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SUPERDEFORMED NUCLEI PRODUCED IN αxn CHANNEL IN THE $A \simeq 150$ MASS REGION *

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The aim of this work is to get more information about the population mechanism of superdeformed (SD) bands in the $A \simeq 150$ mass region. Usually, SD bands were populated in heavy-ion induced fusion reactions and most of them have been seen in xn exit channels. With the new generation of gamma-ray arrays, we are able to see SD structures populated in charged particle channels. Four experiments have been performed at the Vivitron accelerator in Strasbourg using the EUROGAM II spectrometer to study these phenomena (especially in α-particle channels).

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1. Introduction

Since the discovery of superdeformed (SD) bands [1], a large number of experiments has been performed to learn about SD properties. The advent of the new generation of large gamma detector arrays opened a possibility for even more detailed studies of highly deformed structures. One of the new challenges on this field is to observe hyperdeformed (HD) states which are predicted to become yrast at spins above 80 $\hbar$ in the A $\simeq$ 150 mass region [2]. Recently, a possibility to populate HD bands in charged particles channels of heavy-ion fusion reactions has been suggested [3, 4]. However there is no clear experimental evidence indicating whether charged particle emission plays an important role in population of these HD structures. This problem

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could be sorted out by studying the influence of charged particles emission on the population of SD bands.

In this work, we investigate the population of SD bands after emission of an alpha particle. This process has been observed for the first time, in the $A \simeq 190$ mass region [5], where the SD band in ^{192}Hg was populated in the ^{184}W(^{16}O,α4n)^{192}Hg reaction. Both, the intensity and the feeding pattern have been found to be similar to those previously measured in the ^{160}Gd(^{36}S,4n)^{192}Hg reaction.

2. Experiments

Four experiments have been performed with the EUROGAM phase II array in order to study the possibility to populate very high spins in the αxn channel around the mass of $A = 150$. In two of these experiments, the ^{152}Dy nucleus was produced in αxn and xn channels by using the ^{123}Sb(^{37}Cl,α4n)^{152}Dy (i) and the ^{124}Sn(^{34}S,6n)^{152}Dy (ii) reactions, respectively. Similarly, the ^{149}Gd nucleus was formed in two reactions: ^{124}Sn(^{34}S,α5n)^{149}Gd (iii) and ^{124}Sn(^{30}Si,5n)^{149}Gd (iiii). Previous studies [6,7] have shown that optimal conditions to populate SD bands are satisfied by reactions (ii) and (iiii).

3. Analysis

The SD band intensities observed in the α-particle channel are very weak. Therefore, a multifold analysis is needed to estimate the absolute intensity of bands ($I^{\rm abs}_{\rm band}$) with a good accuracy. We can compare the intensity of bands using an indirect method. In order to get full statistics, a spectrum is extracted by setting gates on all transitions of the bands except those contaminated by the intense yrast lines of normal deformed structures and by requiring at least three gates fired. A procedure how to store the events is describe in Ref. [8]. The population ratio R is defined as the intensity of a γ-ray transition corresponding to 100% of the band normalized to the intensity of the transition corresponding to 100% of the channel. Therefore, R is proportional to the absolute intensity of the band: $R = k(f,g) \times I^{\rm abs}_{\rm band}$, where the coefficient k depends on the file gate f and the number of coincidences required g. By setting the same file gate with the same number of conditions, the R values obtained in the two experiments may be directly compared.

Concerning the feeding patterns of SD bands obtained in the two reactions, gates were set on transitions located below the feeding region. For the low deformed band in ^{152}Dy, gates were set on transitions located between 6 $\hbar$ to 22 $\hbar$. We compared feeding in the spin range from 24 $\hbar$ to 40 $\hbar$.

4. Results

The results concerning the population of the SD bands in ^{152}Dy nucleus are presented in Fig. 1 and those of ^{149}Gd nucleus are presented in Fig. 2. For the low deformed band in ^{152}Dy, we found the same feeding pattern in both, ^{123}Sb(^{37}Cl,α4n)^{152}Dy and ^{124}Sn(^{34}S,6n)^{152}Dy reactions but an increase of the intensity by a factor of 1.27 was observed in the reaction involving α-particle evaporation. The situation is different for the yrast SD band. In this case, the feeding pattern indicates that the band is fed at lower spin (by about 2 $\hbar$) when an α-particle is emitted. The highest observed spin is about 60 $\hbar$.

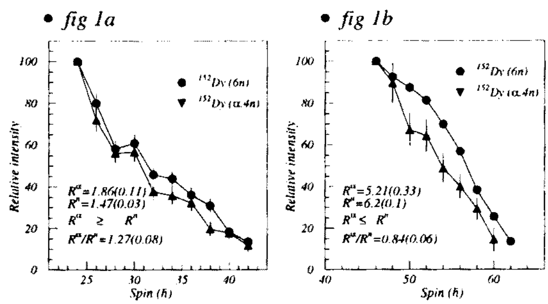

Fig. 1. Feeding of the low deformed band (a) and the superdeformed yrast band (b) of ^{152}Dy. In each figure R represents the intensity of the bands.

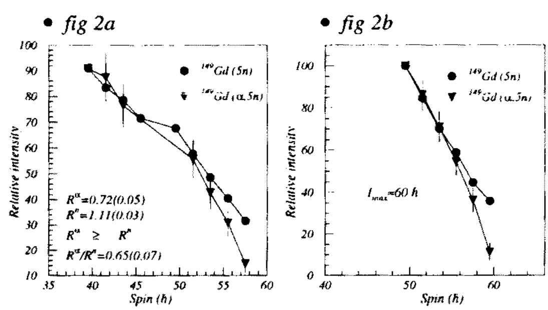

Fig. 2. Feeding of the superdeformed yrast band of ^{149}Gd. In Fig. 2a R represents the intensity of the bands, $I_{\max}$ is the highest spin observed in αxn channel.

For the αxn channel the intensity of the SD band is decreased, on the other hand, the intensity of the low deformed band is increased: it seems easier to populate low spin states after emission of an α particle.

In Fig. 2a the results concerning the population of the SD band in the ^{149}Gd nucleus are displayed. As for the ^{152}Dy nucleus, we did not have optimal conditions to populate SD bands using the ^{124}Sn(^{34}S,α5n)^{149}Gd reaction ($R^n = 1.11$ compared to $R^\alpha = 0.72$). As in a previous case, the region of very high spin (above 60 $\hbar$) is not populated after α-particle evaporation (see Fig. 2b).

5. Conclusion

In conclusion, the population mechanism of SD bands in the $A \simeq 150$ mass region seems to differ from that observed in the $A \simeq 190$ mass region. The α-particle emitted by the compound nucleus does not favor the population of SD states in the $A \simeq 150$ mass region. In contrary, this effect is weak in the $A \simeq 190$ mass region. One unresolved question is to learn why the SD bands are less populated. This could be related to a temperature and/or angular momentum effects. More experimental data, especially with charged particle detectors, are needed to investigate the population mechanism of SD bands.

REFERENCES

[1] P.J. Twin *et al.*, *Phys. Rev. Lett.* **57**, 811 (1986).
[2] J. Dudek *et al.*, *Phys. Lett.* **B211**, 252 (1988).
[3] A. Galindo-Uribarri *et al.*, *Phys. Rev Lett.* **71**, 231 (1993).
[4] D.R. LaFosse *et al.*, *Phys. Rev Lett.* **74**, 5186 (1995).
[5] J. Dupras *et al.*, *Z. Phys.* **A349**, 5 (1994).
[6] B. Haas *et al.*, *Phys. Lett.* **B245**, 13 (1990).
[7] K. Schiffer *et al.*, *Nucl. Phys.* **A520**, 521 (1990).
[8] C.W. Beausang *et al.*, *Nucl. Instrum. Methods* **A364**, 560 (1995).