Comment on "Novel Decay Modes of High-K Isomers: Tunneling in a Triaxial Landscape"

Crowell *et al.* [1] report discovery of a high-spin isomer in ^{176}W with a "...unique character...where the intermediate-K states are bypassed in favor of larger K violations." While this is a valuable contribution to the debate concerning anomalous K-isomer decays, and the question of the relative importance of "K-mixing" and "tunneling" interpretations, some pertinent issues have been neglected. Principally these revolve around an archetypal experimental example in which sufficiently detailed results were obtained [2] to reveal crucial factors controlling such decay modes.

The prior example of the apparent bypassing of intermediate-K states in the decay process belongs to the long-standing case of a $K^\pi=35/2^-$ isomer in ^{179}W, first identified by Bernthal *et al.* [3]. There, a five-quasiparticle isomer appeared to decay directly to a one-quasiparticle rotational band, bypassing the observed three-quasiparticle states. Recent definitive studies [2] showed that the five-quasiparticle isomer decays into the backbending region of the "one-quasiparticle" band. Remarkably, the crossing band which causes the backbend was shown to have a high K value (inferred from both the high band-head spin, $I=23/2$, and analysis of the destructive-interference effects in the γ-ray branching ratios) even though the main intensity flow gives the appearance of a normal s-band crossing. The full details of this work have recently been published [4].

The quasiparticle structure of this new kind of "high-K" crossing band contains two Fermi-aligned $i_{13/2}$ neutrons coupled to $K\approx\Omega_1+\Omega_2$ [2], which, for the Fermi level in midshell corresponds to $\Omega_{1,2}=7/2,9/2$, as opposed to the usual s band with $K\approx|\Omega_1-\Omega_2|$. Fermi alignment of the $i_{13/2}$ neutrons allows both K and the alignment, i, to have well defined average values [5].

The detailed observations and analyses of the effects of the crossing with a high-K band in ^{179}W led therefore to a natural understanding of what had been interpreted previously as an "anomalous" isomer decay [2]. Since related effects could be expected in regional nuclei with comparable neutron Fermi levels, the implications go beyond ^{179}W and should be considered in interpreting other anomalous decays, such as those in ^{182}Os [6] and ^{174}Hf [7], and indeed the decay of the ^{176}W isomer identified by Crowell *et al.* [1]. (That other backbending in the $A=180$ region might also in fact involve high-K bands, contrary to the normal interpretation, was reinforced by the recent results for ^{180}W [8].) Although Crowell *et al.* do not address these implications, they do refer to a related theoretical development of the cranking model, namely "tilted cranking" [9], in which the high-K crossing band (and specifically the exemplar in ^{179}W) is called a "t band" [10].

In this light, we reconsider the ^{176}W, $K^\pi=14^+$ isomer decay. The strongest γ-ray transition from that isomer is a 33%, 714 keV ($M1$) transition to an $I^\pi=14^+$ state, assumed to have $K\approx0$ [1]. Given the ^{179}W results [2] (supported by the more recent ^{180}W data [8]) the strongly populated $I^\pi=14^+$ level could well be a t-band member, which would have $K\approx8$. In this case, the hindrance per degree of K forbiddenness would be $f_\nu\approx20$, which is not an unusual value. A mixing matrix element of 60 keV, between this level and the yrast $I^\pi=14^+$ state would then account for the 6% intensity of the 945 keV transition to the latter. The statement in Ref. [1] that the upper limit on the interaction is 33 keV, based on the 66 keV separation between the two closest $I^\pi=16^+$ states, is not valid if there are more than two 16^+ states, a likely situation considering the known bands and the number of close-lying 12^+ and 14^+ levels.

Further experimental information, beyond that presented by Crowell *et al.* [1], is needed to establish whether or not t-band states *are* involved in the ^{176}W isomer decay, and it is beyond the scope of the present Comment to explore multiband mixing in detail. It appears nevertheless that the main features of the ^{176}W, $K^\pi=14^+$ isomer decay could be accounted for with "normal" band mixing, providing the possibility of a high-K crossing band (t band) is included. Due consideration of that possibility would have to be given before it could be concluded that the tunneling degree of freedom leads to an improved understanding of the physical processes involved in "anomalous" high-K isomer decays, the claim made in Ref. [1].

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