NON-AXIAL DEFORMATION IN TRANSITIONAL NUCLEI?

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Abstract

The experimental results obtained for the odd transitional nuclei ^{191}Pt and ^{197}Hg are compared with two different theoretical approaches: the coupling of an $i_{13/2}$ neutron to a triaxial rotor and to an anharmonic vibrator.

A. Introduction

A large variety of nuclear states arises in transitional nuclei as a consequence of the complicated interplay between collective and particle motion. In order to describe the structure of odd-mass transitional nuclei different models have been applied, such as the rotation-alignment $^{1)}$, the few-particle cluster model $^{2)}$ and the coupling of the odd nucleon to a triaxial rotor $^{3)}$ or to an anharmonic vibrator $^{4)}$. The properties of these different approaches can be studied by investigating not only the yrast-levels built on high-j orbitals, but also the various additional levels based on the same j-shells. The latter ones are in general disfavoured in compound nuclear reactions. With the aim to obtain as much as possible information on these weakly excited states several odd-mass nuclei in the transitional regions close to the magic nucleon numbers Z=82, Z=50 and N=82 have been investigated by means of in-beam spectroscopic methods at the 27 MeV ∝-particle beam of the Rossendorf cyclotron.

B. Results

In the mass region around A≈190 we studied recently the isotopes $^{187,189}Ir$ (ref. $^{5)}$), $^{190,192,194}Pt$ (ref. $^{6)}$), ^{191}Pt, $^{191,193,195}Au$ and ^{197}Hg. In this paper we present our results concerning the $i_{13/2}$ family of levels in the odd-neutron nuclei ^{191}Pt and ^{197}Hg. Fig. 1 shows the level scheme of ^{191}Pt, which contains in addition to the decoupled band close-lying states of equal spin and parity. The original model of rotation alignment between the

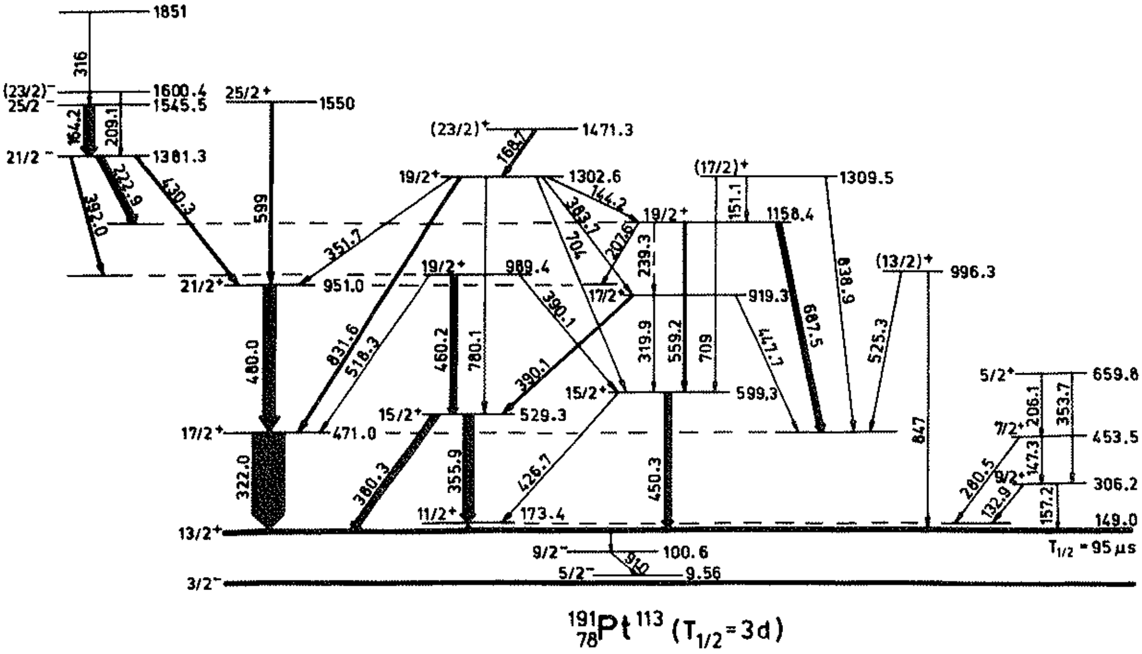

Fig. 1 Level scheme of ^{191}Pt obtained by (∝,2nγ) experiments.

+) Permanent address: UJF Řež/Prague, Czechoslovakia motion of an odd particle and an axial-symmetric core (1) fails in describing such a level structure. However, the coupling of an $i_{13/2}$ neutron to a triaxial rotating core reproduces fairly well the observed level energies and relative transition rates in ^{191}Pt (ref. (7)).

In ^{197}Hg we also found many levels (8) of the $i_{13/2}$ family in addition to the known decoupled band (9). Their energies relative to the $13/2^+$ isomer are shown on the right-hand side of fig. 2. Here again the triaxial rotor gives a qualitative correct description as shown on the left-hand side of fig. 2. The results were obtained +) using a rigid core with deformation parameters of $\beta = 0.14$ and $\gamma = 38^\circ$ and the chemical potential in the middle between the last and the last but one s. p. orbit (8). The energies of the high-spin states could be lowered by using a soft core (10) instead of the rigid one.

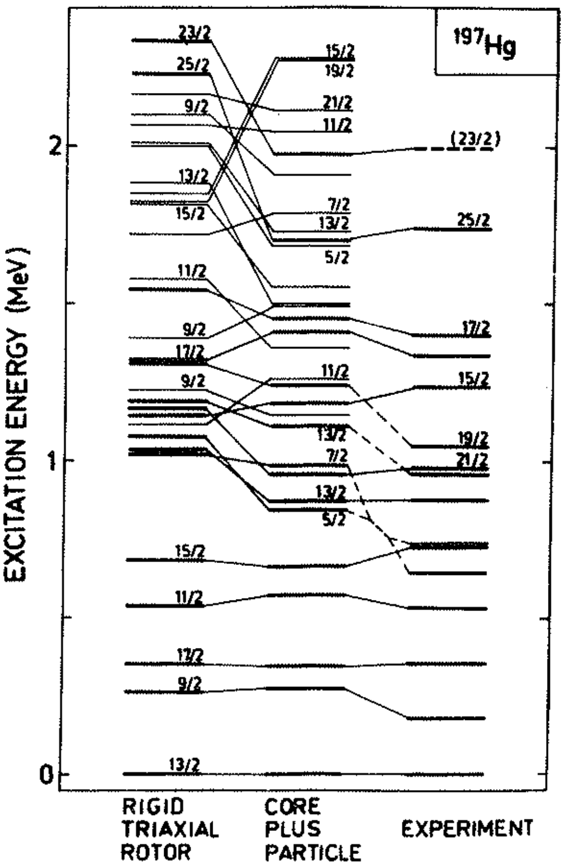

Fig. 2 Comparison of the calculated and experimental level energies in ^{197}Hg.

C. Discussion

The success of the triaxial rotor model might be taken as evidence that such transitional nuclei have indeed fixed triaxial shapes. One should, however, be careful with such a conclusion as long as the description in the framework of other models have not thoroughly been tested.

Thus we calculated the $i_{13/2}$ levels by using an alternative method of coupling the odd particle by a quadrupole-quadrupole interaction to the core. In this approach the core is described as an anharmonic vibrator on the basis of a boson expansion (11). After fitting the level energies the different quadrupole moments of the core are calculated and normalized to the known $B(E2,2^+ \rightarrow 0^+)$ value. For describing the adjacent odd-mass nucleus the experimental energies and calculated quadrupole moments of the core are used. This model has successfully been applied to different transitional nuclei near the Z=50 closed shell (see e. g. ref. (4)). In the middle column of fig. 2 calculated levels for ^{197}Hg are shown (8), where an $i_{13/2}$ hole is coupled to the ^{198}Hg core with the strength of the quadrupole-quadrupole interaction as the only free parameter. The level energies are satisfactorily reproduced.

For ^{191}Pt the particle-plus-core approach reveals some difficulties. Although the ^{192}Pt core can be described (12) by a boson expansion including fourth order terms, such properties of the odd-mass system as the very low-lying j-1 state could not be reproduced. In ^{191}Pt the Fermi surface penetrates the $i_{13/2}$ shell, while it lies outside in the case of ^{197}Hg and probably our present particle-plus-core program fails, because the pairing interaction is treated too simply. There are efforts to overcome this difficulty (13).

The rather similar reproduction of the ^{197}Hg experiment by the triaxial rotor and the anharmonic vibrator is worthy of being discussed. The agreement does not only concern the energies as shown in fig. 2, but also most of the γ-ray branchings are very similar in both types of calculations.

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In both theoretical approaches the interaction between the core and the odd particle is of the pairing-plus-quadrupole type, and since the Fermi surface is outside the $i_{13/2}$ shell the different treatment of the pairing interaction should be unimportant. On the other hand quite different assumptions are made about the core properties. The triaxial core has fixed deformation values β and γ and only rotational degrees of freedom can be excited. The vibrator concept avoids the assumption of a permanent deformation, but involves dynamical effects in the form of anharmonicities. However, it has been shown $^{11)}$ that the anharmonic terms of the boson expansion can be understood in a body fixed system as a potential $V(\beta,\gamma)$. Thus the higher order boson terms neccessary for describing nuclei like ^{198}Hg and ^{192}Pt mean that dynamic nonaxialities occur in these nuclei. The nonaxialities, however, need not be static and permanent deformations as assumed in the triaxial rotor model.

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