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SUPERDEFORMED PROTON ORBITALS BELOW THE Z=80 GAP: ^{191}Au*

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The superdeformation in ^{191}Au has been studied with EUROGAM II. The yrast superdeformed band has been extended to very high rotational frequencies and a new excited band has been observed. The dynamical moment of inertia of the yrast SD band exhibits an interesting saturation feature at the highest rotational frequencies. An interpretation is proposed in terms of blocked SD proton orbitals.

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1. Introduction

About 50 superdeformed (SD) bands have now been identified in the A∼190 mass region, mainly in Hg, Tl and Pb isotopes. Recently the high-Z limit has been extended up to Z=84 with the discovery of SD bands in bismuth [1] and polonium [2] nuclei. Below the Z=80 superdeformed shell gap, theoretical calculations [3-6] predicted a well defined secondary minimum persisting in Au and Pt nuclei. The first experimental evidence for the extension of the SD region below Z=80 was obtained with the discovery of an SD band assigned to ^{191}Au [7]. The intensity of this band (∼0.15% of the total channel intensity) was at the lower possible observational limit for this generation of multidetector arrays. No coincidence with the low-lying transitions in ^{191}Au could be observed and this band was tentatively assigned to ^{191}Au from excitation function considerations.

2. The experiment

In order to investigate further the superdeformed proton orbitals below the Z=80 shell gap, an experiment was carried out with the EUROGAM II multidetector array operating at the Vivitron accelerator in Strasbourg. This array includes 30 large volume Compton-suppressed Ge detectors and 24 composite Ge detectors of the "clover" type [8]. Excited states in ^{191}Au were populated using the ^{186}W(^{11}B,6n) reaction at beam energies of 84 and 86 MeV with a target consisting of a stack of two 280μg/cm^2 ^{186}W self-supporting foils. A total of 9x10^8 quadruple and higher fold events was collected.

3. The yrast SD band

A first analysis of these data has enabled the previously known 13 member yrast SD band [7] to be extended to 20 transitions. A quadruple-gated spectrum is shown in Fig. 1.

The transitions are observed to be coincident with yrast normal-deformed transitions located above the 0.9 s isomer in ^{191}Au [9, 10], which firmly assigns the SD band to this nucleus. No signature partner could be observed for this band. Although this band is among the weakest of all the SD bands identified to date in the A∼190 mass region, it is also one of the longest observed so far in this region. This is due to a significantly reduced fission yield compared to heavier-Z nuclei, which allows the study of SD bands in such nuclei over a long range of rotational frequencies.

The variation of the dynamical moment of inertia with rotational frequency for the yrast SD band is compared to that of the yrast SD band in

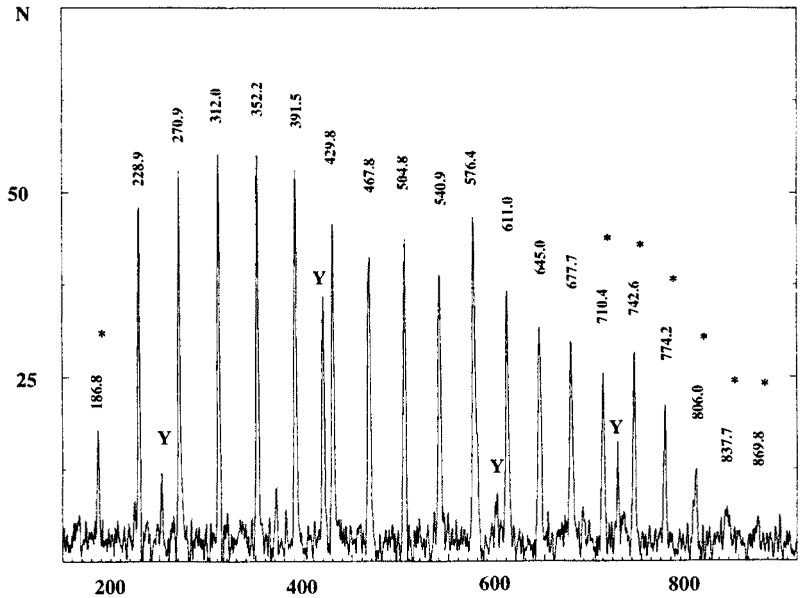

Fig. 1. Quadruple-gated spectrum on 18 transitions of the yrast SD band in ^{191}Au. The new transitions are indicated by stars and the transitions from the yrast level scheme by a Y.

the ^{192}Hg even-even core [11] (Fig. 2). For ^{192}Hg the regular increase of Im^2 is due to the progressive alignment of neutrons and protons, and the associated pairing decrease, with increasing rotational frequency. In ^{191}Au the overall slope of Im^2 is slightly lower than in ^{192}Hg and at high frequencies ($\hbar\omega$ >0.35) a downturn is observed. This indicates that the proton pairing correlations are lowered in this nucleus by a blocking effect due to the presence of the odd proton in an intruder orbital. A similar effect can be observed in bands 1 and 2 of ^{193}Tl [12, 13]. Nevertheless the dynamical moment of inertia of ^{191}Au still behaves with rotational frequency as that of a paired nucleus (an increase of Im^2 followed by a saturation). This is the fingerprint of the remaining pairing correlations mostly dominated by neutron pairing.

Hartree-Fock-Bogoliubov calculations including the Lipkin–Nogami prescription have been performed in the A$\sim$190 mass region [14, 15]. The quasiparticle Routhians for the ^{192}Hg and ^{190}Pt isotones of ^{191}Au are shown in Fig. 3. The ^{191}Au nucleus can be considered as a proton hole in a ^{192}Hg core, or as a proton added to a ^{190}Pt core. The fact that no signature partner has been observed for this yrast band indicates that it originates

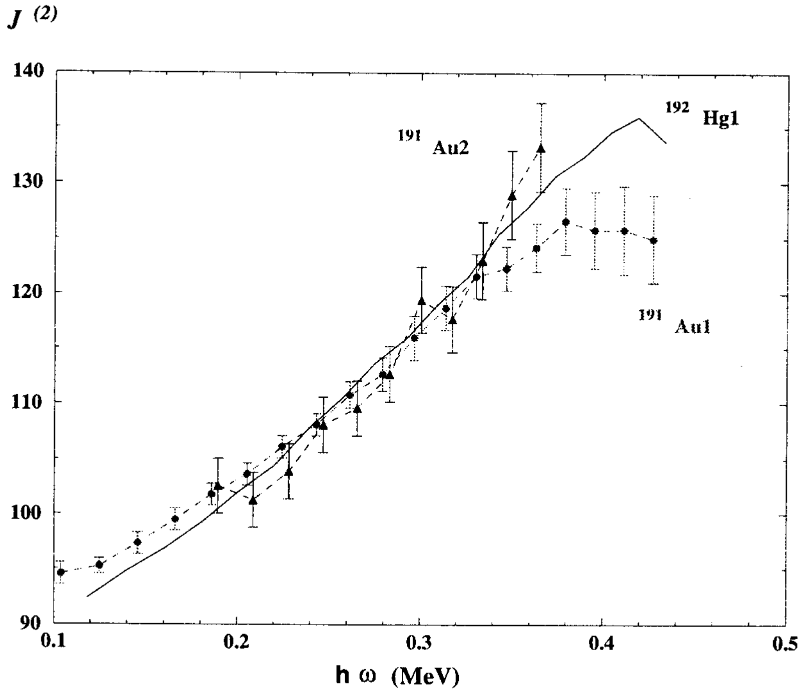

Fig. 2. Dynamical moment of inertia of the yrast and excited bands in ^{191}Au compared to that of the yrast SD band in ^{192}Hg.

from an orbital having a large signature splitting. Due to the absence of a signature partner, it was previously thought that this band would originate from an $\Omega=1/2$ orbital, such as [411]1/2 or [530]1/2 [7]. Since we have now observed the band behaviour to higher rotational frequencies, we propose another interpretation: Such a blocking effect is typical of an intruder orbital (having a significant pairing contribution). One can observe at high frequency a lowering of the $\alpha=+1/2$ [651]3/2 orbital from ^{192}Hg to ^{190}Pt. The yrast SD band in ^{191}Au is therefore likely to originate from the $\alpha=+1/2$ signature of the [651]3/2 orbital.

A crossing is predicted between [651]3/2 $\alpha=+1/2$ and [411]1/2 $\alpha=+1/2$. No sign for a crossing is observed in our data. Hence, we think that the [411]1/2 orbital would actually be higher than the [651]3/2 (or very close-lying) so that the crossing would be absent (or not visible). This gives a new experimental constraint on the respective order of the close-lying proton orbitals in this region.

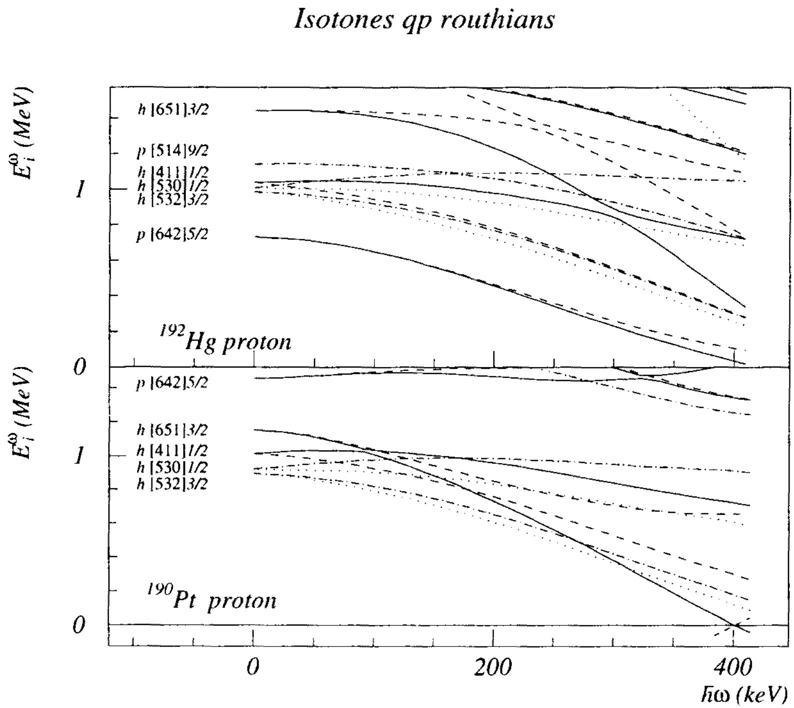

Fig. 3. Quasi-proton Routhians for ^{192}Hg and ^{190}Pt [11, 12]. The convention for the different (parity,signature) combinations is: $(+,+)$ — solid line, $(+,-)$ — dashed line, $(-,+)$ — dot-dashed line, $(-,-)$ — dotted line.

4. The excited SD band

An excited band of 12 transitions has been observed (Fig. 4). This band is in coincidence with yrast transitions in ^{191}Au. The dynamical moment of inertia for this band is also displayed in Fig. 2 and exhibits the same increase with rotational frequency as that of ^{192}Hg. This implies that the pairing contribution of the odd proton hole orbital is not significant and therefore that this SD band should originate from an orbital with a less steep Routhian. This is the case for the [532]3/2, the [530]1/2 and the [411]1/2 orbitals. Since no signature partner has been observed so far, we suggest the last two candidates as being more likely.

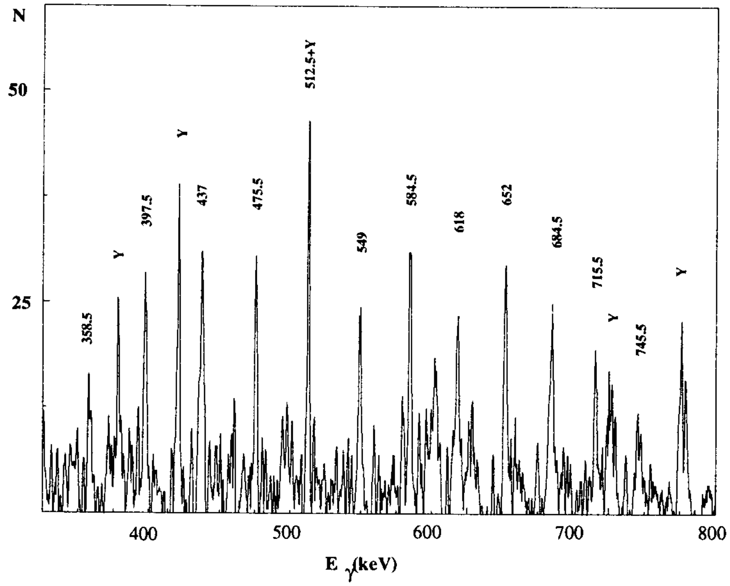

Fig. 4. Quadruple-gated spectrum on the 12 transitions of the new excited SD band in ^{191}Au. Transitions from the yrast level scheme are indicated by a Y.

5. Conclusion

We have observed two SD bands in ^{191}Au. The yrast SD band clearly exhibits a proton blocking effect. The overall behaviour of the dynamical moment of inertia is still characteristic of a paired system mostly dominated by neutron pairing. These experimental results shed a new light on the relative order of the proton orbitals below the Z=80 superdeformed shell gap and provide useful indications for future theoretical calculations.

It should be noticed that the experiment took place only two months ago and that the analysis is still in progress. A search is continuing to try and identify more excited bands, which will help to characterize the group of close-lying proton orbitals below the Z=80 superdeformed shell gap.

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REFERENCES

[1] R.M. Clark *et al., Phys. Rev.* **C51**, R1052 (1995).
[2] D. Mc Nabb *et al.,* to be published.
[3] R.R. Chasman, *Phys. Lett.* **B219**, 227 (1989).
[4] P. Bonche *et al., Nucl. Phys.* **A500**, 308 (1989).
[5] W. Satula *et al., Nucl. Phys.* **A529**, 289 (1991).
[6] S.J. Krieger *et al., Nucl. Phys.* **A542**, 43 (1992).
[7] D.T. Vo *et al., Phys. Rev. Lett.* **71**, 340 (1993).
[8] P.J. Nolan, F.A. Beck, D.B. Fossan, *Ann. Rev. Nucl. Sci.* **44**, 5 (1994).
[9] Y. Gono *et al., Nucl. Phys.* **A327**, 269 (1979).
[10] V. Kölschbach *et al., Nucl. Phys.* **A439**, 189 (1995).
[11] B.J.P. Gall *et al., Z. Phys.* **A347**, 223 (1994).
[12] J.F. Sharpey-Schafer *et al.,* XXXIII Winter Meeting on Nuclear Physics, Bormio, January 1995.
[13] S. Bouneau *et al.,* this issue.
[14] B. Gall, PhD Thesis, Orsay 1994.
[15] B.J.P. Gall *et al., Z. Phys.* **A348**, 183 (1994).