+$ transitions are predicted to be weak compared to those for the $2_\gamma^+\rightarrow 0_g^+$ transitions. For the deformed rare earths the IBA calculations quoted in Ref. [5] predict values for $B(E2,0_g^+\rightarrow 2_\beta^+)/B(E2,0_g^+\rightarrow 2_\gamma^+)$ between $\sim 4\times 10^{-3}$ and $\sim 3\times 10^{-2}$.

The empirical systematics of the $B(E2,0_g^+\rightarrow 2^+)$ values is shown in Fig. 2. Although the $B(E2,0_g^+\rightarrow 2_\beta^+)$ are indeed surprisingly small, in most cases they are not very small compared to the $B(E2,0_g^+\rightarrow 2_\gamma^+)$ as predicted by the IBA. We also note that the $B(E2,0_g^+\rightarrow 2_\gamma^+)$ vary smoothly, as expected for a collective excitation, whereas the $B(E2,0_g^+\rightarrow 2_\beta^+)$ show large fluctuations. This latter behavior is more typical for a quasiparticle structure of the levels rather than a collective structure.

We thus conclude, in agreement with Ref. [3] and in contrast to Ref. [4], that the energies and $B(E2{:}g\rightarrow\beta)$ values do not support the description of the 0_β^+ excitations as phonon excitations on the γ band. However, as emphasized in Refs. [2,4], the key criterion for the interpretation of the 0_β^+ excitations as phonons on the 2_γ^+ excitations is that they

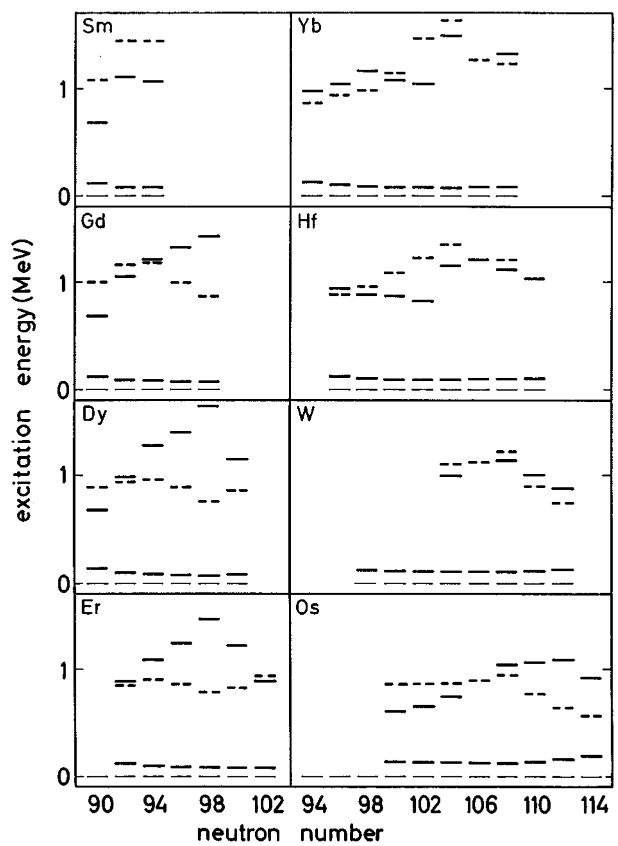

FIG. 1. Systematics of the excitation energies of the first-excited $K^\pi=0^+$ (solid lines) and 2^+ (dashed lines) excitations.

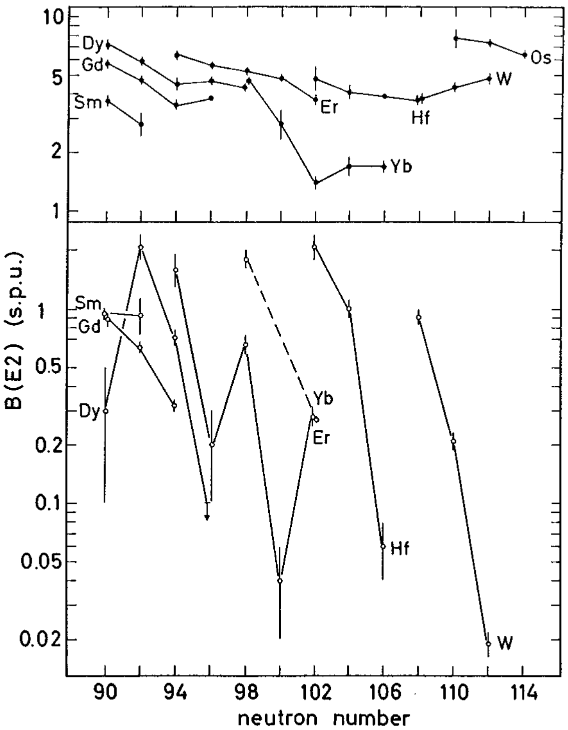

FIG. 2. Systematics of the $B(E2,0_g^+\rightarrow 2^+)$ values for deformed nuclei. The $B(E2)$ values to the 2_γ^+ (2_β^+) levels are shown in the upper (lower) part of the figure in single particle units (s.p.u.): $B_{\rm sp}(E2)=5B_w(E2)=(5/4\pi)(3/5)^2(0.12A^{1/3})^4\ e^2\,{\rm b}^2$.

decay by collective $E2$ transitions to the γ band.

(iii) The IBA predicts

$$B(E2,0_\beta^+\rightarrow 2_\gamma^+)\approx B(E2,0_g^+\rightarrow 2_\gamma^+).$$

Casten and von Brentano consider the ratio

$$R'=\frac{B(E2,0_\beta^+\rightarrow 2_\gamma^+)}{B(E2,0_\beta^+\rightarrow 2_g^+)}$$

as an indicator for collectivity of the $0_\beta^+\rightarrow 2_\gamma^+$ $E2$ transition. This ratio can be determined from the ratio of the intensities of the corresponding γ transitions. This latter ratio is, however, difficult to measure because the $0_\beta^+\rightarrow 2_\gamma^+$ γ ray is very weak due to its low energy as compared to the energy of the $0_\beta^+\rightarrow 2_g^+$ transition. In fact, with present-day techniques measurements seem only possible for the Gd, Dy, and Er nuclei around $N=98$, unless R' is very large. For two cases, ^{164}Er and ^{166}Er, the appropriate γ-ray intensities have been measured [6,7], yielding $R'=1.9(10)$ and 0.79(7), respectively. Assuming $B(E2,0_\beta^+\rightarrow 2_g^+)=B(E2,0_g^+\rightarrow 2_\beta^+)$ and using the experimental $B(E2,0_g^+\rightarrow 2_\beta^+)$ values from [8,9] one obtains $B(E2,0_\beta^+\rightarrow 2_\gamma^+)=0.4(3)$ s.p.u. and 0.52(7) s.p.u. for ^{164}Er and ^{166}Er, respectively. These values are not collective as already noted by Gill *et al.* [7]. However, these authors claim that the two Er nuclei show an anomalous behavior, whereas large R' values are found for several other Gd, Dy, and Er nuclei with an average of ~200.

The results for R' for all nuclei other than ^{164}Er and ^{166}Er referred to in Ref. [7] were derived from $E2$ branching ratios from higher-spin states [4]. The measured $B(E2)$ ratios are multiplied by the appropriate Clebsch-Gordan coefficients to derive the R' values. This approach seems at first appealing since one gains in the ratio of transition energies involved in the γ-ray intensity ratios. However, this advantage is more than offset by serious disadvantages.

(i) The factor gained by the E_γ^5 ratio is in most cases destroyed by the Clebsch-Gordan factor. Consequently, for all cases considered in Ref. [4] the γ ray assigned as the $\beta\rightarrow\gamma$ transition is very weak and, except for ^{158}Gd and ^{168}Er, both its energy and intensity have large uncertainties.

(ii) Due to the small Clebsch-Gordan coefficients the $B(E2{:}\beta\rightarrow\gamma)$'s for the higher-spin states are very small compared to $B(E2,0_\beta^+\rightarrow 2_\gamma^+)$ [for example, for the $4_\beta^+\rightarrow 2_\gamma^+$ $E2$ transitions which are involved in five of the eight R' reported in Ref. [4] one has $B(E2,4_\beta^+\rightarrow 2_\gamma^+)$ $=B(E2,0_\beta^+\rightarrow 2_\gamma^+)/126$] and therefore sensitive to small K admixtures to the levels involved. In particular, one has to expect a mutual mixing of the close-lying β and γ vibrational bands leading to rotational contributions to the $B(E2{:}\beta\rightarrow\gamma)$.

(iii) The higher-spin states are located between 1.4 and 1.6 MeV, where the level density is already high, and therefore the levels can be misassigned or have mixed K. That this is in fact the case is obvious from the $E2$ branching ratios observed for the $\beta\rightarrow g$ transitions, which deviate greatly in all cases considered in Ref. [4] from the theoretical ratios for pure $K=0$.

In the following we will discuss the cases presented in Ref. [4] individually.

^{158}Gd. The $R'=360(80)$ is derived from the γ-ray intensities of the $E2$ transitions depopulating the 1407 keV 4_β^+ level to the 2_γ^+ and 2_g^+ levels measured by Greenwood *et al.* [10]. In the procedure adopted in Ref. [4] any mixing of the levels involved is neglected. In this limit one has $B(E2,0_\beta^+\rightarrow 2_g^+)=B(E2,0_g^+\rightarrow 2_\beta^+)=0.0080(6)$ $e^2\,{\rm b}^2$ [11] and with the R' one obtains $B(E2,0_\beta^+\rightarrow 2_\gamma^+)=2.9(7)$ $e^2\,{\rm b}^2$. This value can be compared with the $B(E2,0_g^+\rightarrow 2_g^+)=4.99(3)$ $e^2\,{\rm b}^2$ and $B(E2,0_g^+\rightarrow 2_\gamma^+)$ $=0.088(4)$ $e^2\,{\rm b}^2$, which immediately suggests that it cannot be correct.

The problem in deriving this $B(E2,0_\beta^+\rightarrow 2_\gamma^+)$ value is clear: it is obtained by multiplying the small experimental $B(E2,4_\beta^+\rightarrow 2_\gamma^+)$ with the ratio of Clebsch-Gordan coefficients $1/\langle 4022|22\rangle^2=126$, ignoring any band mixings. However, as already discussed in detail by Greenwood *et al.* [10], the $B(E2,4_\beta^+\rightarrow 2_\gamma^+)$ can be entirely explained by the rotational transition induced by the mutual mixing of the close-lying β and γ bands. This can be seen from a simple estimate corresponding to the four-band mixing calculation reported in [10].

From the measured $B(E2,4_\beta^+\rightarrow 2_\gamma^+)/B(E2,4_\beta^+\rightarrow 2_g^+)$ $=9.3(14)$ and $B(E2,4_\beta^+\rightarrow 2_g^+)=0.0021(2)$ $e^2\,{\rm b}^2$ calculated from the experimental $B(E2,0_g^+\rightarrow 2_\beta^+)$ including a ~10% correction for the mixing of the ground and β bands, one obtains

$$B(E2,4_\beta^+\rightarrow 2_\gamma^+)=0.019(3)\ \ e^2\,{\rm b}^2.$$

The coupling of the β and γ bands treated in first-order perturbation theory, assuming equal Q_0 for the β and ground bands, yields [12]

$$B(E2,I_\beta \rightarrow I_\gamma) = 2\langle I_\beta 022|I_\gamma 2\rangle^2 |m_i + [I_\gamma(I_\gamma+1) - I_\beta(I_\beta+1) - 4]\sqrt{6}\varepsilon_2 m_r|^2, \quad (1)$$

where m_i and $m_r = \sqrt{B(E2,0_g^+ \rightarrow 2_g^+)}$ are the intrinsic and rotational $E2$-matrix elements and $\varepsilon_2 = \langle h_2\rangle/\Delta E$ is the spin-reduced amplitude describing the admixture of the two bands. If one now assumes that band mixing is the primary cause of the $I_\beta \rightarrow I_\gamma$ $E2$ transitions one obtains

$$B(E2,I_\beta \rightarrow I_\gamma = I_\beta + 2) = 12\,\frac{(I_\beta+3)(I_\beta+4)(2I_\beta+1)}{2I_\beta+3}\,\varepsilon_2^2 B(E2,0_g^+ \rightarrow 2_g^+), \quad (2)$$

and

$$B(E2,I_\beta \rightarrow I_\gamma = I_\beta - 2) = 12\,\frac{(I_\beta-3)(I_\beta-2)(2I_\beta+1)}{2I_\beta-1}\,\varepsilon_2^2 B(E2,0_g^+ \rightarrow 2_g^+). \quad (3)$$

From the $B(E2)$'s given above for ^{158}Gd and Eq. (3) one obtains then $|\varepsilon_2| = 1.1(1)\times 10^{-2}$, and with the experimental 4_β^+-4_γ^+ energy splitting of $\Delta E = 48$ keV an interaction-matrix element of $|\langle h_2\rangle| = 0.53(4)$ keV. As already emphasized by Greenwood *et al.*, this value is entirely reasonable and thus the observed $4_\beta^+ \rightarrow 2_\gamma^+$ $E2$ transition is almost certainly induced by the mutual mixing of the β and γ bands.

^{160}Gd. The R' given in Ref. [4] are derived from the decay of a 1537 keV level observed in the ^{160}Gd$(n,n'\gamma)$ reaction and assigned as the 4^+ member of the β band. The crucial transition is a 549 keV γ ray to the 2_γ^+ level with an intensity of 0.6(2), compared to a total intensity of $\sim$10 000 of the strongest line, the 75 keV $2_g^+ \rightarrow 0_g^+$ transition. We give two arguments why the R' derived from these data are questionable.

(1) If the assignment of the 4_β^+ level, and its γ depopulation, are correct, we obtain an average of $R' = 1100(500)$ after suitable correction of the two $\beta \rightarrow g$ transitions for the mutual β-g mixing. The 1537 keV level decays, in addition to the interband transitions to the ground and γ bands, by a 160 keV intraband transition to the 2_β^+ level, yielding $B(E2,4_\beta^+ \rightarrow 2_g^+)/B(E2,4_\beta^+ \rightarrow 2_\beta^+) = 9(3)\times 10^{-6}$. Assuming this ratio to be equal to $B(E2,0_g^+ \rightarrow 2_\beta^+)/B(E2,0_g^+ \rightarrow 2_g^+)$ one obtains, with $B(E2,0_g^+ \rightarrow 2_g^+) = 201$ s.p.u. and the above given R', values of $B(E2,0_g^+ \rightarrow 2_\beta^+) = 1.8(6)\times 10^{-3}$ s.p.u. and $B(E2,0_\beta^+ \rightarrow 2_\gamma^+) = 1.9(11)$ s.p.u. The $B(E2,0_g^+ \rightarrow 2_\beta^+)$ is very small but not totally unreasonable (see Fig. 2) and the $B(E2,0_\beta^+ \rightarrow 2_\gamma^+)$ is not really collective. Moreover, the $4_\beta^+ \rightarrow 2_\gamma^+$ transition, from which the latter $B(E2)$ is derived, can again, at least partly, be explained by the rotational transition induced by the β-γ mixing. Assuming $B(E2,4_\beta^+ \rightarrow 2_\beta^+) = \frac{2}{7}B(E2,0_g^+ \rightarrow 2_g^+)$ one obtains from the experimental γ-ray branchings $B(E2,4_\beta^+ \rightarrow 2_\gamma^+)/B(E2,0_g^+ \rightarrow 2_g^+) = 1.2(5)\times 10^{-4}$ and with Eq. (3) $|\varepsilon_2| = 2.0(8)\times 10^{-3}$. With the experimental 4_β^+-4_γ^+ energy splitting of 467 keV this yields $|\langle h_2\rangle| \approx 0.9$ keV, again a reasonable value.

(2) In the $(n,n'\gamma)$ work the 0_β^+ level is also reported at 1325.7 keV and for its 1250.4 keV decay to the 2_g^+ level a γ-ray intensity of 13 is given. The 337.2 keV $0_\beta^+ \rightarrow 2_\gamma^+$ transition is not reported and unless it is masked by a strong background line its intensity, estimated from neighboring lines, must be $\leqslant 1$, yielding $R' \leqslant 60$.

^{160}Dy. This case will be treated below, where we obtain a value of $R' \leqslant 25$ from a direct measurement of the γ-ray branchings from the 0_β^+ level.

^{162}Dy. The $R' = 120(20)$ given in Ref. [4] was derived from the (n,γ) data reported recently by Berzins *et al.* [13]. From the level energies quoted there one obtains energies of 392.48(1) and 1187.80(1) keV for the $2_\beta^+ \rightarrow 4_\gamma^+$ and $2_\beta^+ \rightarrow 4_g^+$ transitions, respectively. The γ rays observed in the (n,γ) measurements and associated with these transitions have energies of 392.76(10) and 1188.3(1) keV and intensities of 3.4(3) and 17(2), respectively. The γ-ray intensities can be compared with the total intensity of the strongest transition, the 80.7 keV $2_g^+ \rightarrow 0_g^+$ transition, of 1750. Thus, if the errors quoted in [13] are correct, the assignments of the γ rays to the transitions from the 2_β^+ level are at least doubtful.

Even if we assume the assignments to be correct, the observed $B(E2,2_\beta^+ \rightarrow 4_\gamma^+)$ can probably again be explained by the mutual β-γ mixing. If one neglects the β-g mixing [the experimental-to-theoretical ratio $B(E2,2_\beta^+ \rightarrow 4_g^+)/B(E2,2_\beta^+ \rightarrow 0_g^+) = 33(20)/2.57$ might indicate an appreciable mixing] one obtains from the experimental ratio $B(E2,2_\beta^+ \rightarrow 4_\gamma^+)/B(E2,2_\beta^+ \rightarrow 4_g^+) = 51(7)$ and the limit on $B(E2,0_g^+ \rightarrow 2_\beta^+)$ given in Ref. [11] an estimate of $|\langle h_2\rangle| \leqslant 4$ keV.

We also mention here that Berzins *et al.* [13] report the γ-ray branching from the 0_β^+ level to the 2_γ^+ and 2_g^+ levels (with the γ-ray intensity of the $0_\beta^+ \rightarrow 2_\gamma^+$ transition quoted as ''H. G. Börner, R. F. Casten, W. Gelletly, and D. D. Warner, private communication'') yielding $R' = 12$.

^{168}Er. The β band is established in this nucleus up to the 6^+ level [14]. The 4^+ and 6^+ members of this band decay by intraband $I_\beta \rightarrow I_\beta - 2$ transitions as well as by interband transitions to the ground and γ bands. This enables a complete analysis of the $B(E2:\beta \rightarrow \gamma)$ values as previously discussed by Warner, Casten, and Davidson [15]. Casten and von Brentano [4] consider only the R' values derived from the $I \rightarrow I' = I - 2$ transitions assuming the validity of the Alaga rules. Absolute $B(E2:\beta \rightarrow \gamma)$ values can be derived from the γ-ray branching ratios by assuming rotational $B(E2)$'s for the $I_\beta \rightarrow I_\beta - 2$ transitions with $Q_{0,\beta} = Q_{0,g}$. These values are compared in Table I with different model calculations. As is apparent from columns 3 to 5 the predictions of the Alaga rule and the IBA (taken from Ref. [15]) do not reproduce the experimental data. On the other hand, the $B(E2)$ values calculated with the generalized intensity relation [Eq. (1)] with $m_i = 0.60(4)$ (s.p.u.)$^{1/2}$ and $\varepsilon_2 m_r = -0.0109(13)$ (s.p.u.)$^{1/2}$ are in excellent agreement with the data. This yields $B(E2,0_\beta^+ \rightarrow 2_\gamma^+) = 2[m_i + 2\sqrt{6}\varepsilon_2 m_r]^2 = 0.60(9)$ s.p.u. and—with $m_r = 14.8$ (s.p.u.)$^{1/2}$ and $\Delta E_{\beta\gamma} = 385$ keV—an interaction-matrix element of $\langle h_2\rangle = -0.29(4)$ keV. The latter value is close to that given above for ^{158}Gd and the $B(E2)$ value agrees with those observed in the neighboring nuclei ^{164}Er and ^{166}Er.

It is thus clear that the R' values derived from the higher-spin levels discussed in Ref. [4] are not reliable. It is indis-

TABLE I. Comparison of experimental and theoretical $B(E2)$ values for the $\beta\rightarrow\gamma$ transitions in ^{168}Er.

		$B(E2,I_\beta\rightarrow I_\gamma)$ (s.p.u.)			
I_β^π	I_γ^π	Expt.[a]	Alaga[b]	IBA[c]	BM[d]
4^+	2^+	0.017(3)	0.021	0.025	0.019
	3^+	0.21(3)	0.30	0.39	0.19
	4^+	0.32(7)	0.95	1.3	0.35
	5^+	0.13(5)	1.05	1.7	0.15
6^+	4^+	0.069(9)	0.057	0.061	0.071
	5^+	0.23(14)	0.42	0.49	0.33
	6^+	0.61(22)	0.98	1.3	0.36

[a]From Ref. [14] with $E2$ contents of 67(22)%, 75(15)%, 100%, 47(16)%, and 50(30)% for the $4_\beta^+\rightarrow5_\gamma^+$, $4_\beta^+\rightarrow4_\gamma^+$, $4_\beta^+\rightarrow3_\gamma^+$, $6_\beta^+\rightarrow6_\gamma^+$, and $6_\beta^+\rightarrow5_\gamma^+$ transitions, respectively.
[b]$B(E2,I_\beta\rightarrow I_\gamma)=2\langle I_\beta 022|I_\gamma 2\rangle^2 m_i^2$ with $m_i^2=1.35$ s.p.u. from the $I_\beta\rightarrow I_\gamma=I_\beta-2$ transitions.
[c]From Table VI of Ref. [15].
[d]Equation (1) with $m_i=0.60$ (s.p.u.)$^{1/2}$ and $\varepsilon_2 m_r=-0.011$ (s.p.u.)$^{1/2}$.

pensable to measure the $E2$ branchings from the 0_β^+ levels directly unless detailed $E2$ branching ratios are known, as in ^{168}Er. For the $0_\beta^+\rightarrow2_\gamma^+$ $E2$ transitions the influence of the β-γ mixing can be expected to be small, as can be seen, for example, for ^{166}Er: the experimental $B(E2)$ quoted above yields

$$|m_i+2\sqrt{6}\varepsilon_2 m_r|=\sqrt{B(E2,0_\beta^+\rightarrow2_\gamma^+)/2}=8.4(6)\times10^{-2}\ e\ \text{b},$$

compared to $2\sqrt{6}|\varepsilon_2|m_r\approx8\times10^{-3}$ e b obtained with $|\langle h_2\rangle|\approx0.5$ keV.

A survey of the possible candidates for direct measurements of the $0_\beta^+\rightarrow2_\gamma^+$ γ branches revealed that ^{160}Dy is the only nucleus for which this is possible with the experimental techniques available to us. The 0_β^+ level is firmly known in this nucleus at 1280 keV: The 0^+ and 2^+ members of the 0_β^+ band (and possibly also the 4^+ member) are weakly populated in the β^+ decay of the 2^- isomer of ^{160}Ho, which in turn is populated by electron capture (EC) decay of ^{160}Er with a half-life of 29 h [16–18]. The 0^+ level is identified by its 1279.6(3) keV $E0$ decay to the ground state and its 1193.2(2) keV γ decay to the 2_g^+ state. The observed value of $B(E0,0_\beta^+\rightarrow0_g^+)/B(E2,0_\beta^+\rightarrow2_g^+)$ supports these assignments. The 0^+ assignment to the 1280 keV level is strongly supported by a measurement of the ^{162}Dy(p,t) reaction where a first-excited 0^+ level is found at $E_{\rm exc}=1275(5)$ keV [19]. Finally, the 2_β^+ level is observed in Coulomb excitation with $B(E2,0_g^+\rightarrow2_\beta^+)=0.71(6)$ s.p.u. [11].

In the present work we have made an attempt to observe the 313.6 keV γ ray from the $0_\beta^+\rightarrow2_\gamma^+$ transition. The ^{160}Er radioactivity was produced by an irradiation of natural dysprosium metal with 60 MeV α particles. A mass-separated source was prepared by the Bonn isotope separator. Singles γ-ray spectra were measured with a Compton-suppressed Ge detector. A γ-ray spectrum in the region of interest is shown in Fig. 3, where the position of the expected 313.6 keV γ ray is indicated by an arrow. The results for the γ rays of interest, and some neighboring γ rays, are given in Table II. From these data one obtains $R'\leqslant25$, as compared to the value of $R'=300(150)$ derived in Ref. [4] from the $(4_\beta^+\rightarrow2_\gamma^+)/(4_\beta^+\rightarrow6_g^+)$ γ-ray intensity ratio. As is evident from Fig. 3 an observation of the 313.6 keV γ ray is hardly possible if $R'\approx1$, as we expect it to be.

In summary, the $4_\beta^+\rightarrow2_\gamma^+$ transition in ^{158}Gd can be explained as rotational transition induced by the coupling of the β and γ bands. The $E2$ branching ratios from the 4_β^+ and 6_β^+ levels in ^{168}Er are consistent with a noncollective

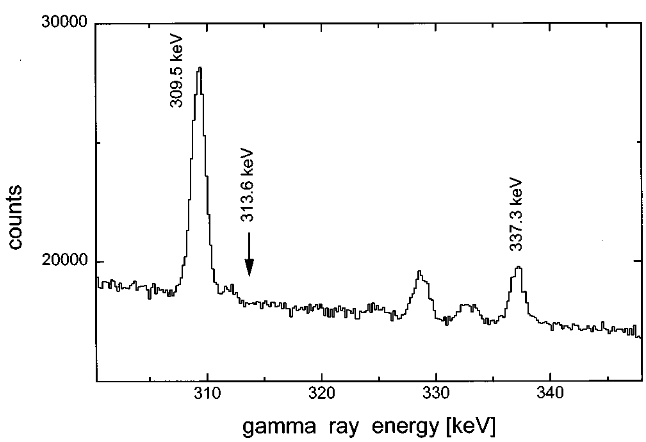

FIG. 3. γ-ray spectrum observed in the decay of 29 h ^{160}Er. The energy resolution in the region shown in the figure was full width at half maximum (FWHM) ~1.4 keV.

TABLE II. γ-ray intensities of selected transitions in ^{160}Dy observed in the decay of ^{160}Ho.

Alexandrov *et al.* [16]		Present work	
E_γ (keV)	I_γ	E_γ (keV)	I_γ
309.57(3)	22(3)	309.45(5)	21(1)
		313.6	$\leqslant0.45$
337.30(4)	7(3)	337.30(5)	5.5(3)
363.9(1)	10(3)	363.57(5)	8.2(4)
1193.2(2)	13(2)	1193.0 (1)	15.2(8)

$B(E2,0^+_\beta \to 2^+_\gamma)$ close to that observed in the neighboring ^{164}Er and ^{166}Er nuclei. The $\beta \to \gamma$ $E2$ transitions in ^{160}Gd and ^{162}Dy are less reliable due to experimental difficulties and inconsistencies and the $B(E2)$ ratios R' extracted in Ref. [4] are questionable due to the neglect of band mixings. Finally, for ^{160}Dy we obtain an upper limit of $R' \leqslant 25$, and the published experimental data indicate $R' \leqslant 60$ and ≈ 12 for ^{160}Gd and ^{162}Dy, respectively, all in complete disagreement with the values suggested by Casten and von Brentano [4]. We therefore conclude that the answer to the question raised in the title of our work is ‘‘no.’’

One of the authors (C.G.) is grateful to P. von Brentano for helpful discussions and for making available his work prior to its publication. We appreciate the help of K. Assmus with the α-particle irradiation and the financial support by the Kernforschungszentrum Karlsruhe. This work was financially supported by the Deutsche Forschungsgemeinschaft.

[1] R. F. Casten and P. von Brentano, Phys. Rev. C **50**, R1280 (1994).
[2] K. Kumar, Phys. Rev. C **51**, 3524 (1995).
[3] D. G. Burke and P. C. Sood, Phys. Rev. C **51**, 3525 (1995).
[4] R. F. Casten and P. von Brentano, Phys. Rev. C **51**, 3528 (1995).
[5] R. F. Casten, P. von Brentano, and N. V. Zamfir, Phys. Rev. C **49**, 1940 (1994).
[6] E. N. Shurshikov and N. V. Timofeeva, Nucl. Data Sheets **65**, 365 (1992); **67**, 45 (1992).
[7] R. L. Gill, C. Barton, R. F. Casten, and N. V. Zamfir, Phys. Rev. C **51**, 2801 (1995).
[8] R. M. Ronningen *et al.*, Phys. Rev. C **26**, 97 (1982).
[9] F. K. McGowan, W. T. Milner, R. L. Robinson, P. H. Stelson, and Z. W. Grabowski, Nucl. Phys. **A297**, 51 (1978).
[10] R. C. Greenwood *et al.*, Nucl. Phys. **A304**, 327 (1978).
[11] F. K. McGowan and W. T. Milner, Phys. Rev. C **23**, 1926 (1981).
[12] A. Bohr and B. R. Mottelson, *Nuclear Structure* (Benjamin, Reading, MA, 1975), Vol. II.
[13] J. Berzins *et al.*, Nucl. Phys. **A584**, 413 (1995).
[14] V. S. Shirley, Nucl. Data Sheets **71**, 261 (1994).
[15] D. D. Warner, R. F. Casten, and W. F. Davidson, Phys. Rev. C **24**, 1713 (1981).
[16] A. A. Aleksandrov, V. S. Buttsev, Ts. Vylov, E. P. Grigor’ev, K. Ya. Gromov, V. G. Kalinnikov, and N. A. Lebedev, Bull. Acad. Sci. USSR Phys. Ser. **38**, 71 (1974).
[17] E. P. Grigor’ev and T. R. Dadamukhamedov, Bull. Acad. Sci. USSR Phys. Ser. **51**, 68 (1987).
[18] C. W. Reich, Nucl. Data Sheets **68**, 405 (1993).
[19] J. V. Maher, J. J. Kolata, and R. W. Miller, Phys. Rev. C **6**, 358 (1972).