THE DECAY OF ^{185}Hg : LOW-SPIN STATES IN ^{185}AU AS A PROBE OF THE NUCLEAR MODELS

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Abstract :

The ^{185}Au has been studied from the β^+/EC decay of $^{185m+g}$Hg using the ISOCELE facility. Conversion electron measurements have been performed by means of a semi-circular magnetic spectrograph : new low-energy transitions have been observed. A 330 keV Very Converted Transition has also been found. Its existence is discussed. In addition to the usual states observed in heavier gold isotopes, numerous negative-parity low-spin states have been located. The experimental states corresponding to a prolate shaped nucleus are compared with those extracted from an "axial rotor + quasi-particule" coupling model. They could be identified with two state families, the first one arising from the h9/2 + f5/2 sub-shells , the second from the p3/2 + f7/2 sub-shells.

1. Introduction

The Au nuclei lie in a very complex transitional region where several states corresponding to different nuclear shapes occur within the same energy value. Numerous experimental and theoretical studies have been already carried out in this region. In order to improve our comprehension of the observed phenomena it was useful to extend the systematic study of the gold nuclei down to ^{185}Au. Indeed in this nucleus, the deformation is expected to be larger than those of the heavier odd gold isotopes and thus new levels should appear.

The high-spin states of ^{185}Au (from $7/2^-$ up to $45/2^-$) have already been investigated $^{1)}$ by means of (HI, xnγ) reactions. Four decoupled level sequences, I, I+2, I+4... have been observed. They arise from the alignment of the single-particle angular momentum with the core-rotation angular momentum under the effect of Coriolis force. The shape coexistence in the ^{185}Au nucleus has been established from these results but the $11/2^-$, $9/2^-$ and $13/2^+$ quasi-rotational bandhead states could not be located with

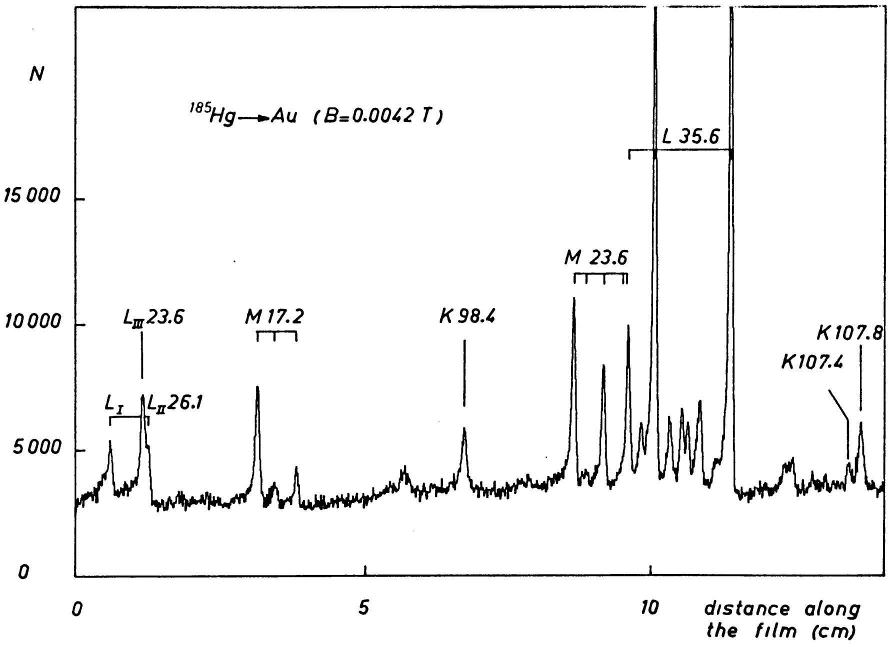

Fig. 1 : Low-energy electron microdensitogram from a film obtained with the β-spectrograph. The 26.1 keV transitions belongs to ^{185}Hg.

respect to the ground state. The ground state spin had been measured (I = 5/2) by C. EKSTROM et al.[2).

We present here our most recent results concerning the low-spin states of ^{185}Au (from $1/2^-$ up to $17/2^-$) populated by the β^+/EC decay of $^{185g+m}$Hg. In order to produce mercury, a molten gold target was irradiated by the proton beam (E_p = 200 MeV, I_{max} = 2.5 μA) of the synchrocyclotron of the Institut de Physique Nucléaire (ORSAY) and then the mercury isotopes were mass-separated using the ISOCELE facility[3).

2. Experimental procedure

Usual $\gamma_1 - \gamma_2 - t_{12}$ coincidence measurements have been performed. In order to improve the conversion electron measurements we have used the semi-circular magnetic spectrograph working on-line with the mass-separator ISOCELE II. Radioactive ions are collected on a mylar/aluminium tape, the sources are then transported into the spectrograph by means of a fast mechanical tape-transport system. The electrons are deflected by a magnetic field and then detected by a photographic plate. For sources as thin as 0.7 mm, the energy resolution of this system is 0.2 %.

It is very useful to have such an equipment for spectroscopic measurements : it allows us to see low energy transitions, to measure the transition energy with good accuracy, to verify that a transition belongs to the element of interest, to determine the transition multipolarities and consequently to assign spin values to the excited states.

3. Results

The electron conversion spectra obtained by means of the magnetic spectrograph have shown the existence of a 17.2 keV transition (M1 + E2), a 23.6 keV transition (M2) and a 107 keV doublet in ^{185}Au (Fig. 1). Moreover, the 330.2 keV, transition has been found to be abnormally converted (α_k = 1.1) (Fig. 2).

Gamma-Gamma coincidence results added to the existence of the 107 keV doublet have allowed us to locate the $9/2^-$ state at 8.9 keV with respect to the 5/2 ground state. We have also been able to locate the $1/2^+$ state at 23.6 keV and numerous negative-parity states connected to the 17.2 keV state. Furthermore the lowest energy states belonging to the high spin bands arising from the h 9/2, h 11/2 and i13/2 sub-shells have also been observed during the course of this work.

The low-energy level scheme of ^{185}Au which has been built from all these results is shown in figure 3.

Table 1

Sub-shell mixing percentages corresponding to the wave functions of the low-energy negative-parity states in ^{185}Au (calculations performed with ^{186}Hg prolate core)

I	E_{th} keV	h 9/2	f 5/2	p 3/2	f 7/2	h 11/2
$5/2^-$	0	68 %	21 %			
$3/2^-$	23	65	20			
$9/2^-$	63	69	22			
$1/2^-$	518	64	30			
$3/2^-$	142			39 %	32 %	13 %
$1/2^-$	233			40	32	12
$7/2^-$	235			38	31	8

4. Discussion

4.1 Negative-parity low-spin levels

Most of the models which can be used in this transitional region are able to explain high spin sequences. This is however not always the case for low spin states. Thus their representation provide a good test of nuclear models. Here we shall compare our experimental results concerning the h 9/2 system with the theoretical results extracted from a rotor + quasi-particle coupling model[4). A brief survey of the method is given in another contribution to this conference[5). This model has already given a good description of soft[4,5) and largely[6) deformed nuclei. The theoretical calculations have been performed from the ^{184}Pt and ^{186}Hg prolate-shaped cores. A family of states which comes from the coupling of the h9/2 + f5/2 single-particle to the core is calculated to appear at low-energy from both ^{184}Pt and ^{186}Hg cores. A second state family corresponding to the p3/2 + f7/2 sub-shells is calculated to appear at lower energy from ^{186}Hg core than from ^{184}Pt core. We can observe in figure 4a a good agreement between theory and experiment for the high-spin states. The model that we use is also able to reproduce nicely the low-spin states (cf. fig. 4b). The main wave function percentages of the lowest energy states are given in table 1 for both state families.

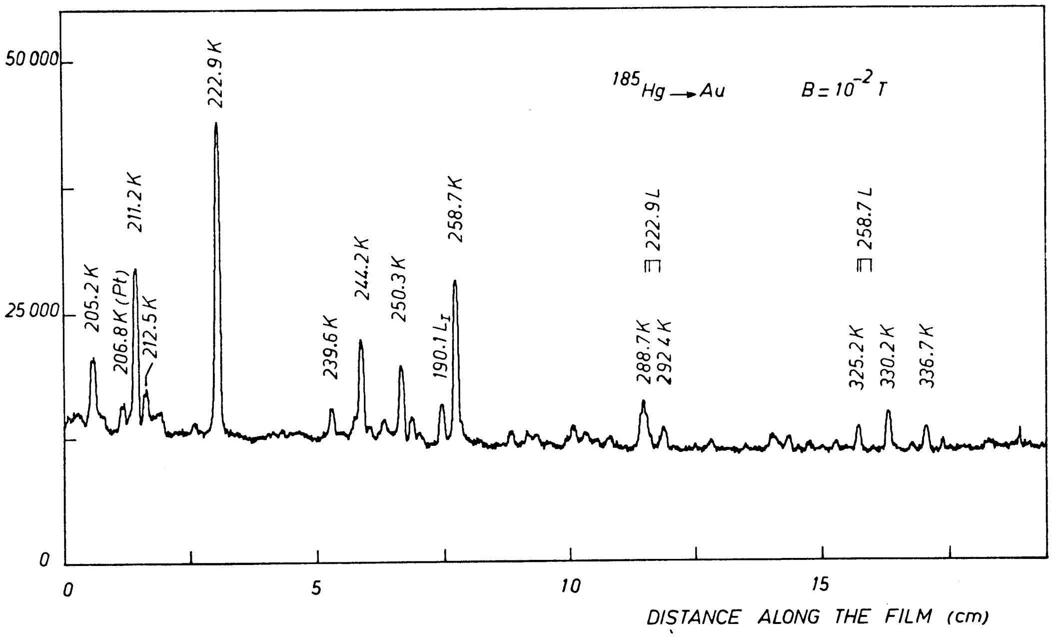

Fig. 2 : Partial microdensitogram obtained with $B = 10^{-2}$ *T.*

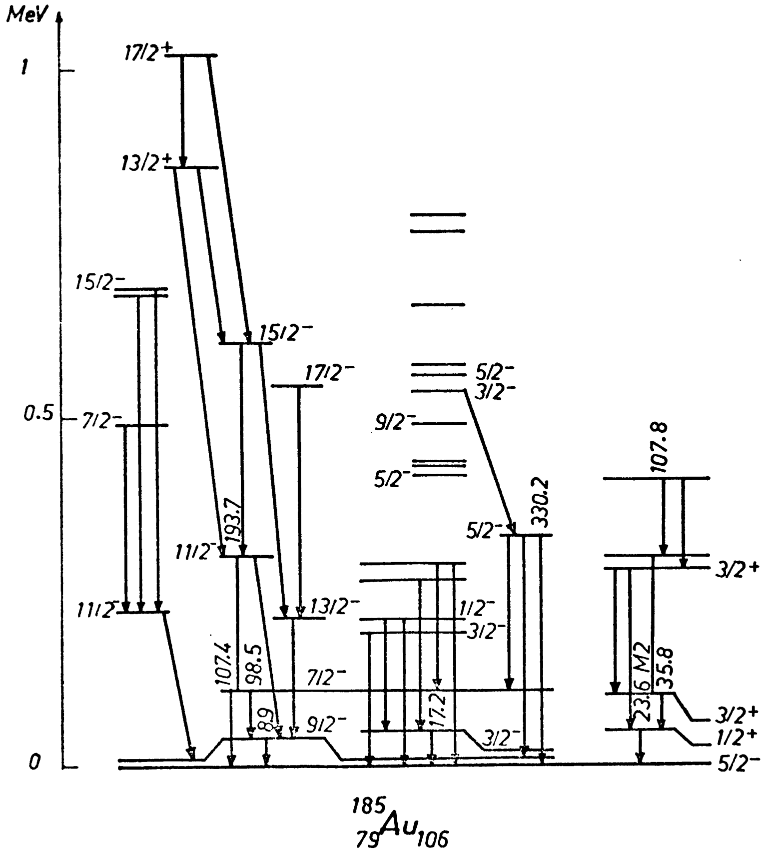

Fig. 3 : ^{185}*Au partial level scheme established from mass-separated* $^{185m+g}$*Hg decay.*

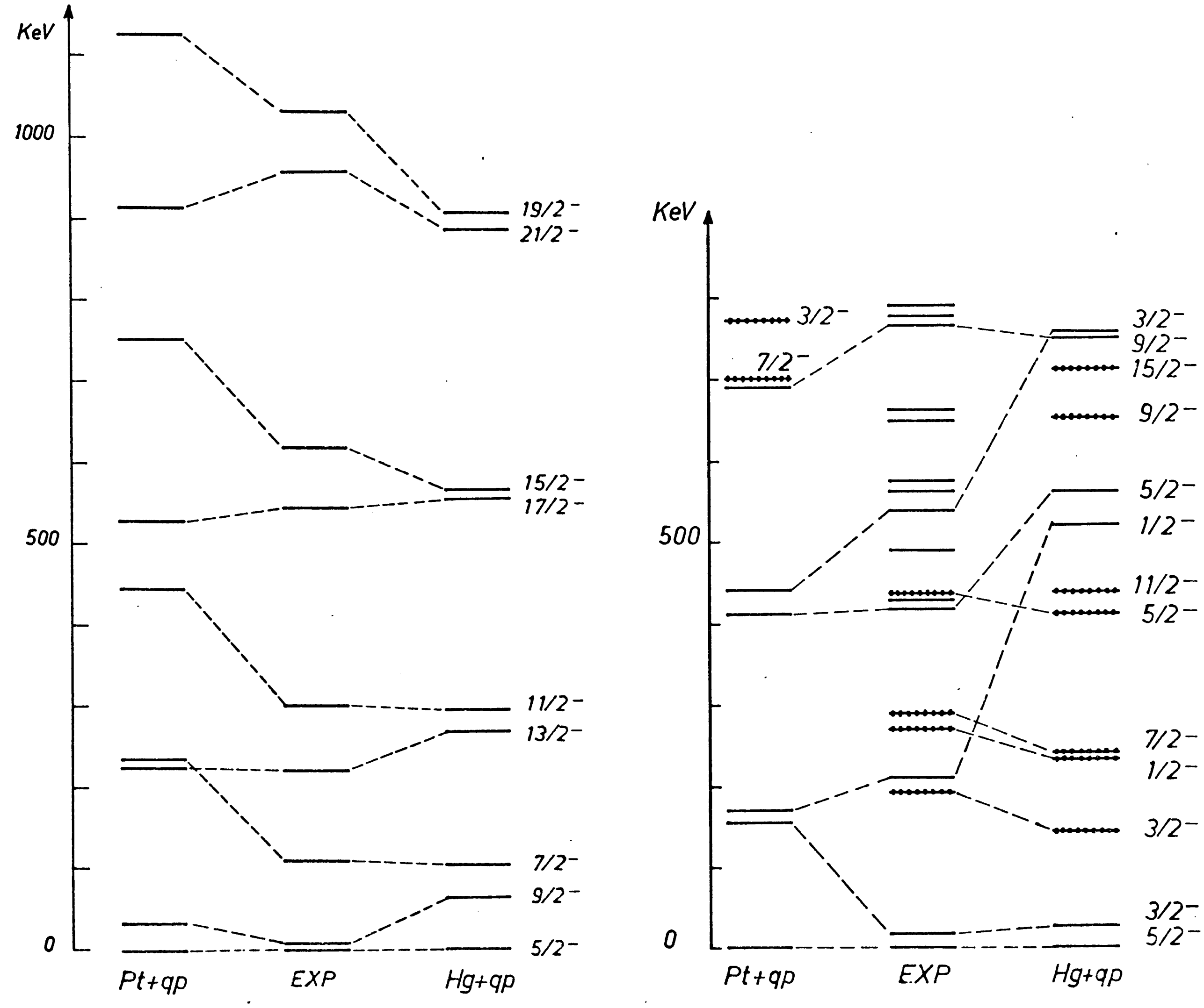

Figure 4.a *Figure 4.b*

Comparison between the experimental excited states of ^{185}Au and the calculated levels using HF qp states coupled to ^{184}Pt and ^{186}Hg prolate core (—— levels from h9/2 + f5/2 subshells, ◆◆◆ levels from f7/2 + p3/2 subshells).
a) High-spin states
b) low-spin states

Table 2
Very Converted Transitions in ^{185}Au and ^{187}Pt. The theoretical α_k are calculated with the assumption of (I) a point nucleus[7)] and (II) a finite size nucleus[8)].

Nucleus	Energy keV	α_k exp.	α_k(M1)		α_k(E2)	
			I	II	I	II
^{185}Au	330	1.1		0.23		0.05
^{187}Pt	260.3	3.4	0.47	0.38	0.085	0.105
	262.5	5.4		0.37		0.102
	498.2	0.58	0.08	0.07	0.019	0.019
	498.8	0.95		0.07		0.019

In order to get a more complete identification of the experimental levels it is quite clear that we still have to take into account their de-excitation modes. The B(M1) and B(E2) transition probably calculations are in progress in this region.

4.2 Very Converted Transitions

The 330 keV transition is abnormally converted : its conversion coefficient α_k is five times greater than the one expected for an M1 transition. This result looks like those we obtained in 1977, concerning four transitions in ^{187}Pt[10)]. The experimental α_k values were found to be about ten times greater than theoretical M1 α_k values (table 2). So we are in the presence of a new kind of transitions which we have called Very Converted Transitions (V.C.T.). The VCT are either anomalously converted M1 transitions or more likely caused by the existence of a large percentage of E0. In both cases, dynamic penetration effects$^{9)}$ of the electronic wave function inside the nucleus are responsible for the VCT phenomenon. The ρ(E0) strength being related to the variation of the mean square charge radius between the initial and final states, it seems very likely that VCT phenomenon is related to shape coexistence. VCT are very interesting because they may be a new probe to improve our knowledge of the nuclear structure, in particular to study shape, rigidity or softness of the transitional nuclei. It may be noted that such transitions have also been found in ^{233}Th$^{11)}$ and ^{197,195,193}Hg $^{12)}$.

5. Conclusion

The study of the low-energy low-spin states in the ^{185}Au transitional nucleus provides a good test of theoretical approaches. The experimental difficulties to establish such levels have been overcome by precise conversion electron measurements using a magnetic spectrograph. An open question is the occurence of VCT in this region which is probably related to shape coexistence phenomenon.

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DISCUSSION

D. Hamilton: In order to use transitions containing an E0 contribution it is necessary to know the M1 and E2 contributions. Do you have the possibility to determine E2:M1 ratios with sufficient accuracy to all E0 matrix elements to be extracted?

J. Sauvage-Letessier: In the case of the VCT of which I talked here, the experimental conversion lines in the L_{II} and L_{III} shells are extremely weak, thus we cannot determine the E2:M1 ratios from conversion measurements. In order to determine these ratios, we have to perform other kinds of experiment like $\gamma\gamma$ and $e\gamma$ angular correlations, for example.