Comment on "Spin Alignment in Superdeformed Hg Nuclei"

Recently, Stephens *et al.*[1,2] concluded that mass-190 superdeformed nuclei exhibit nonzero quantized spin alignment. We suspect that current data do not sustain this conclusion.

The suggested alignment comes from the I vs ω plot. For example, the two lines in Fig. 1 representing ^{192}Hg and ^{194}Hg* (excited bands $b2$ and $b3$), respectively, differ by $1\hbar$ over a wide range of ω, which the authors interpret as a nonzero quantized alignment ($i \approx 1$) in ^{194}Hg* relative to ^{192}Hg. A similar situation exists for other $A \sim 190$ nuclei. However, this conclusion relies on the assignment of unknown spins which are uncertain by at least $\pm 2\hbar$. If spin assignments are shifted down by one unit (two units for Tl) compared to those in Refs. 1 and 2, all I vs ω plots (including ^{194}Hg*) coalesce and coincide with the solid line (^{192}Hg) as shown by the symbols in Fig. 1, implying essentially no alignment. Therefore, evidence for the putative quantized alignment requires knowledge of spins.

An attempt to find a spin-independent test of quantized alignment has been made.[2] The authors defined an incremental alignment Δi, depending only on γ-ray energies E_γ, and related to the total alignment i through $i = \Delta I + \Delta i$, where ΔI is the spin difference between states in a band and those of the reference band (^{192}Hg). The value of i is unknown, but ΔI is quantized; if Δi is quantized, i must be quantized. The data do show that Δi is quantized. However, notice that if $i = 0$, then $\Delta i = -\Delta I$ is also *quantized,* so the empirically quantized Δi is not proof of a nonzero quantized alignment. The value of i depends on ΔI, so a test of nonzero quantized alignment remains dependent on spins.

The authors used the Harris expansion to determine spin for the current situation in which only the E_γ are known. They first fitted the moment of inertia by $\mathcal{J}^{(2)}(\omega) = 2\alpha + 4\beta\omega^2 + 6\gamma\omega^4$, and then by integration obtain $\sqrt{I(I+1)} = 2\alpha\omega + \frac{4}{3}\beta\omega^3 + \frac{6}{5}\gamma\omega^5$. Unfortunately, such a procedure contains uncertainties. The parameters in the expansion are fitted to the data, which only exist for a certain range from ω_{ext} ($\neq 0$) to ω_2, where ω_{ext} is the exit-spin frequency, so the expansion is well defined only for this region. However, to determine I_{ext}(exit spin) the integration range is from 0 to ω_{ext},

$$I_{\text{ext}} = \int_0^{\omega_{\text{ext}}} \mathcal{J}^{(2)}(\omega)\, d\omega + I_0 \,,$$

which demands knowledge of both $\mathcal{J}^{(2)}(\omega)$ in the unknown region and the unknown initial spin I_0. The expansion determined from ω_{ext} to ω_2 is irrelevant to the determination of the exit spin, unless one assumes that $I_0 = 0$ and that $\mathcal{J}^{(2)}(\omega)$ behaves the same in different frequency ranges; but there is no justification for this assumption. For example, data in the mass-130 region indicate a significant increase of $\mathcal{J}^{(2)}(\omega)$ at low frequency.[3] There is no empirical reason to believe that this or other low-frequency effects cannot occur in the mass-190 region. Hence, I_{ext} determined in this way has an uncertainty which cannot reliably be estimated.

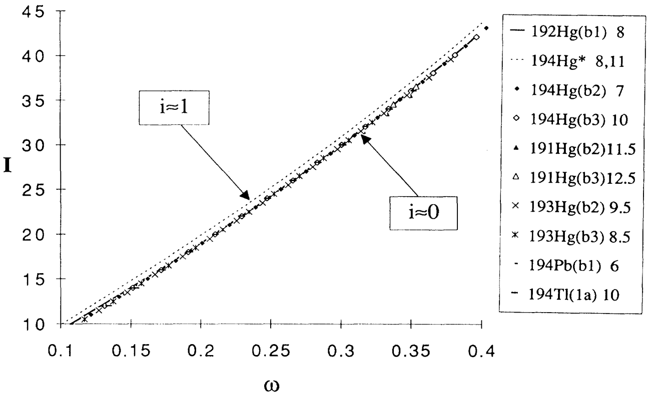

FIG. 1. Spin alignment in $A \sim 190$ superdeformed bands. The dotted line is an example (^{194}Hg*) to show $1\hbar$ alignment ($i \approx 1$) if the exit spins are assigned according to Ref. 1; the solid line is the reference (^{192}Hg). The alignment vanishes ($i \approx 0$) as shown by symbols, which coincide with the solid line, if the exit spins are shifted down by $1\hbar$ ($2\hbar$ for Tl) compared to those in Refs. 1 and 2. The exit-spin assignments are shown on the right-hand side of the legend for each case.

In addition, *even if* $I_0 = 0$ and the expansion were valid for the entire range of ω, our exhaustive calculations[4] indicate that in changing spin by 1 or 2 units the fitting rms error does not change much $[(0.14\text{–}2.6)\hbar^2/\text{MeV}^{-1}]$. The spin assignments leading to no alignment appear to be at least as plausible as those suggesting nonzero quantized alignment. Of course, $i \approx 0$ is also nontrivial; however, separately we discuss a new theory[4] of superdeformation for which this remarkable behavior is expected on quite general grounds.

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[4] C.-L. Wu *et al.* (to be published).