Influence of band interaction on superdeformed rotational bands

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Introduction

With the first discovery of high spin superdeformed (SD) band in ^{152}Dy [1], more than 250 SD bands have been observed in A ~190, 150, 130, 80 mass regions. Except for a few SD bands, the spins of most of them have not been established experimentally. In the past few years, several approaches to predict the spins of SD bands have been developed [2-5]. The spins of SD bands were predicted by the least square fitting of calculated transition energies [3] with the experimental results, which is usually referred to as the best fit methods (BFM). Liu and Zeng [5] proposed the spins of SD bands by using band moment of inertia systematic, J_0. It was noted that in BFM, the root mean square deviation (rms) of the calculated results from experiment, depends on the number of transitions involved in the least square fitting, and in some cases it is difficult to make a unique and reliable spin prediction. More careful analysis shows that the difficulty is intimately connected with the occurrence of band mixing. The majority of SD bands observed in A=190 region display a smooth rise in moment of inertia as a function of rotational frequency and no significant band mixing is found. So, the spins of most SD bands in A ~ 190 region could be predicted uniquely and reliably [5]. However, in the A ~ 150 region, the variation of moment of inertia with angular momentum displays a rather complicated and irregular behavior, which seems to be an indication of frequently occurring band mixing. As a result, the spin prediction in A ~ 150 mass region is not so reliable as it is in the 190 mass region. Another important reason is that, unlike the SD bands in A~190 region, the spins of the lowest levels observed in the SD bands in the A~150 region are usually rather high, which makes a unique spin prediction very difficult.

Influence of band interaction

If in an SD nuclide, if the energy levels of two SD bands having the same parity and signature are close to each other, i.e., $E_1(I) \approx E_2(I)$ for $I \approx I_c$, a mixing may be expected. If the interaction between two bands is neglected, the two SD bands can approximately be considered as perfect rotational bands. When the interaction W between the two SD bands is taken into account, the bands may be described by the well known two band mixing formula,

$$E_{\pm} = \frac{1}{2}\left[(E_1(I)+E_2(I) \pm \sqrt{(E_1(I)-E_2(I))^2+4W^2}\,\right]$$

The γ-transition energies can be classified into two classes; those falling in the 'band crossing' variety (weak interaction) and those falling in the 'band mixing' (strong interaction) variety. For band crossing case, the γ transitions follow the level sequence

$\ldots \rightarrow E_+ (I_c+4) \rightarrow E_+ (I_c+2) \rightarrow E_+ (I_c) \rightarrow E_+ (I_c-2) \rightarrow E_+ (I_c-4) \rightarrow \ldots$

and for the band mixing case they follow the level sequence,

$\ldots \rightarrow E_+ (I_c+4) \rightarrow E_+ (I_c+2) \rightarrow E_+ (I_c) \rightarrow E_- (I_c-2) \rightarrow E_- (I_c-4) \rightarrow \ldots$

a. A=190 mass region

The excited SD band ^{192}Hg(2) serves as an example for the band crossing [see Fig 1]. A significant band crossing occurs in the upper part of this band. It can be seen that the $J^{(2)}$ pattern in the band –crossing region of this band is of V type or inverted–V type. For this SD band, a reliable spin prediction can be made from the observed lower seven transitions by BFM approach. However, due to this band crossing it is difficult to make a unique spin prediction.

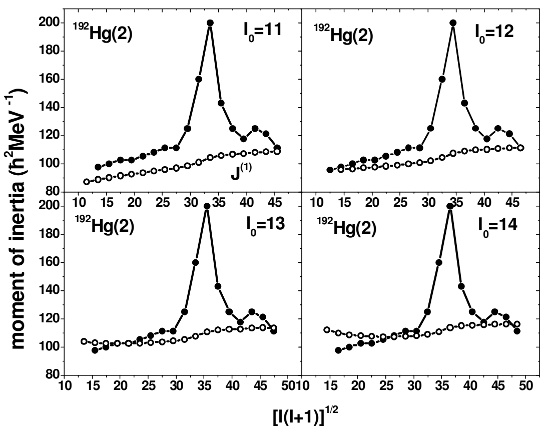

Fig. 1: The kinematic and dynamic moment of inertia, $J^{(1)}$ (open circles) and $J^{(2)}$ (full circles), for excited SD band ^{192}Hg(2) [7,8].

b. A=150 mass region

Unlike the situation in A=190 mass region, band mixing has often been observed between two SD bands in A=150 mass region [7]. Figure 2 gives the typical $J^{(2)}$ patterns for the band mixing between SD bands in A = 150 mass region ^{150}Gd plots. It is observed that the $J^{(2)}$ pattern in the band mixing region of perturbed bands is of W or inverse-W type but $J^{(2)}$ remains generally unperturbed outside the band mixing region. It seems that this kind of band mixing occurs rather generally and frequently in the A=150 region, which makes a unique spin prediction difficult.

c. 130 mass region

Like A~150 mass region, SD bands in A=130 mass region also shows a band mixing as well as band crossing; we have not shown the plots of dynamic moment of inertia for the bands

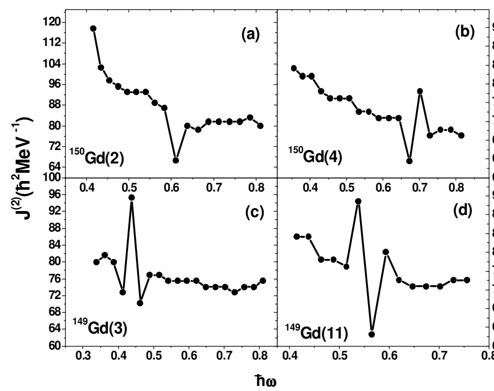

Fig. 2: Some examples of experimental $J^{(2)}$ patterns [7,8] for the band mixing between two SD bands observed in the A~150 region.

in this mass region. It turns out to be very difficult to propose reliable spins for SD

Summary

The influence of band interaction on SD bands is investigated in detail. There exist two types of $J^{(2)}$ patterns; i.e. for the band crossing case, the $J^{(2)}$ pattern is of V or inverse-V type and for band mixing case $J^{(2)}$ patterns is of W or inverse-W type. We will present results based on an analysis of the band-mixing of two bands for such bands.

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References

[1] P. J. Twin et al., Phys. Rev. Lett. 57, 811 (1986).
[2] J A Becker et al., Phys Rev C 46, 889 (1992).
[3] J Y Zeng et al., Phys. Rev. C 44, 745 (1991)
[4] I Ragnarsson Nucl. Phys. A 557, 167 (1993).
[5] S X Liu and J Y Zeng Phys. Rev. C. 58, 3266 (1998).
[6] S X Liu, X B Xin, Y A Lei and J y Zeng J: Phys.G: Nucl.Part.Phys. 26, 79(2000).
[7] Balraj Singh et al., Nuclear Data Sheets 97, 241 (2002).
[8] www.nndc.bnl.gov/ensdf.