Comment on "New interpretation of the lowest $K=0$ collective excitations of deformed nuclei as a phonon excitation of the γ band"

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It is pointed out that the interpretation offered by the authors is not new. Essentially the same interpretation was published previously. Also, their statement concerning the lack of success of previous theories is questioned.

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Recently, Casten and von Brentano [1] have claimed that the structure of the lowest $K=0$ excitations of deformed nuclei has always been an enigma, that its properties have never been described as successfully as those of the γ vibration. Furthermore, the title of their paper, as well as the concluding statements, suggests that they have found a new interpretation for many such states which decay largely to the γ band.

The purpose of this Comment is to point out that although Casten and von Brentano are correct in asserting that there is a general misunderstanding of the nature of the first excited $K=0$ collective band, that such a band is not always the β-vibrational band, they are incorrect in suggesting that (1) their interpretation of many such bands as $K=0$ two-phonon (possibly $\gamma\gamma$) bands is new, and (2) previous theories have not been able to describe such bands successfully.

One of the references quoted by the authors is a 1983 paper [2] where it was pointed out that (Ref. [2], p. 269) "The excited $K = 0$ band should be called a $\gamma\gamma$-band and not a β-band if it decays mainly to the γ-band. If this is done then most of the mystery concerning the decays of the β bands [discussed by Warner, Casten, and Davidson [3]] disappears."

A very general argument for the lowering of the $\gamma\gamma$ band below the β band was also presented there (Ref. [2], p. 269): "As pointed out previously [4], a large deformation energy is not sufficient for obtaining a rotational nucleus obeying the $I(I+1)$ law and the Alaga Rules. Such a nucleus must have a substantial prolate-oblate difference. Consequently, the barrier against γ-vibrations (usually the oblate saddle point relative to the prolate minimum) *must be* much lower than the (spherical) barrier against β-vibrations."

It was proposed on the same page of the same reference, "In order to avoid the kind of confusion mentioned above, it is hereby proposed that all $K^{\Pi} = 0^+$ - bands decaying largely to the $K^{\Pi} = 2^+$ (γ) - bands be henceforth called $\gamma\gamma$-bands, rather than β-bands."

Moreover, the same reference gives several figures comparing theoretical [dynamic deformation model (DDM), a large-configuration-space microscopic model with no inert core, and one set of global parameters for all nuclei from ^{12}C to ^{240}Pu] and experimental spectra, where such bands are clearly labeled $\gamma\gamma$ bands. There is also ample comparison and agreement to conclude that such bands are described in the dynamic deformation model as well as the γ bands.

If the new idea, proposed by Casten and von Brentano, is that such bands might not always be $\gamma\gamma$ bands, but some other phonon excited on top of the γ band, then it is not clear to the present author what is the nature of such a phonon. If the phonon is built out of a few quasiparticle excitations (which are not already included in the γ phonon), then why should it give a collective (relatively large) $B(E2)$ value? Moreover, why should it obey the phonon-selection rules concerning large $n = 2$ to $n = 1$ transitions and forbidden $n = 2$ to $n = 0$ transitions?

Even in the interacting-boson approximation (IBA), the model employed by Casten and von Brentano, there is no other plausible candidate for the "phonon." After discussing the possibility of an *independent* $K=2$ excitation superimposed on the γ band, the authors concluded, "What is clear at the moment is that, in the IBA, which in all other respects accounts for the energetic and decay properties of the lowest $K=0$ band, there is at least *no other* plausible candidate for a $\gamma\gamma K=0$ excitation since no other $K=0$ band decays to the γ band. Further experimental study of this is necessary and encouraged with particular emphasis on searches for other empirical candidates for $K=0$ $\gamma\gamma$ vibrations."

In conclusion, both the DDM (a microscopic version of the collective model of Bohr and Mottelson) and the IBA lead to a new interpretation of the first excited $K=0+$ bands, which decay largely to the first excited $K=2+$ bands, as $K=0$ $\gamma\gamma$ bands rather than β-vibrational bands.

[1] R. F. Casten and P. von Brentano, Phys. Rev. C **50**, R1280 (1994).
[2] K. Kumar, in *Progress in Particle and Nuclear Physics*, edited by D. Wilkinson (Pergamon, New York, 1983), Vol. 9, p. 233.
[3] D. D. Warner, R. F. Casten, and W. F. Davidson, Phys. Rev. C **24**, 1713 (1981).
[4] K. Kumar, Phys. Rev. C **1**, 369 (1970).

