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PROPOSAL TO THE ISOLDE COMMITTEE

# SPIN AND PARITY VALUES OF THE $^{182}$Ir GROUND STATE

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**Summary :** Previous study of $^{182}$Ir performed by (HI,xnγ) reactions and $\beta^+$/EC decay of $^{182}$Pt, combined with theoretical predictions suggest that the $^{182}$Ir ground state could possibly be the $3^+$ state of the doubly-decoupled band corresponding to the $\pi$ h 9/2 $\otimes$ $\nu$ 1/2$^-$ [521] configuration. Spin and parity values of ground state of nuclei are the most fundamental properties from which the nuclear structure can be studied. So, we propose to establish the spin and parity values of the $^{182}$Ir ground state by detecting internal conversion electrons of the $5^+ \rightarrow 3^+$ transition of the doubly-decoupled band - if it exists - by means of a high-resolution semi-circular magnetic spectrograph. The electrons are emitted by radioactive sources of $^{182}$Pt obtained by the $^{182}$Hg decay. The beam time request is :

| | |
|---|---|
| off-line stable beam | 3 shifts. |
| on-line | 6 shifts. |

## SPIN AND PARITY VALUES OF THE $^{182}$Ir GROUND STATE

## I - INTRODUCTION

Spin and parity values of the nuclear ground state are fundamental properties from which other nuclear phenomena may be determined. It can be very difficult to resolve ambiguities in assigned spin and parity values which, in turn, lead to greater uncertainty in the overall level scheme. In particular the case of $^{182}$Ir is interesting because of evidence furnished by previous measurements using (HI,xn$\gamma$) reactions [1-6] and $\beta^+$/EC decays [7-9]. The results of these measurements combined with theoretical predictions [3,10] suggest that the $^{182}$Ir ground state could be the $3^+$ state of the doubly- decoupled band corresponding to the $\pi$ h 9/2 $\otimes$ $\nu$ 1/2$^-$ [521] configuration. We propose to establish the spin and parity values of the $^{182}$Ir ground state by detecting internal conversion electrons of the $5^+ \rightarrow 3^+$ transition of the doubly-decoupled band from the decay of $^{182}$Pt by means of a high-resolution semi-circular magnetic spectrograph.

## II - INFORMATION ALREADY KNOWN ON $^{182}$Ir

### *1) In-beam study*

The doubly-odd $^{182}$Ir nucleus has recently been studied using $^{172}$Yb ($^{14}$N,4n) $^{182}$Ir reactions and three rotational bands have been observed [1]. The band located at the lowest energy is a cascade of stretched E2 transitions. Such a band structure, called doubly-decoupled, has already been observed in $^{184,186}$Ir, $^{176,178}$Re and $^{172,174}$Ta and attributed to the $\pi$ h 9/2 $\otimes$ $\nu$ 1/2$^-$ [521] configuration [2-6]. The $3^+$ and $5^+$ states of this configuration are expected to be located within a few keV from systematic knowledge of doubly-decoupled bands and theoretical predictions. In the in-beam experiment performed on $^{182}$Ir the $3^+$ level which should be the bandhead of the doubly-decoupled band was not found and the lowest lying level observed was the $5^+$. The $5^+ \rightarrow 3^+$ E2 transition very likely has an energy smaller than 50 keV ($\alpha_t \simeq$ 120). It could not be detected in the experiment because of its large internal conversion coefficient. On the other hand, the two other rotational bands observed in the experiment are connected to the $5^+$ level via an M1 45.4 keV ($\alpha_t$ = 12) and an E1 81.5 keV ($\alpha_t \simeq$ 0.7) transition (see fig.1a).

*2) $\beta^+$/EC decay studies*

No data on the $\beta^+$/EC decay of $^{182}$Ir have been recently published. The poor statistics obtained in previous experiments [7] do not allow a valid determination of the $^{182}$Ir ground-state spin value.

The partial level scheme of $^{182}$Ir shown in fig. 1b was recently built from a study of the $\beta^+$/EC decay of $^{182}$Pt. We can see that the level located at 320.6 keV decays two ways. One way (shown on the left) leads to the ground state and the other (on the right) stops at the level located 25.3 keV above the ground state and, furthermore, includes two transitions already observed in the in-beam experiment (45.4 keV and 81.5 keV transitions). This latter way drives at least 4% of the total intensity to the 25.3 keV level but no 25.3 keV $\gamma$ transition was observed. This suggests that either the 25.3 keV level is an isomeric state or the 25.3 keV transition has a large conversion coefficient corresponding at least to an E2 or an M1 + E2 transition ($\alpha_t$ (M1) $\simeq$ 60 ; $\alpha_t$ (E2) $\simeq$ 3000). So the ground state of $^{182}$Ir could be the $3^+$ state of the doubly-decoupled band and an E2 25.3 keV transition could de-excite the $5^+$ state located at 25.3 keV towards the ground state.

*3) Systematics*

Figure 2 shows the systematics of the i) doubly-odd Ir isotopes from 182 to 186 (part a) and ii) odd-A Ir nuclei from 181 to 187 (part b). It is worth noting that the transition which links the $5^+$ to the $3^+$ states in the doubly-decoupled bands has never been observed except in $^{172,174}$Ta where its energy is 91.3 and 76.2 keV respectively [5-6]. For $^{186}$Ir, a $\beta^+$/EC decay study of $^{186}$Pt has been performed to search for the $3^+ \rightarrow 5^+$ transition but it was not observed and only a limit for its energy (E < 2.6 keV) could be extracted from the data [8]. Nor was the transition in $^{184}$Ir, however the $5^+$ state observed in the in-beam study could be indirectly located 6.4 keV above the $3^+$ state [2] which was observed in both the in-beam [2] and $\beta^+$/EC decay studies [9]. It was concluded from these results that the crossing of these $5^+$ and $3^+$ states can be correlated with the crossing observed for the $9/2^-$ and $5/2^-$ states of the decoupled h9/2 band in odd-A Ir isotopes [8] (see fig.2). So we can conclude that a $3^+$ state located 25 keV below the $5^+$ state in $^{182}$Ir would fit rather well with the systematics displayed in fig.2.

It is worth noting that the $^{182}$Ir nucleus is the most favourable isotope to observe - if it exists - the $5^+ \rightarrow 3^+$ transition. The doubly-decoupled band is the ground-state band, which makes possible the feeding of the $5^+$ level in the $\beta^+$/EC decay experiment. Furthermore the energies of the internal conversion electrons in L and M subshells of a 25 keV transition are large enough to be observed.

## III - PROPOSED EXPERIMENT

### *1) Experimental method*

We propose to record the spectrum of the internal conversion electrons emitted in the decay $^{182}Pt \rightarrow {}^{182}Ir$ and search for the electron lines corresponding to a 25.3 keV transition by means of a high-resolution semi-circular magnetic spectrograph. The electrons are detected by a photographic plate. In order to preserve the high resolution at low energy it is necessary to prevent a deep implantation of the ions into the transport tape. For that purpose, the radioactive ions are decelerated by a high voltage from 60 kV to 500 V before collection on aluminium deposits which have been atomized on the insulating tape. The sources obtained are then moved into the spectrograph and a high voltage (-10 kV) is applied to the aluminium deposit to accelerate the electrons emitted by the source. The radioactive source has to be in the shape of a rectangle with around 10 mm height and from 0.1 to 1.0 mm width. It is worth noting that the source width determines the electron spectrum resolution. Therefore a diaphragm is used and the efficiency depends on the quality of the ion-beam focalization. To cover an electron energy range from 2.5 to 80 keV a magnetic field of 0.5 $10^{-2}$T is used. A more detailed description of this apparatus can be found in [ref.11].

### *2) Beam time request*

The ISOLDE users'guide yields of mercury are reported for a 1 μA proton beam intensity. Up to now ISOLDE lead target could not stand more than 0.5 μA. At this moment, in collaboration with the ISOLDE separator group, we are working at Orsay for an improved target that would be able to stand the full intensity.

Using the yield of $^{182}Hg$ reported in the users'guide we estimate that 4 shift measurement will allow us to observe the conversion lines in the subshells $L_I$, $L_{II}$, $L_{III}$, $M_I$, $M_{II}$ and $M_{III}$ of a 25.3 keV transition. We need time off-line with stable beam for testing of the retardation and transmission and on-line mode 1 shift for calibration and 1 shift to optimize the focalization of the beam through the diaphragm. Therefore the beam time requested is :

| | |
|---|---|
| off-line stable beam | 3 shifts. |
| on-line | 6 shifts. |

### *3) Results expected*

This experiment will allow us to clearly establish the multipolarity of the 25.3 keV transition if it exists and to confirm the multipolarities proposed for the 45.4 and 81.5 keV transitions from angular distribution measurements.

A spin and parity values $I^{\pi} = 3^{+}$ can be attributed to the $^{182}$Ir ground state if an E2 25.3 keV transition exists. This would also establish that the structure of the $^{182}$Ir ground state mainly corresponds to a $\pi$ h 9/2 $\otimes$ $\nu$ 1/2$^{-}$ [521] configuration, that would in turn check the theoretical predictions about the doubly-decoupled band.

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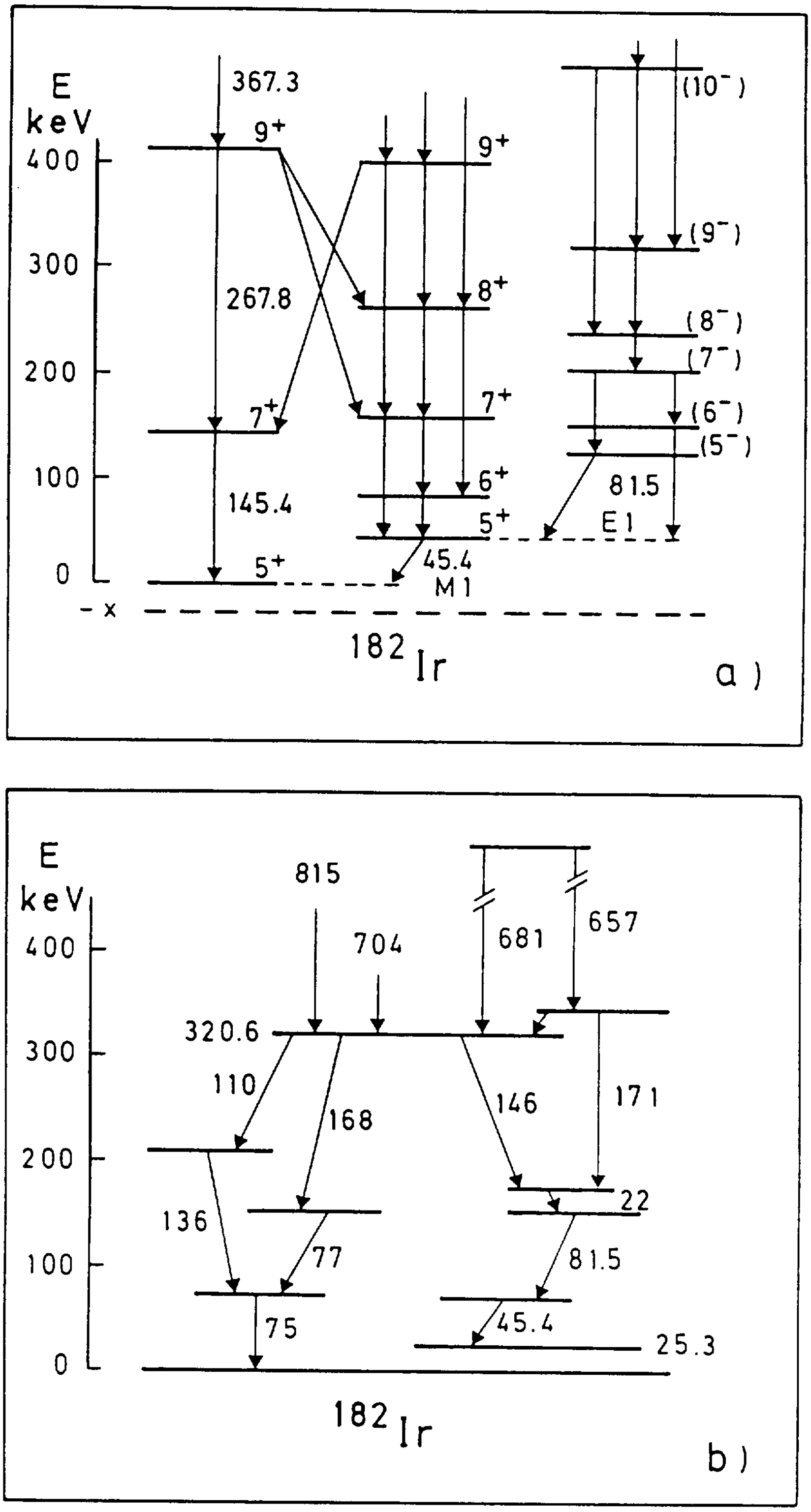


Fig. 1 Partial level scheme of $^{182}$Ir obtained by a) in-beam study, b) $\beta^{+}$/EC decay of $^{182}$Pt.

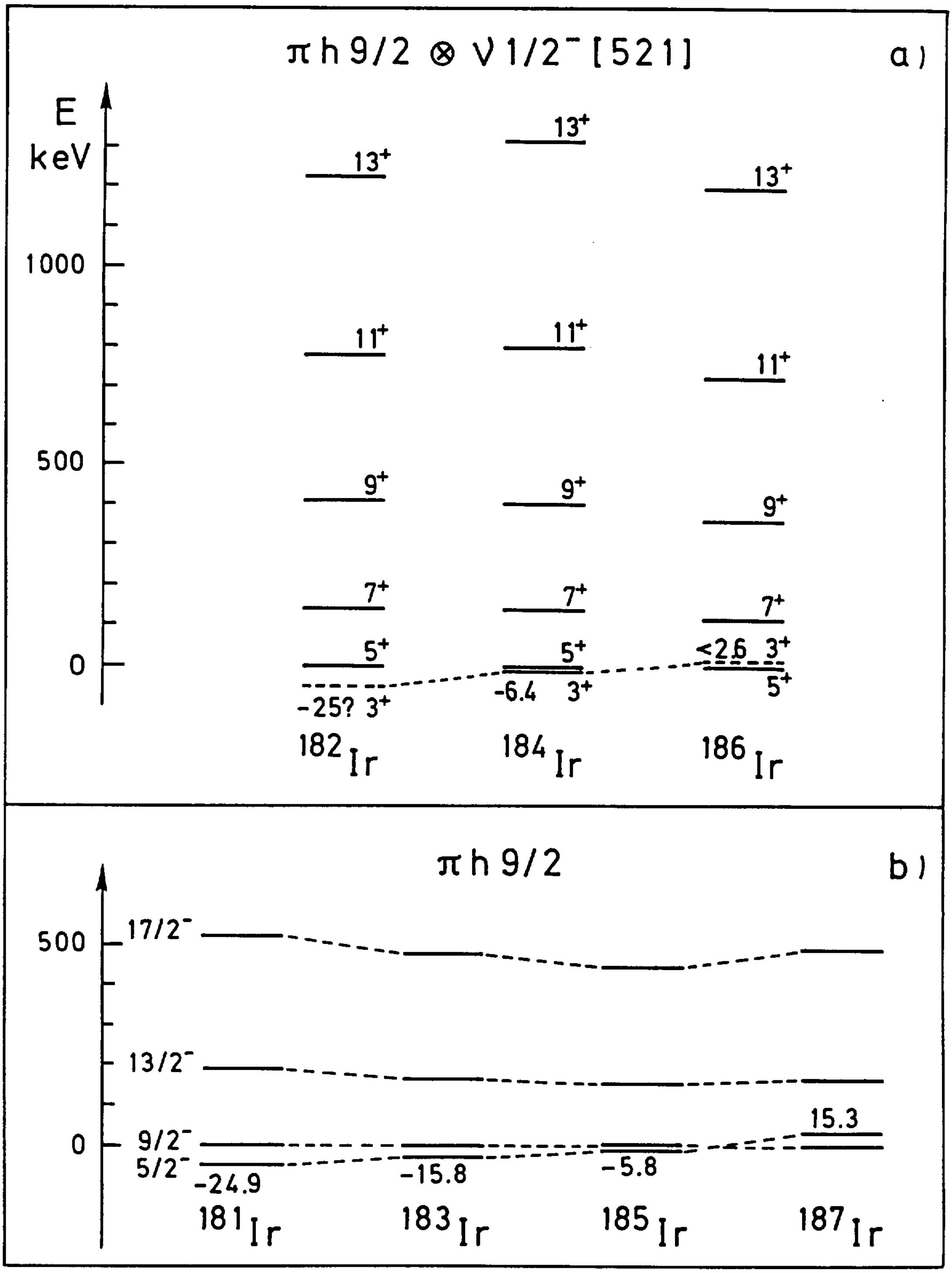


Fig.2 a) Systematics of the doubly-decoupled bands observed in the doubly-odd Ir nuclei.
b) Systematics of the π h 9/2 decoupled band observed in the odd-A Ir isotopes.