Fast beta transition in ^{183}Pt and the systematics of Nilsson states in the $N = 105$ isotones

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A β-decaying state in ^{183}Pt with a half-life of 43 ± 5 seconds is observed for the first time and is identified as ν 7/2$^-$ 514$\downarrow$ based on a logft of 4.3 deduced from the mass tables of Wapstra and Bos. It decays to the π 9/2$^-$ 514$\uparrow$ state in ^{183}Ir at 645 keV, which deexcites to the 5/2$^-$, 7/2$^-$, and 9/2$^-$ members of the 1/2$^-$ 541$\downarrow$ band at 0, 329, and 16 keV, respectively. This is strong evidence for the applicability of the Nilsson model to the light Pt isotopes.

[RADIOACTIVITY ^{183}Pt [from ^{180}W(^{14}N,$p10n$), ^{180}W(^{14}N,$\alpha 7n$), $E = 187$ MeV; ^{183}Hg and ^{183}Au decays]; mass-separated sources. Measured E_γ, $I_\gamma(t)$. ^{183}Pt [from ^{181}Ta(^{16}O,xn), $E = 160$–200 MeV]; measured $T_{1/2}$, E_γ, I_γ, $\gamma-\gamma$ and $\gamma-X$ coincidence. Deduced logft, ^{183}Ir levels, $J\pi$, Nilsson. Ge(Li), He gas-jet recoil transport, mass separation.]

A variety of isotopes, produced by deep-inelastic processes, were observed above a laboratory energy of 160 MeV during the bombardment of Ta targets with ^{16}O ions at the Oak Ridge Isochronous Cyclotron. In this initial survey the reaction products were carried to the γ-ray detectors by a He-jet recoil transport system. In particular, strong yields of ^{182}Pt and ^{184}Pt were inferred from the γ-ray data and the information given in Ref. 1; but due to a lack of γ-decay information, it was not possible to identify ^{183}Pt. The latter has been reported[2,3] as an α activity with a half-life of 6.5 min. However, five strong γ-ray lines in coincidence with Ir x-rays, and decaying with a half-life of 43 ± 5 s, were initially ascribed to ^{180}Pt or ^{181}Pt on the basis of a comparison with half-lives measured[2] by α counting.

In recent on-line investigations of the $A = 183$ mass chain at UNISOR, mass-separated sources were studied by entering the mass chain at ^{183}Hg and ^{183}Au following the bombardment of a target of ^{180}W (enriched to 92%) with 190 MeV ^{14}N ions. The same five γ-ray lines were observed (see Fig. 1) showing secular equilibrium with ^{183}Au ($T_{1/2} = 48$ s).

From the earlier coincidence and the recent multiscaling data it is now possible to assign these five lines (see Table I) to a new β-decaying state in ^{183}Pt. Based upon our coincidence data and the systematics of the $\frac{1}{2}^-$ [541] bands in the odd-Ir isotopes (Fig. 2), we propose the decay scheme shown in Fig. 3. We estimate, from the γ-ray spectra of the $A = 183$ mass separated activities (taken over an energy range of 20 to 1750 keV), that more than 50% of the ^{183}Pt decay goes to the 645 keV state. By taking the value $Q_{EC} = 4460$ keV given by Wapstra and Bos,[10] and assuming that all the ^{183}Pt decay goes to the 645 keV state in ^{183}Ir, the tables of Gove and Martin[11] yield a logft of 4.3, indicating allowed unhindered β decay. This is a particular feature of the β

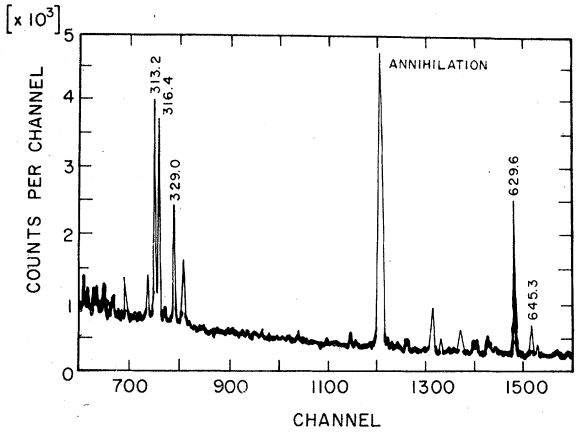

FIG. 1. Gamma-ray spectrum of mass separated, $A = 183$ activities ($E \approx 300$ to 700 keV) measured with a Ge(Li) detector. Lines assigned to ^{183}Pt (43 s) are explicitly indicated. All other lines belong to the decay of 48 s ^{183}Au.

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TABLE I. Gamma-ray lines assigned to the decay of 43 s ^{183}Pt.

E_γ[a]	I_γ[b]	Coincidences
313.2[c]	28	Ir K_α, Ir K_β, 316, 511
316.4	53	Ir K_α, Ir K_β, 313, 329, 511
329.0	36	Ir K_α, Ir K_β, 316, 511
629.6	100	Ir K_α, Ir K_β, 511
645.3	23	

[a] The errors in these energies are ±0.3 keV.
[b] The errors in these intensities are ±7%.
[c] The 313 keV line in the $A=183$ mass separated spectrum contains a ^{183}Au line of 312.4 keV. The 313.2 keV γ-ray intensity given in this table is entirely due to ^{183}Pt.

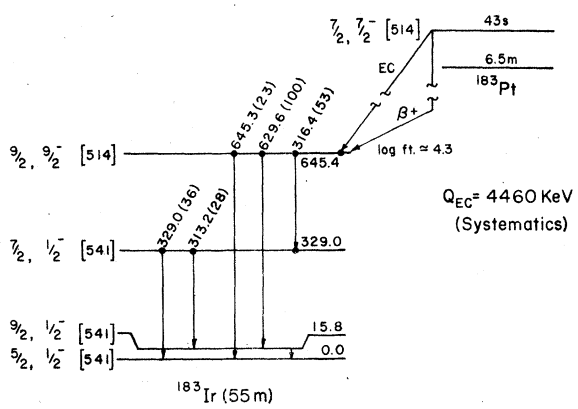

FIG. 3. Decay scheme of 43 s ^{183}Pt. We do not observe the 15.8 keV transition. The relative γ-ray intensities are given in parentheses following the transition energies. The logft is deduced from $Q_{EC}=4460$ keV (Ref. 10) and by assuming all the ^{183}Pt decay goes to the 645 keV state in ^{183}Ir (discussed further in the text).

decay of the $N=105$ isotones, being well known in ^{179}W and ^{181}Os (see Fig. 4), and is due to the Fermi energy being close to the Nilsson state $\nu\frac{7}{2}^-$ 514↓ which decays to $\pi\frac{9}{2}^-$ 514↑ in the daughter nuclei with a logft of 4.4→4.6 (Refs. 14 and 15). We thus identify the 43 s activity in ^{183}Pt as $\nu\frac{7}{2}^-$ 514↓ and propose that it is isomeric to a $\nu\frac{1}{2}^-$ 521↓ ground state which is the origin of the 6.5 min α activity assigned[2,3] to ^{183}Pt. The 6.5 min state presumably gives rise to the β strength seen by Hornshøj *et al.*[22] The assignment $\frac{9}{2}^-$ [514] to the 645 keV level in ^{183}Ir is consistent with the deexcitation of this level to the $\frac{5}{2}^-$, $\frac{7}{2}^-$, and $\frac{9}{2}^-$ members of the $\frac{1}{2}^-$ [541] band; and, its deexcitation to the $\frac{5}{2}^-$ state rules out the possibility of an $h_{11/2}$ assignment (and thus excludes the possibility that the decay is due to the spherical states $\pi h_{11/2}$ and $\nu h_{9/2}$).

The observation that the state $\nu\frac{7}{2}^-$ 514↓ persists as an identifiable structure through the $N=105$ isotones into ^{183}Pt, clearly indicates that the Nilsson model is applicable to the light Pt isotopes. This would not be expected[24] on the basis of rotational band spacing in the even-Pt isotopes and suggests that the odd-neutron is causing the core to deform. There is evidence that this effect occurs also for ^{185}Pt (Ref. 25) and for ^{177,179,181}Pt (Ref. 26), but not for the heavier odd-mass Pt isotopes (see Ref. 25). Both of these points are of particular interest for the $N=105$ isotone, ^{185}Hg. This nucleus is of historical significance in that it was unexpectedly found to have a strongly deformed ground state based on optical pumping measurements of its isotope shift by Otten and co-workers.[18] A Nilsson assignment of $\frac{1}{2}^-$ [521] was made for the 50 s ground state based on the spin and g factor deduced from these[18] measurements. More re-

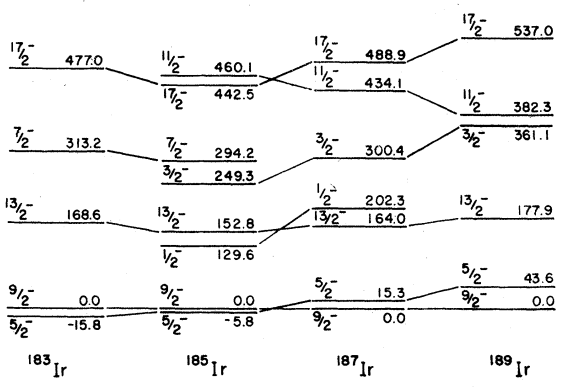

FIG. 2. The systematics of the $\frac{1}{2}^-$ [541] band through the odd-mass Ir isotopes. Energies given relative to the $\frac{9}{2}^-$ band member. Data are from this work and Ref. 4 (^{183}Ir), Refs. 4 and 5 (^{185}Ir), Refs. 6, 7, 8 (^{187}Ir), and Refs. 7, 8, 9 (^{189}Ir).

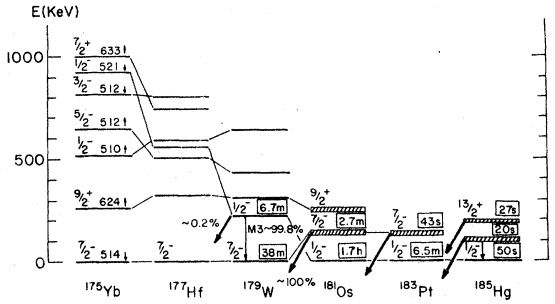

FIG. 4. The systematics of Nilsson states through the $N=105$ isotones. The energies of the $\frac{7}{2}^-$ states in ^{181}Os and ^{183}Pt and the $\frac{13}{2}^+$ state in ^{185}Hg relative to the $\frac{1}{2}^-$ ground states are unknown. Data are from Ref. 12 (^{175}Yb), Ref. 13 (^{177}Hf), Ref. 14 (^{179}W), Refs. 15 and 16 (^{181}Os), this work and Ref. 17 (^{183}Pt), and Refs. 18, 19, 20, 21 (^{185}Hg). The $\frac{13}{2}^+$ state in ^{185}Hg is a shape isomer with a weakly oblate deformation. The nature of the 20 s isomer in ^{185}Hg is discussed in the text.

cently, this group has shown[19] using laser spectroscopy that the high-spin isomer[21] ($T_{1/2}$ = 27 s) in ^{185}Hg is a near-spherical $i_{13/2}$ state with a small deformation comparable to that observed[19,27] in neighboring even-Hg isotopes. They also suggest[19] that yet another isomer exists in ^{185}Hg which is strongly deformed and has a half-life of 20 s. We see evidence[21] for the β decay of a $\lesssim$20 s activity in ^{185}Hg. Grüter *et al.*[20] report an 18 s isomeric state in ^{185}Hg and have shown that it is <14 keV above the $\frac{1}{2}^-$ 521 ground state and decays ~50% by an isomeric transition. Although our observation of the persistence of the state $\frac{7}{2}^-$ 514 through the $N = 105$ isotones to ^{183}Pt would suggest that the 20 s isomer in ^{185}Hg is also $\frac{7}{2}^-$ 514, this would be inconsistent with our β-decay scheme[21] which does not exhibit allowed unhindered behavior, and with the fact that the $M3$ transition $\frac{7}{2}^-$ 514 → $\frac{1}{2}^-$ 521 would not be as fast as the observed[20] isomeric decay in ^{185}Hg (cf. ^{179}W in Fig. 4). A possible explanation of the isomerism in ^{185}Hg is that the state $\frac{7}{2}^+$ 633 has entered the Fermi energy region: $\frac{1}{2}^-$ 521 → $\frac{7}{2}^+$ 633 gives rise to an $E3$ isomer in ^{169}Yb with a half life and decay energy[28] similar to the isomer in ^{185}Hg.

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