LIFETIMES IN ^{181}Ir AND ^{187}Au: ENHANCED DEFORMATION OF THE $\pi i_{13/2}$ INTRUDER ORBITAL*

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Lifetimes have been measured in the $\pi h_{9/2}$ (yrast) and $\pi i_{13/2}$ (excited) bands in the nuclei ^{181}Ir and ^{187}Au using the Recoil Distance Method (RDM). The results clearly indicate that the $\pi i_{13/2}$ band exhibits an increased deformation over the $\pi h_{9/2}$ band, in keeping with the premise that the delayed crossing in this band is due to enhanced quadrupole deformation.

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Recent studies of nuclei in the heavier rare-earth region (namely Ta, Re and Ir) have shown some very interesting configuration-dependent phenomena at high spins. Perhaps the most notable of these is the differing alignments between the bands built on the $\pi h_{9/2}$ and $\pi i_{13/2}$ orbitals. In the $\pi h_{9/2}$ band, a clear $\nu i_{13/2}$ band crossing is observed at $\hbar\omega \cong 0.3$ MeV.

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However, the alignment for the $\pi i_{13/2}$ band shows a significantly delayed crossing, or in some cases (Re and Ir), no crossing at all over the frequency range of $0.1 < \hbar\omega < 0.4$ MeV [1].

One possible explanation for this anomalous alignment behavior is that the quadrupole deformation is larger for the $\pi i_{13/2}$ band than for the $\pi h_{9/2}$ band. A previous lifetime measurement by Kaczarowski *et al.* [2] had indicated that this indeed might be the case in ^{181}Ir, but it was necessary to confirm this up to higher spins in the $\pi i_{13/2}$ band. In the case of ^{187}Au, two protons have been added so that the Fermi level now lies closer to the $\pi i_{13/2}$ orbital than it did in ^{181}Ir. Presumably this is still a pure particle state, and as such, will drive the nucleus to a larger deformation. However, since the Fermi level lies closer to the $\pi i_{13/2}$ orbital, the deformation increase should not be as pronounced as in the case of ^{181}Ir.

In order to test these ideas, we have measured the lifetimes of several levels in the $\pi h_{9/2}$ and $\pi i_{13/2}$ bands in both ^{181}Ir and ^{187}Au using the Recoil–Distance technique. The experiments were performed at the Argonne Tandem Linear Accelerating System (ATLAS) using the ^{154}Sm(^{31}P,4n)^{181}Ir and ^{154}Sm(^{37}Cl,4n)^{187}Au reactions at beam energies of 140 and 160 MeV, respectively. The Notre Dame Plunger device was used in conjunction with the Argonne–Notre Dame γ-ray Facility, which consisted of 12 Compton-suppressed HPGe detectors and a 50 element BGO array used as a multiplicity filter. The Notre Dame Plunger uses three computer-controlled dc actuators for precise positioning of the target foil with respect to the stopper foil and in this case allowed a minimum distance of $\sim 7\mu m$ to be reached. Approximately 20 runs of 2–3 hours in length were taken for each reaction, with recoil distances ranging from 7μm to as large as 10000μm. The target used was enriched ^{154}Sm (1.1 mg/cm^2 thick) evaporated onto a stretched 1.5 mg/cm^2 thick Au foil. The stopper was a stretched Au foil of 22.1 mg/cm^2 thickness, which was more than sufficient to stop all recoils.

From a standard analysis of the data (which included the usual corrections, including cascade feeding from unobserved sources [3]) lifetimes were extracted for the $\pi h_{9/2}$ and $\pi i_{13/2}$ bands in these nuclei; sample fits to the ^{181}Ir data are shown in Fig. 1. The resulting lifetimes, B(E2) values, and corresponding Q_t values from these fits are given in Tables I and II. These values result in average transition quadrupole moments of: ^{181}Ir ($\pi h_{9/2}$ band), Q_t(avg)=6.04(33) eb and ($\pi i_{13/2}$ band), Q_t(avg)=8.99(37) eb; ^{187}Au ($\pi h_{9/2}$ band), Q_t(avg)=6.18(35) eb and ($\pi i_{13/2}$ band), Q_t(avg) =8.25(50) eb.

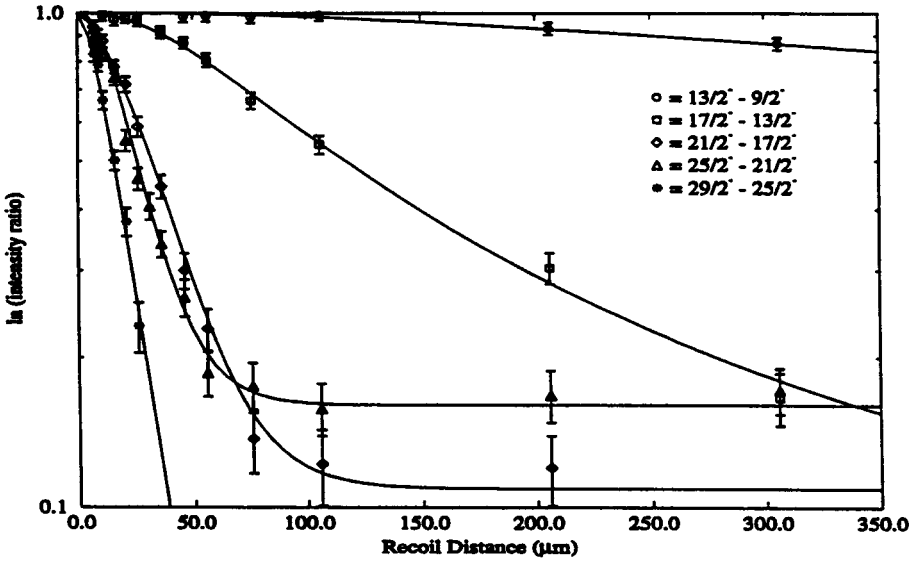

Fig. 1. Fits to levels in the $\pi h_{9/2}$ band in ^{181}Ir using the computer code LIFETIME [3].

TABLE I

Results for ^{181}Ir

$I_i - I_f$	E (keV)	τ (ps)	$B(E2)$ (e^2b^2)	Q_t
$13/2^- - 9/2^-$	187.8	210 ± 18	1.16 ± 0.10	6.03 ± 0.26
$17/2^- - 13/2^-$	335.7	14.8 ± 1.2	1.20 ± 0.10	6.03 ± 0.25
$21/2^- - 17/2^-$	455.9	3.1 ± 0.3	1.30 ± 0.13	6.19 ± 0.30
$25/2^- - 21/2^-$	546.1	1.3 ± 0.2	1.31 ± 0.20	6.18 ± 0.48
$29/2^- - 25/2^-$	605.1	0.8 ± 0.1	1.16 ± 0.16	5.77 ± 0.36
$33/2^- - 29/2^-$	621.5	2.6 ± 0.3*		
$21/2^+ - 17/2^+$	295.1	11.8 ± 0.9	2.81 ± 0.21	9.11 ± 0.35
$25/2^+ - 21/2^+$	385.0	3.4 ± 0.3	2.70 ± 0.24	8.86 ± 0.39
$29/2^+ - 25/2^+$	467.3	4.5 ± 0.5*		

*Level lifetime could not be separated from the feeding lifetime. The value given is therefore an upper limit.

TABLE II

Results for ^{187}Au

$I_i - I_f$	E (keV)	τ (ps)	$B(E2)$ (e^2b^2)	Q_t
$13/2^- - 9/2^-$	233.4	81.3 ± 8.5	1.18 ± 0.12	6.08 ± 0.31
$17/2^- - 13/2^-$	334.7	13.7 ± 1.5	1.32 ± 0.14	6.31 ± 0.35
$21/2^- - 17/2^-$	413.8	5.0 ± 0.5	1.29 ± 0.13	6.17 ± 0.31
$25/2^- - 21/2^-$	491.6	2.1 ± 0.3	1.30 ± 0.19	6.16 ± 0.44
$29/2^- - 25/2^-$	566.8	$2.8 \pm 0.3^*$		
$21/2^+ - 17/2^+$	316.4	10.8 ± 0.9	2.19 ± 0.20	8.05 ± 0.37
$25/2^+ - 21/2^+$	400.4	3.1 ± 0.4	2.41 ± 0.31	8.38 ± 0.54
$29/2^+ - 25/2^+$	470.9	1.4 ± 0.2	2.40 ± 0.34	8.32 ± 0.59
$33/2^- - 29/2^-$	470.9	$3.7 \pm 0.4^*$		

*Level lifetime could not be separated from the feeding lifetime. The value given is therefore an upper limit.

From these results, it is clear that the $\pi i_{13/2}$ orbital significantly enhances the core deformation. Indeed, the enhancement in the case of ^{181}Ir is as much as 50%. These results clearly support the explanation of the anomalous band-crossing behavior of this orbital in terms of significantly different deformations in the different bands. In addition, the data are consistent with the expectation in that the deformation of the $\pi i_{13/2}$ band would be larger in the case of ^{181}Ir than in ^{187}Au due to the location of the Fermi level (the Fermi level lies closer to the $\pi i_{13/2}$ orbital in ^{187}Au than in ^{181}Ir).

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[3] Computer code LIFETIME courtesy of J.C. Wells, Oak Ridge National Laboratory, Oak Ridge, TN, USA.