EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

ALPHA DECAY OF NEUTRON-DEFICIENT MERCURY ISOTOPES AND THEIR DAUGHTERS

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ABSTRACT

Half-lives, decay energies and branching ratios have been measured for the α-decay of neutron-deficient mercury isotopes and their daughters. The lightest mercury isotope, ^{177}Hg (E_α = 6.580 MeV) has a half-life of 0.17 ± 0.05 sec. The heaviest observed α-emitter is ^{188}Hg. Coincidences between α-particles and γ-rays were measured and weak transitions to excited states could be determined. The spectroscopic results are interpreted as evidence for rotational structure in the light odd-mass platinum isotopes. The existence of a pronounced even-odd variation in the Q-values for α-decay of mercury isotopes has been confirmed.

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RADIOACTIVITY $^{177,178,179,180,181,182,183,188}Hg$, $^{181,182}Au$, $^{173,174,175,176,177,178,179,188}Pt$, ^{171}Os [from Pb (p,spall.)]; measured $T_{\frac{1}{2}}$, E_{α}, I_{α}, E_{γ}, I_{γ}, $\alpha\gamma$-coin.; deduced α-branching ratios. Mass-separated samples, natural target; Ge(Li), surface-barrier Si detectors, position-sensitive Si detector.

1. INTRODUCTION

Considerable interest is attached to the study of neutron-deficient nuclides near $^{186}_{80}Hg$. For the lighter mercury isotopes a pronounced even-odd staggering of the charge radii has been observed[1], and at the same time the energy spectra of the even isotopes show a pattern that is consistent with the coexistence and crossing of two bands, one strongly deformed and one nearly spherical[2], the latter being lowest. A low-lying 0^+ excited level observed down to ^{184}Hg has been interpreted as the band head of a deformed band.

The light platinum isotopes, on the other hand, all appear deformed, and both the even- and the odd-mass isotopes show rotational fine structure[3,4]. A point of particular interest is the observation of an excited 0^+ level at approximately 500 keV; this level has been followed[5] down to ^{182}Pt.

The present work represents a continuation of previous studies[3] of the α-decay chains of the mercury isotopes. We have, in particular, been interested in confirming the irregular even-odd behaviour of the α-decay Q-value in the region $^{182-186}Hg$ and in using the α fine structure to identify rotational bands in the platinum daughter nuclides. The observation of strong even-odd effects in the inertial parameters of the platinum isotopes has already been reported[6].

2. EXPERIMENTAL PROCEDURE

Mercury isotopes were produced at the ISOLDE Facility at CERN through spallation reactions with 600 MeV protons from the synchro-cyclotron. The target of molten lead at a temperature of 700°C was vibrated mechanically[7] in order to break up oxide films which inhibit the release of mercury atoms from the target into an ion source. The chemical selectivity for mercury in this target is very high as the neighbouring elements have too low vapour pressure to be released at noticeable rates. The beam extracted from the ion source was separated into its constituent atomic masses by an analysing magnet. For a selected mass, the beam could then either be intercepted by a 20 $\mu g/cm^2$ carbon foil, or stopped on the tape of a tape-transport system[8].

Alpha-spectra were measured with a 200 mm^2 silicon surface barrier detector mounted directly behind the carbon foil. This arrangement subtended a solid angle of 21% of 4π sr. A combined source of ^{239}Pu, ^{241}Am, and ^{244}Cm served as a standard for energy calibration. The energy resolution in the experiments was typically about 25 keV full width at half maximum (FWHM). Through comparison of the intensities of α-lines from parent and daughter activities in the same spectrum, the α-branching ratios for the daughter could be deduced.

Alpha-gamma coincidence measurements were performed in order to establish α-decay to excited levels in the daughter nucleus. The mass-separated isotopes were collected on the tape and subsequently brought in front of a 100 mm^2 surface barrier α-detector. A 43 cm^2 Ge(Li) γ-detector (2.1 keV FWHM at 1.33 MeV) was placed 2 cm behind the tape viewing the collected activity through the α-detector. The energy signals for the α-particle and the γ-ray as well as the TAC signal (time difference between the detection of a α-particle and a γ-ray) were stored, event by event on magnetic tape, for subsequent playback with selected gating conditions.

3. RESULTS

In the following section, the experiments on each mass number are discussed individually. As the even- and odd-mass isotopes present rather different problems we have chosen to treat them separately. The resulting spectroscopic data are summarized in tables 1 and 2, which also summarize results from earlier investigations.

3.1 Even-mass isotopes

Mass 178

The measured α-decay energy for ^{178}Hg is in agreement with the value reported earlier[3]). Owing to the increased intensities at the reconstructed ISOLDE Facility, the half-life of ^{178}Hg could be remeasured with improved precision. The data shown in fig. 1 yield a half-life of 0.26 ± 0.03 sec, considerably lower than the old value of 0.47 ± 0.15 sec. Based on the daughter/parent ratio in the singles α-spectrum, the α-branching ratio[9] for the daughter ^{174}Pt, was determined to be 0.83 ± 0.05.

Mass 180

The α-decay energies measured for ^{180}Hg and its daughter ^{176}Pt are in agreement with previously reported values[3]. In addition to the main α-group of ^{180}Hg, an α-line of 5.860 ± 0.010 MeV, leading to the first excited 2^+ level at 263 ± 1 keV in ^{176}Pt, was observed in a coincidence experiment. The intensity of this α-group was (5.4 ± 0.9) × 10^{-4} relative to that of the ground-state transition. From the energy of the coincident γ-ray, the excitation energy of the 2^+ level was found to be 263 ± 1 keV, which is substantially larger than the excitation energy for the 2^+ levels in ^{178,180}Pt. Another α-group of 5690 ± 15 keV and an intensity of 1.2 × 10^{-4} relative to the ground-state transition was found to be in coincidence with γ-lines of 170 and 263 keV. This α-group is therefore taken to populate a second excited state in ^{176}Pt at an energy of 433 keV, a state which is de-excited by gammas of 170 keV to the first excited state.

Mass 182

Two α-lines with the energies of 5.867 ± 0.005 MeV and 5.700 ± 0.005 MeV, both previously[3] assigned to the decay of ^{182}Hg, were seen at this mass position. The latter α-group was in a coincidence experiment observed to populate a 170.7 ± 0.7 keV excited state in ^{178}Pt with an intensity of 5.8 × 10^{-3} relative to that of the ground-state transition. In addition to the α-lines mentioned above, α-particles with an energy of 5.455 ± 0.010 MeV were observed in coincidence with two γ-lines of 170.7 and 251.2 keV energy, with almost the same intensities. We therefore assign this α-group to populate a 421.9 keV level in ^{178}Pt. The intensities of the two coincident γ-rays, corrected for internal conversion[11], yielded in both cases a branch of (9 ± 2) × 10^{-4} for the 5.455 MeV α-group relative to that of the ground-state decay.

Two other α-lines, observed at this mass position, with the energies 5.458 ± 0.005 MeV and 5.302 ± 0.008 MeV have previously been assigned to the decay of ^{178}Pt by Hansen et al.[3]. The measured α-branching ratios are in good agreement with their results (table 2).

The γ-coincident α-activity at 5.455 MeV mentioned above, which in the α singles spectrum is hidden under the ^{178}Pt ground-state α-peak, was also observed by Hansen et al.[3]. Limited by their low counting statistics, they did not observe any distinct γ-lines and therefore suggested that this activity might originate from the decay of ^{182}Au. A previously unreported α-line of 5.353 ± 0.010 MeV, observed in coincidence with a 55 keV γ-ray, is assigned to the decay of ^{182}Au. The branching ratio for the 5.353 MeV α-group, deduced by means of the known α-branch of ^{182}Hg [3], was found to be $(3.8 \pm 0.8) \times 10^{-4}$. The 5.353 MeV α-line was measured to decay with a half-life of 20 ± 2 sec and thus cannot be due to cross contamination from ^{183}Au, which is reported to have a similar decay energy but a half-life of 42 sec [3,12]

Mass 188

A weak α-group of energy 4.61 ± 0.02 MeV observed at this mass number was assigned to ^{188}Hg. The total amount of ^{188}Hg atoms collected during the experiment was determined by absolute γ-counting of the residual activity of ^{188}Pt ($T_{\frac{1}{2}}$ = 10.2 d) on the collector foil. From this the α-branching ratio of ^{188}Hg was deduced to be $(3.7 \pm 0.8) \times 10^{-7}$.

By extending the measuring time to several days, an α-branching ratio of $(2.2 \pm 0.5) \times 10^{-7}$ was determined for the 3.905 ± 0.015 MeV α-group assigned[9,13] to ^{188}Pt, which is in good agreement with the findings of Karras et al.[13].

3.2 Odd-mass isotopes

In an odd-A nucleus, the α-transitions leaving the last odd particle moving in the same orbital in the daughter as that of the parent are designated as favoured transitions. These transitions are found to have reduced transition probabilities close to those for the ground-state-to-ground-state transition in even nuclei, while transitions to other states are appreciably slower. The favoured transitions therefore are a valuable tool[14] for identifying intrinsic states in odd-mass nuclei.

Mass 177

The singles α-spectrum obtained at this mass position is shown in fig. 2. The α-group assigned to ^{177}Hg was measured to have an energy of 6.580 ± 0.008 MeV in agreement with previous measurements[15]. The half-life was measured to be 0.17 ± 0.05 sec. From the daughter/parent ratio, the ^{173}Pt [16] α-branching ratio was deduced to be 0.84 ± 0.06.

Mass 179

For the single α-group earlier assigned[3] to ^{179}Hg, we obtained an energy of 6.288 ± 0.005 MeV. This α-group in all likelihood populates the ground state of ^{175}Pt, since the α-γ coincidence experiment did not show any α-lines that could be associated with the decay of ^{179}Hg.

The α-line of 5.964 ± 0.005 MeV, previously the only α-line[3,9] assigned to ^{175}Pt, was observed in coincidence with a 76.4 ± 1.0 keV γ-ray. The energy of the weak ^{175}Pt ground-state α-transition, measured from the singles spectrum, was determined as 6.038 ± 0.010 MeV. To confirm the assignment of the 6.038 MeV group to ^{175}Pt a multispectrum analysis was performed. From the growth and decay curves for the 5.964 and 6.038 MeV α-groups, the half-lives were derived to be 2.56 ± 0.10 sec and 2.54 ± 0.15 sec, respectively. These results are in good agreement with the value 2.52 ± 0.08 sec, reported for the 5.964 MeV α-group by Gauvin et al.[15]. An α-group at 5.831 ± 0.010 MeV (fig. 3) was found to be coincident with a 134.4 ± 1.0 keV as well as a 211.8 ± 1.0 keV γ-ray. Based on energy balance considerations we assign this α-group, from the decay of ^{175}Pt, to feed a 211.8 keV excited state in ^{171}Os.

The α-branching ratios for ^{175}Pt and ^{171}Os, shown in table 2, were obtained from the ratio of the daughter and parent intensities in the same spectrum. From the observed intensities, the 5.964 MeV α-group appears to be a favoured transition, so that the 76.4 keV level must have the same Nilsson quantum numbers as the ground state of ^{175}Pt. Equilibrium deformation calculations predict spin $5/2^+$ for the first excited rotational band in ^{171}Os as well as for the ground state of ^{175}Pt.

Mass 181

The investigation of ^{181}Hg concentrated on coincidence measurements in which four α-groups populating excited states in ^{177}Pt were identified. In fig. 4 is shown the singles α-spectrum obtained at this mass position. The coincident γ-spectra obtained with gates set on four of the α-peaks in this spectrum are shown in fig. 5. The decay scheme based on these observations is presented in fig. 6.

The intense line at 6.006 ± 0.005 MeV was found to populate a 147.4 keV excited state in ^{177}Pt. The half-life of this state was measured with a delayed coincidence technique. The time spectrum of the 147.4 keV γ-ray depopulating this excited state is shown in fig. 7. The half-life was determined as 2.2 ± 0.3 μsec. The fine structure reported[3] at 5.92 MeV was in the present coincidence experiment resolved into two lines with energies of 5.916 ± 0.010 MeV and 5.938 ± 0.010 MeV. The two new α-lines at 6.071 ± 0.010 MeV and 6.148 ± 0.010 MeV were also assigned to the decay of ^{181}Hg.

The odd neutron in ^{181}Hg almost certainly belongs to the orbital $\frac{1}{2}^-$ [521] as indicated by the spin and magnetic moment of this nucleus[17,18]. Consequently, the favoured α-decay to the 147.4 keV excited state shows that the same orbital must be involved in this state. The two excited levels at 211.4 and 239.8 keV appear to be the $\frac{3}{2}^-$ and $\frac{5}{2}^-$ members of this K = $\frac{1}{2}$ rotational band. The deduced value of the rotational parameters for this band (table 3) indicate that ^{177}Pt is almost as strongly deformed as the nuclides with the same number of neutrons in the rare-earth region[6].

The decay of ^{177}Pt revealed two α-lines at 5.527 ± 0.006 MeV and 5.435 ± 0.010 MeV, which in a coincidence experiment were found to populate the ground state and an excited state at 91.8 ± 1.0 keV in ^{173}Os. The absolute intensities for these transitions were obtained to be (5.0 ± 0.4) × 10^{-2} and (6.5 ± 0.5) × 10^{-3}, respectively.

In addition to the main α-group from ^{181}Au at 5.625 ± 0.005 MeV, two other α-groups were observed in a coincidence experiment. They populate excited levels in ^{177}Ir; one group at 5.480 ± 0.008 MeV, previously assigned as fine structure in the decay of ^{177}Pt by Hansen et al.[3] and in the decay of ^{181}Au by Siivola[12], was observed in strong coincidence with a 148.0 ± 1.0 keV γ-ray. Another α-group at an energy of 5.365 ± 0.010 MeV was observed to be in coincidence with a γ-line of 265.0 ± 1.0 keV. Based on the agreement between the difference in the Q_α-value and the observed γ-energies these α-groups are assigned to ^{181}Au. The α-branching ratios for the three groups are given in table 2.

Mass 183

The singles α-spectrum of ^{183}Hg reveals two α-lines with energies 5.905 and 5.830 MeV, which have previously been observed[3]. The broad α-group at 5.830 MeV is in coincidence with two γ-lines with the energies 71.4 ± 1.0 keV and 87.4 ± 1.0 keV. By selecting proper gating conditions in the coincidence analysis, it was established that the low-energy part of the 5.830 MeV peak was predominantly in coincidence with the 87.4 keV γ-ray. The counterpart of the peak showed a pronounced coincidence relation with the 71.4 keV γ-ray, while at the same time, the 87.4 keV γ-ray became suppressed. The 5.830 MeV α-peak is apparently composed of two α-lines with the energies of 5.820 ± 0.010 MeV and 5.835 ± 0.010 MeV.

The coincidence experiment at this mass also showed a weak α-line of 5.670 ± 0.010 MeV in coincidence with a 153.8 keV γ-ray. This α-group is probably populating a 241.2 keV excited state in ^{179}Pt, which in turn mainly decays by γ-emission to the 87.4 keV excited state.

The spin and magnetic moment of ^{183}Hg measured by Bonn et al.[17] indicate that the ground-state configuration of ^{183}Hg is the $\frac{1}{2}^-$ [521] Nilsson orbital. The favoured α-decay therefore identifies the ground state of ^{179}Pt as the same Nilsson orbital. The excited levels at 71.4 and 87.4 keV are taken to be the two first members of this rotational band. The energy of the 241.2 keV excited state is consistent with the calculated energy for an $I = \frac{7}{2}^-$ member of this band. As can be seen in table 3, the rotational energy constants for the $\frac{1}{2}^-$ [521] bands in ^{177}Pt and ^{179}Pt are practically equal, while the decoupling parameters differ only very little. Theoretically[16], the decoupling factor is predicted to have a value of 0.80 in this region.

Mass 185

We have no new data for this nucleus. It is tempting, however, to re-interpret the findings of Grüter et al.[19] in the following way: they observed an α fine-structure line in coincidence with two γ-lines of the energy 79 and 94 keV. They concluded that the α-group was populating a 94 keV level in ^{181}Pt, which was then depopulated through the two γ-lines. The observed decay of ^{185}Hg is very similar to what we have found in ^{183}Hg. Thus, in analogy with ^{183}Hg, one may assume that two separate α-groups with an energy difference of 15 keV are feeding excited levels in ^{181}Pt at 94 and 79 keV, respectively. The favoured α-transition of ^{185}Hg indicates that ^{181}Pt and ^{185}Hg have the same ground-state configuration[17], namely $1/2^-$ [521].

4. DISCUSSION

The favoured α-transitions from the odd mercury isotopes with mass numbers 181, 183, and 185, which identify the $1/2^-$ [521] Nilsson orbitals in the platinum daughters, have been discussed in a paper[6] preceding the present one. The moment-of-inertia parameters, extracted from the rotational fine structure, were found to show a strong staggering when compared with the same parameter for the even platinum isotopes.

Here, we focus our discussion on the new information on Q_α-values and reduced α-widths, which show unexpected features probably connected with the special character of this transitional region. The appearance of excited 0^+ levels in ^{176,178}Pt and the lifetime of the 147 keV excited state in ^{177}Pt will also be discussed.

4.1 Energy systematics

The systematics of Q_α-values for the elements osmium, platinum, mercury and lead is shown in fig. 8. The α-energies for osmium and lead fall on smooth curves, while the energies of some of the odd mercury and platinum isotopes deviate strongly from the trend followed by the even ones. The coincidence experiments presented in this paper confirm that ^{181,183,185}Hg exhibit anomalously high Q_α-values, a behaviour that earlier[3] has been observed for the mass numbers 183 and 185. The α-energy for ^{179}Hg, on the other hand, appears to follow the same trend as the even isotopes.

From mass-formula predictions one expects in this mass region an odd-even staggering of the α-energies similar to the one observed for mercury, but with smaller amplitude. It is therefore interesting to note that the absence of staggering in osmium and lead in fact seems to be as unexpected as the relatively violent deviation in mercury.

By a combination of optical- and γ-spectroscopic experimental data it is established that the odd mercury nuclei below mass 187 are strongly deformed, while the even-mass neighbouring isotopes retain near-spherical shapes. If the strongly deformed odd isotopes have an additional increase in their masses, as compared to the normal odd-even staggering, one could maybe explain the patterns for mercury and lead since this would make higher energy available for the mercury decay and at the same time imply a corresponding decrease in the Q_α-value for lead.

4.2 Alpha widths

The reduced α-widths given in tables 1 and 2 were obtained from penetrabilities calculated from the diffuse surface potential used by Rasmussen[20]. The s-wave α-widths for even-even nuclides have earlier been discussed in detail[10]. For platinum and mercury the reduced widths exhibit a very smooth behaviour with the platinum isotopes having 2 to 4 times higher widths than those for mercury[21]. With our new data we have extended the d-wave systematics to include both even and odd mercury isotopes. The d-wave α-widths shown in fig. 9 reveal an odd-even effect, where the favoured transitions in the odd-mass isotopes have higher reduced widths than the even ones. The strong hindrance of the d-wave rates in the even isotopes has earlier been discussed[10]. For the odd masses, however, it is specially interesting to observe the increasing trend with decreasing neutron number. The odd-mass isotopes show a tendency to approach the $0^+ \rightarrow 2^+$ values for the even platinum isotopes, while the widths of the even mercury isotopes tend to go in the opposite direction. The d-wave rates are expected to be enhanced from strongly deformed parent nuclei and, therefore, it appears likely that the α-widths in mercury are closely connected with the systematic change of shapes between the odd and the even isotopes.

4.3 Excited 0^+ states in the even Pt isotopes

In the even platinum isotopes, A = 180-186, a 0^+ as well as a 4^+ level are systematically found at an energy of approximately 500 keV [4,5]. The second excited state at 422 keV observed in ^{178}Pt is from the energy systematical point of view consistent with a first excited 4^+ state. The 2^+ state in ^{176}Pt is found at 263 keV and the first excited 4^+ state is from systematics[4] expected at an energy of approximately 650 keV. However, the second excited state in ^{176}Pt is observed at 433 keV.

The reduced widths for the α-decay to the second excited states in $^{176,178}Pt$ are found to be slightly larger than the widths for the d-wave α-decay (table 1) of the same nuclides. Based on the assumption that g-wave α-decay is more hindered than d-wave decay, it appears likely that these transitions represent s-wave α-decay to excited 0^+ levels. The energies found for the excited states in question agree very well with the systematics of excited 0^+ states in the heavier platinum isotopes[4].

4.4 The 147 keV state

The excited state in ^{177}Pt at 147 keV excitation energy has by means of favoured α-decay been identified as the $1/2^-$ [521] Nilsson state. The de-excitation of this 2.2 μsec state proceeds most strongly to the ground state. From systematics of the N = 99 isotones (^{165}Dy, ^{167}Er, ^{169}Yb, and ^{171}Hf)[22] the $7/2^+$ [633] Nilsson orbital could be expected to account for the ground state in ^{177}Pt. In such a case the 147 keV γ-transition would be of multipolarity E3 with an expected half-life of a few seconds. The much faster de-excitation observed indicates therefore a transition of lower multipolarity. One possibility is that the ground state has changed to the configuration $5/2^-$ [512].

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Table 1

Summary of alpha-decay measurements: mercury isotopes

Isotope	E_α (MeV)	$T_{1/2}$ (sec)	α/total[a)] (%)	Final level E (keV)	Final level I^π	Reduced width[b)] W_α
^{177}Hg	6.580 ± 0.008	0.17 ± 0.05	(85)			0.6
^{178}Hg	6.430 ± 0.006	0.26 ± 0.03	(50)	g.s.	0^+	0.8
^{179}Hg	6.288 ± 0.005		(53)	g.s.		0.7
^{180}Hg	6.120 ± 0.005		(35)	g.s.	0^+	0.7
"	5.860 ± 0.010		0.018	263 ± 1	2^+	0.005
"	5.690 ± 0.015		0.004	433	(0^+)	0.006
^{181}Hg	6.148 ± 0.010	3.3 ± 0.4	0.13 ± 0.03	g.s.		0.002
"	6.071 ± 0.010	3.4 ± 0.3	0.39 ± 0.07	81.1 ± 1.0		0.01
"	6.006 ± 0.005	3.6 ± 0.1[c)]	23 ± 4	147.4 ± 1.0	$1/2^-$	1.1
"	5.938 ± 0.010	3.4 ± 0.3	1.6 ± 0.4	214.2 ± 1.0	$3/2^-$	0.15
"	5.916 ± 0.010	3.4 ± 0.3	1.2 ± 0.5	239.8 ± 1.0	$5/2^-$	0.14
^{182}Hg	5.867 ± 0.005		9 ± 2 [c)]	g.s.	0^+	0.53
"	5.700 ± 0.005		0.052 ± 0.009	170.7 ± 0.7	2^+	0.02
"	5.455 ± 0.010		0.008 ± 0.002	421.8 ± 1.0	(0^+)	0.04
^{183}Hg	5.905 ± 0.005		10.6 ± 2.0 [c)]	g.s.	$1/2^-$	0.52
"	5.835 ± 0.010		0.61 ± 0.12	71.4 ± 1.0	$3/2^-$	0.06
"	5.820 ± 0.010		0.43 ± 0.08	87.4 ± 1.0	$5/2^-$	0.05
"	5.670 ± 0.010		0.03	241.2 ± 1.5	$7/2^-$	0.02
^{188}Hg	4.61 ± 0.02		$(3.7 \pm 0.8) \times 10^{-5}$	g.s.	0^+	0.4

a) Numbers in parentheses are estimated values.

b) The reduced widths are calculated for s-waves and are given in a scale where W_α (^{212}Po) ≡ 1 .

c) Ref. 3.

Table 2

Summary of alpha-decay measurements: mercury daughter activities

Isotope	E_α (MeV)	$T_{1/2}$ (sec)	α/total (%)	Final level E (keV)	Final level I^π	Reduced width a) W_α
^{181}Au	5.625 ± 0.005	11.5 ± 1.0 b)	0.52 ± 0.09	g.s.		0.2
"	5.480 ± 0.008	13 ± 3	0.46 ± 0.11	148.0 ± 1.0		0.7
"	5.365 ± 0.010		0.06 ± 0.01	265.0 ± 1.5		0.3
^{182}Au	5.353 ± 0.010	20 ± 2	0.038 ± 0.008	55 ± 1		0.1
^{173}Pt	6.216 ± 0.015		84 ± 6			1.1
^{174}Pt	6.035 ± 0.010		83 ± 5	g.s.	0^+	2.4
^{175}Pt	6.038 ± 0.010	2.54 ± 0.15	4.8 ± 0.8	g.s.		0.04
"	5.964 ± 0.005	2.56 ± 0.10	55 ± 5	76.4 ± 1.0		0.8
"	5.831 ± 0.010		4.7 ± 1.0	211.8 ± 1.0		0.3
^{176}Pt	5.757 ± 0.005		38 ± 3	g.s.	0^+	2.0
"	5.537 ± 0.010		0.10 ± 0.05	227.7 ± 1.0	2^+	0.14
^{177}Pt	5.527 ± 0.006		5.0 ± 0.4	g.s.		1.5
"	5.435 ± 0.010		0.65 ± 0.05	91.8 ± 1.0		0.5
^{178}Pt	5.458 ± 0.005		7.2 ± 0.8 c)	g.s.	0^+	2.3
"	5.302 ± 0.008		0.2 ± 0.07 c)	158.9 ± 1.0	2^+	0.34
^{179}Pt	5.194 ± 0.010		0.27 ± 0.04 c)	g.s.		0.9
^{188}Pt	3.905 ± 0.015		$(2.2 \pm 0.5) \times 10^{-5}$	g.s.	0^+	0.23
^{171}Os	5.267 ± 0.015		1.7 ± 0.3			1.1

a) The reduced widths are calculated for s-waves and given in a scale where W_α (^{212}Po) ≡ 1 .

b) Ref. 9.

c) Ref. 3.

Table 3

Calculated rotational parameters for the band $\frac{1}{2}^-$ [521]

Isotope	Experimental energies (keV)				Calculated energies (keV)	$\frac{\hbar^2}{2\mathcal{J}}$ a) (keV)	a a)
	$I = \frac{1}{2}^-$	$I = \frac{3}{2}^-$	$I = \frac{5}{2}^-$	$I = \frac{7}{2}^-$	$I = \frac{7}{2}^-$		
^{177}Pt	147.4	214.2	239.8		395	13.7	0.63
^{179}Pt	0	71.4	87.4	241.2	254	13.5	0.76
^{181}Pt	0	79	94		279	14.7	0.80

a) The inertial and decoupling parameters are calculated from

$$E_I = E_0 + \frac{\hbar^2}{2\mathcal{J}} \left[I(I+1) + \delta_{K,\frac{1}{2}}\, a(-1)^{I+\frac{1}{2}} (I+\tfrac{1}{2}) \right] .$$

Figure captions

Fig. 1 : Decay curve for the 6.430 MeV ^{178}Hg α-group. The half-life measurement was performed with a 45 mm × 7 mm position-sensitive detector in combination with a tape transport system[8]. The activity collected on the tape was moved continuously with a preset speed along the sensitive area of the detector. Energy and position signals were stored in a 32 (position) × 128 (energy) channel mode, where the position channels could be converted to time by means of the known speed of the tape.

Fig. 2 : Single α-spectrum for mass number 177. The inset shows the decay curve for the 6.580 MeV ^{177}Hg α-group. For this very neutron deficient nucleus, produced through the rare spallation reaction ^{208}Pb(p,3p29n)^{177}Hg, we observed an intensity of 50 α-particles per minute in a solid angle of 4π. The cross contamination from heavier mercury isotopes, observable in the spectrum, are due to tails from these, more abundant, products. The relative intensity of the neighbouring contamination ^{178}Hg is about 6×10^{-4} (normalized to the same yield) and for ^{180,181}Hg approximately 4×10^{-5} and 6×10^{-6}, respectively.

Fig. 3 : Proposed decay schemes of the ^{179}Hg α-decay chain. Estimated data are given within parentheses.

Fig. 4 : Alpha spectrum recorded at saturation of a stationary source collected from the separated ^{181}Hg ion beam.

Fig. 5 : Alpha-gamma coincidence spectra from ^{181}Hg. The energy of the gated α-peak is indicated in each spectrum. See the corresponding decay scheme, Fig. 6.

Fig. 6 : Proposed α-decay schemes for ^{181,183,185}Hg. The hindrance factor is denoted by HF. Estimated data are given within parentheses. The α-branching ratio for the 5.670 MeV ^{183}Hg α-group was estimated with the restriction that the 241.2 keV level is only de-excited by the 153.8 keV γ-ray and that this transition is a pure E2. The two α fine-structure lines in the decay of ^{185}Hg are constructed from the

data given in Ref. 19. The α-branching ratios are deduced by assuming the ratio of the α-particle intensities for the two fine-structure lines to be equal to what we observed for the fine-structure intensity ratio in ^{183}Hg.

Fig. 7 : Half-life of the 147.4 keV excited state in ^{177}Pt measured with a delayed coincidence technique.

Fig. 8 : Experimental Q_α-values as a function of neutron number for osmium, platinum, mercury and lead isotopes. Even and odd isotopes are indicated as open and filled circles, respectively.

Fig. 9 : Reduced d-wave α-widths $W_\alpha(2^+)$ as a function of the neutron number, N, of the parent. The pair of circles in the odd-mass mercury isotopes symbolize d-wave α-decay from the $1/2^-$ to the $3/2^-$ and $5/2^-$ rotational states. The figure is taken from Ref. 21.

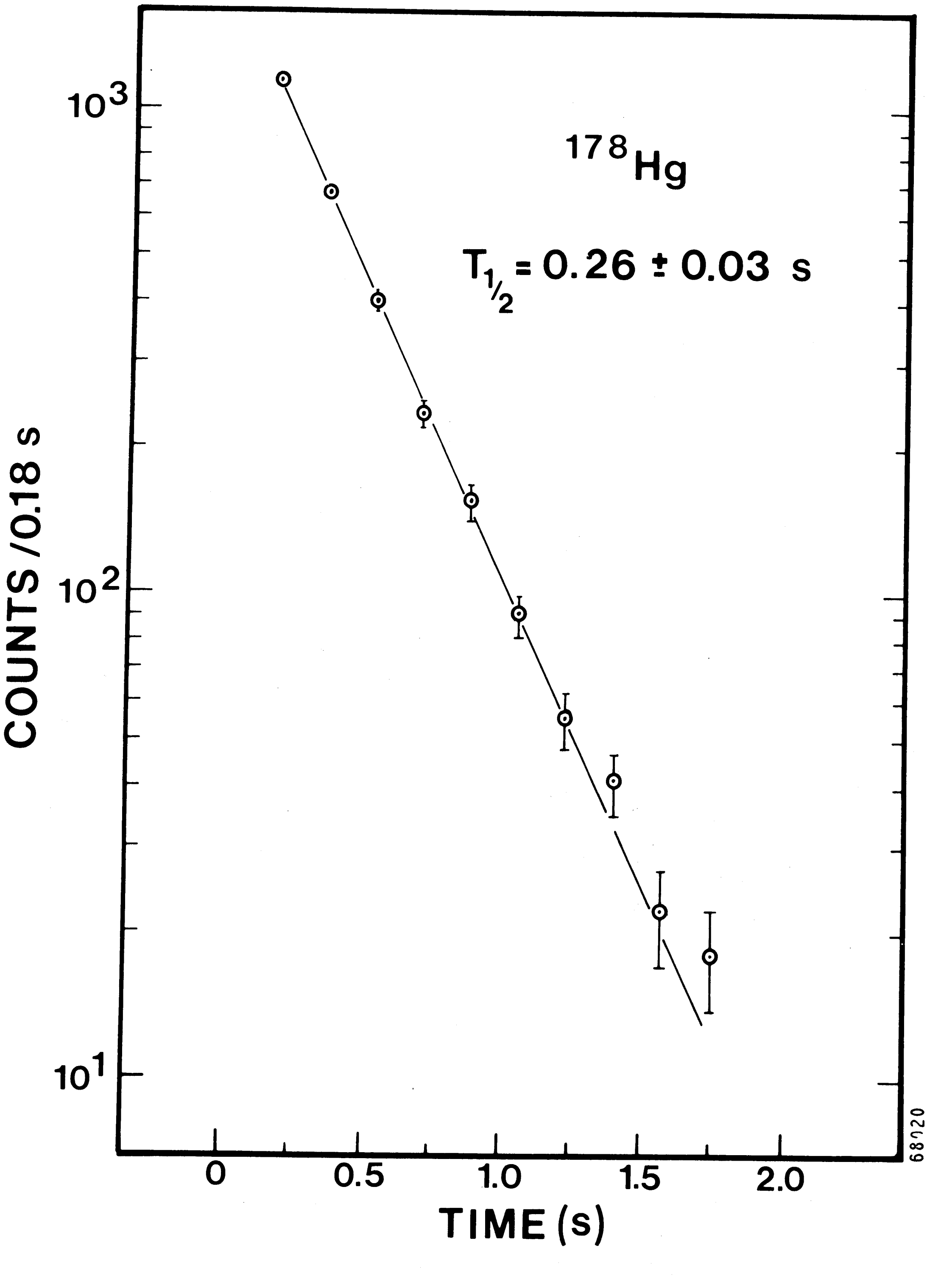

^{178}Hg
$T_{1/2} = 0.26 \pm 0.03$ s
COUNTS /0.18 s
10^3
10^2
10^1
0
0.5
1.0
1.5
2.0
TIME (s)
68120

Fig. 1

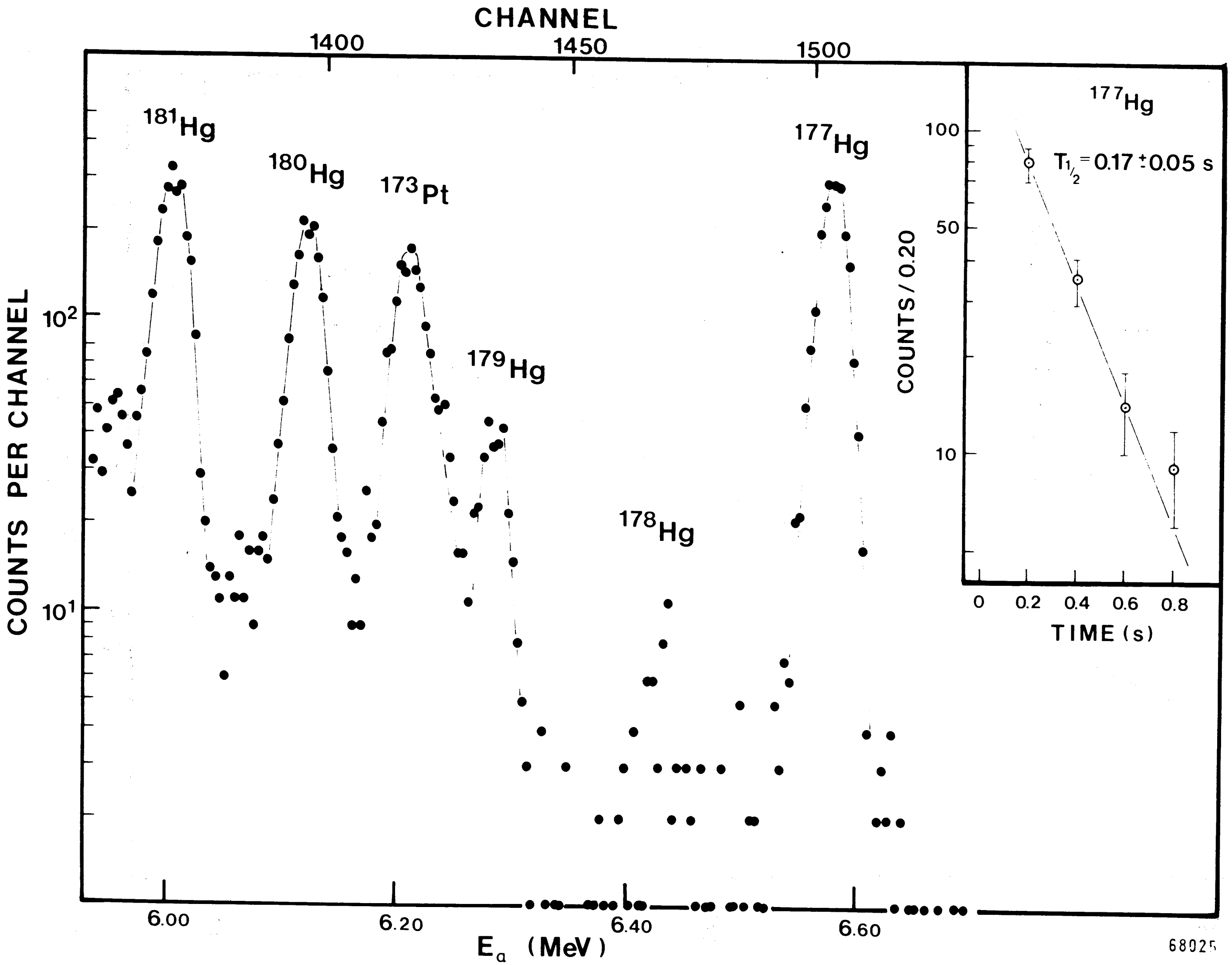
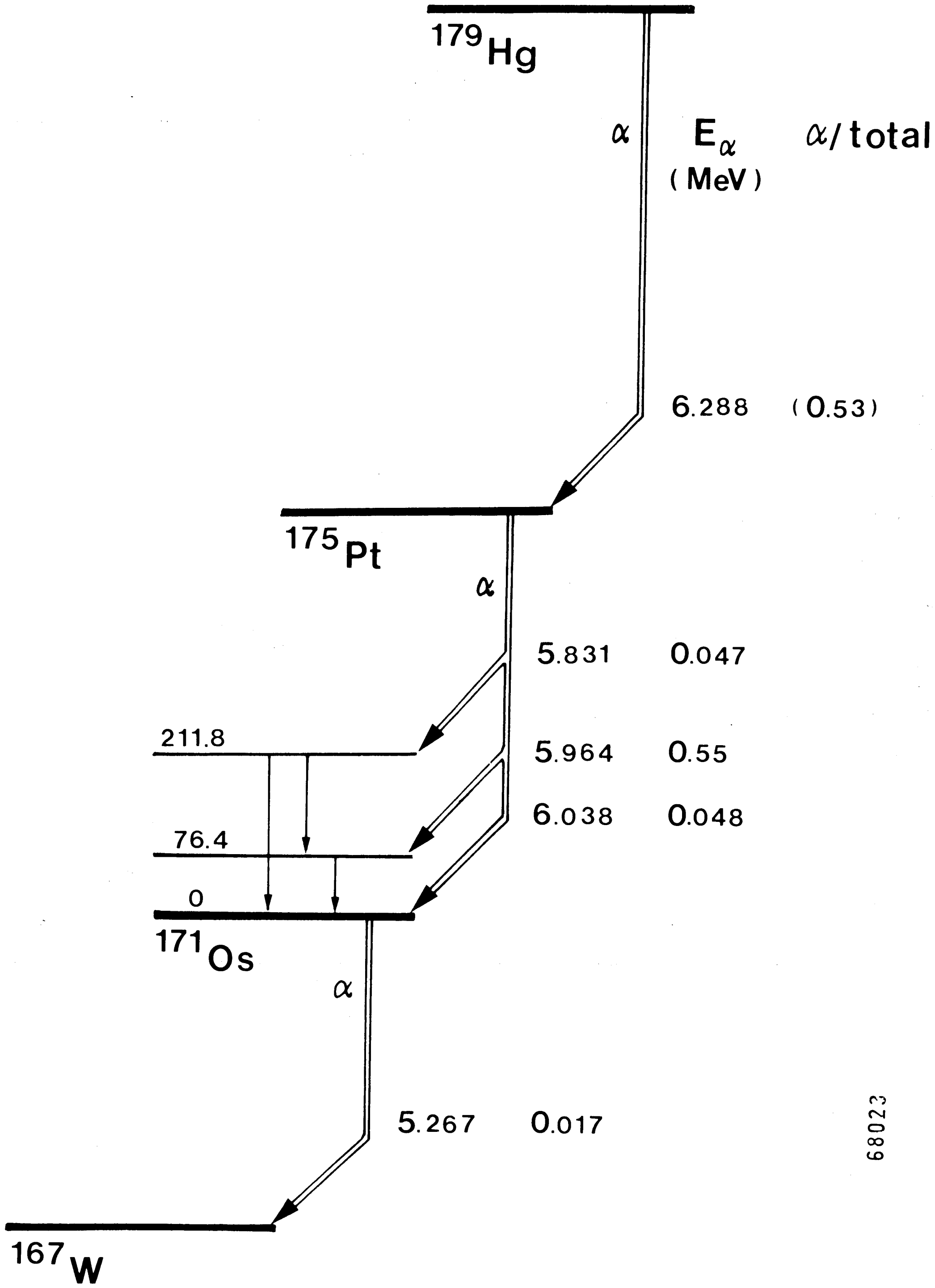

CHANNEL
1400
1450
1500
181Hg
180Hg
173Pt
179Hg
178Hg
177Hg
COUNTS PER CHANNEL
10^2
10^1
6.00
6.20
6.40
6.60
Eα (MeV)
177Hg
T1/2 = 0.17 ± 0.05 s
COUNTS / 0.20
100
50
10
0
0.2
0.4
0.6
0.8
TIME (s)
68025

Fig. 2



179Hg
α
Eα
(MeV)
α/total
6.288
(0.53)
175Pt
α
5.831
0.047
211.8
5.964
0.55
6.038
0.048
76.4
0
171Os
α
5.267
0.017
68023
167W

Fig. 3

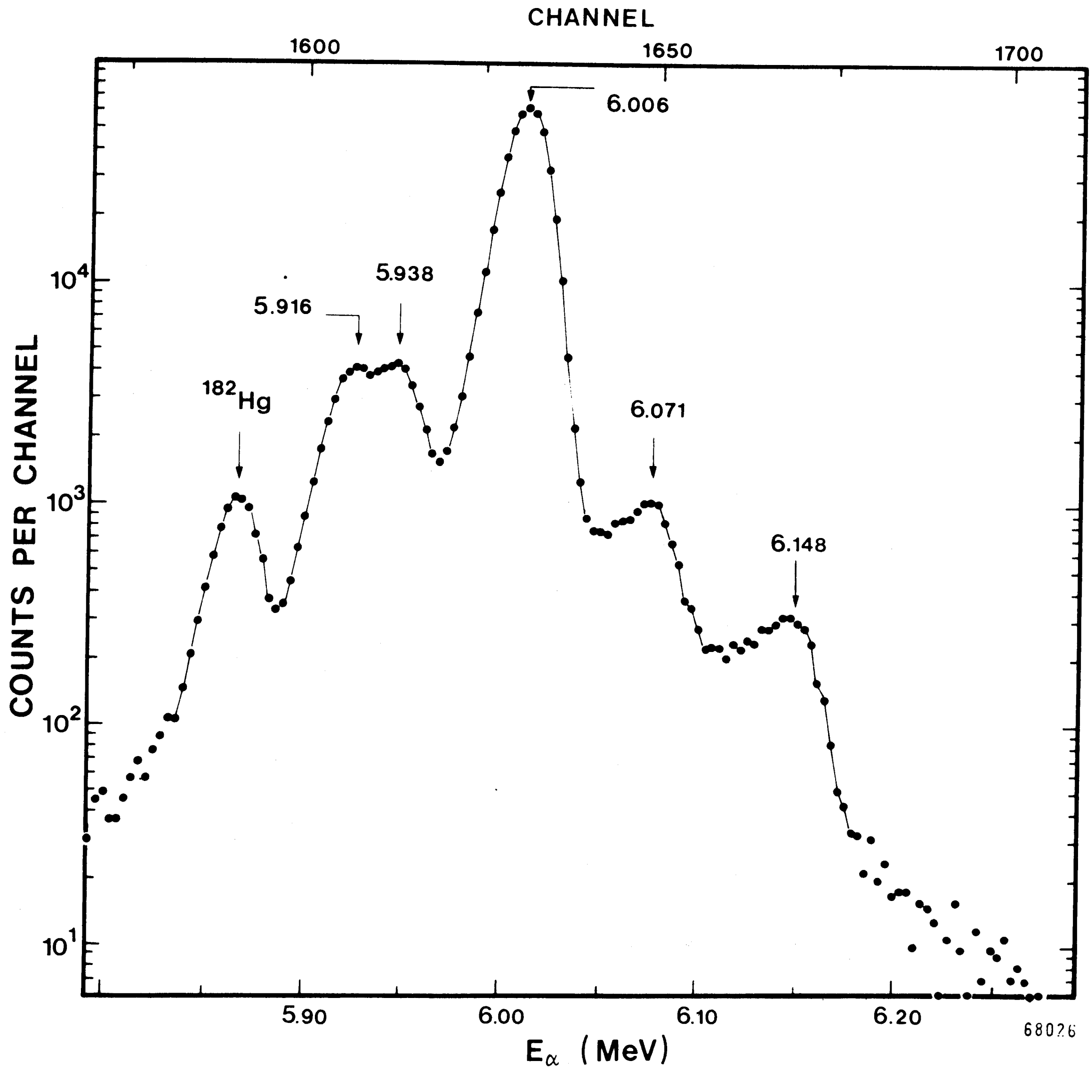
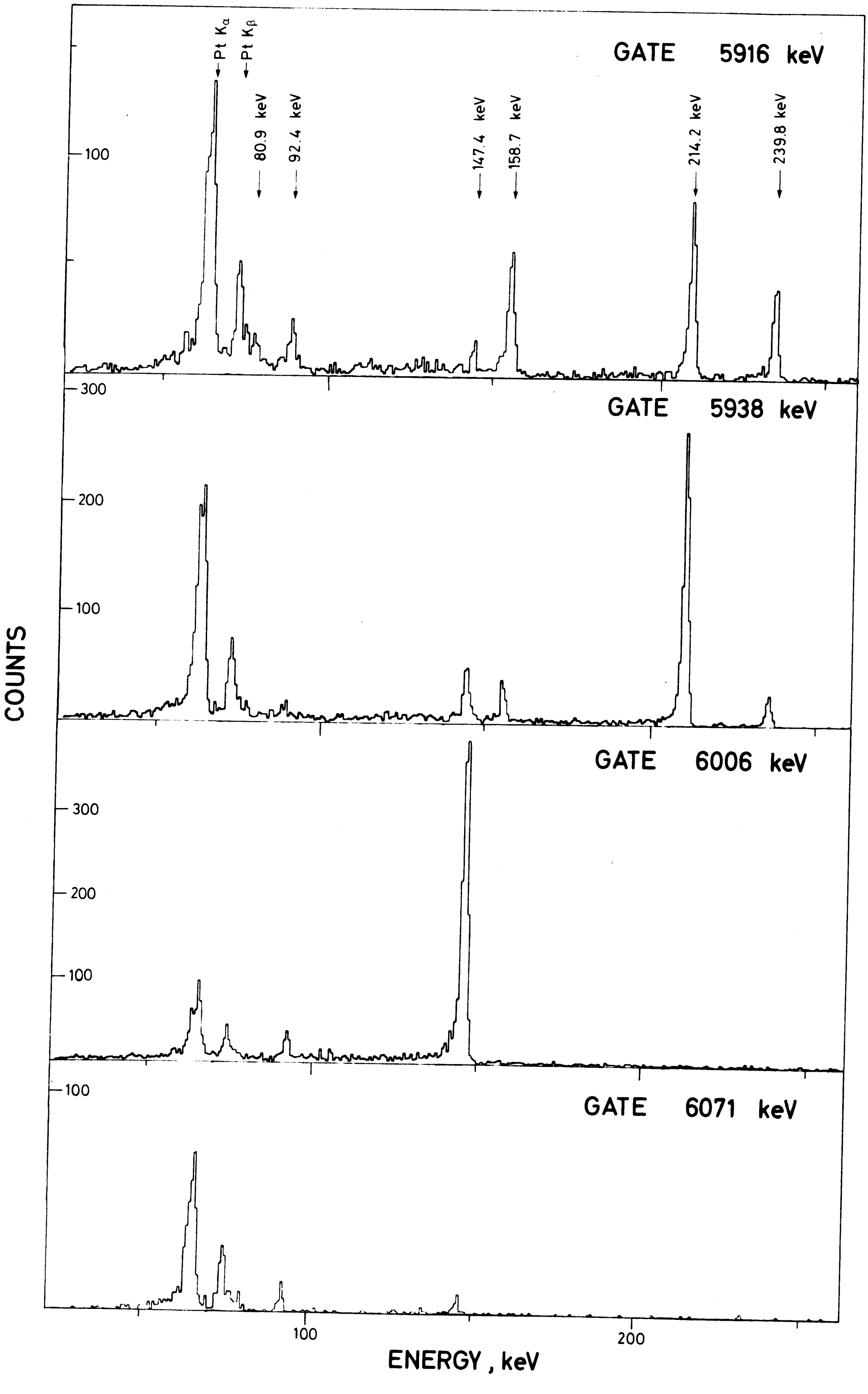
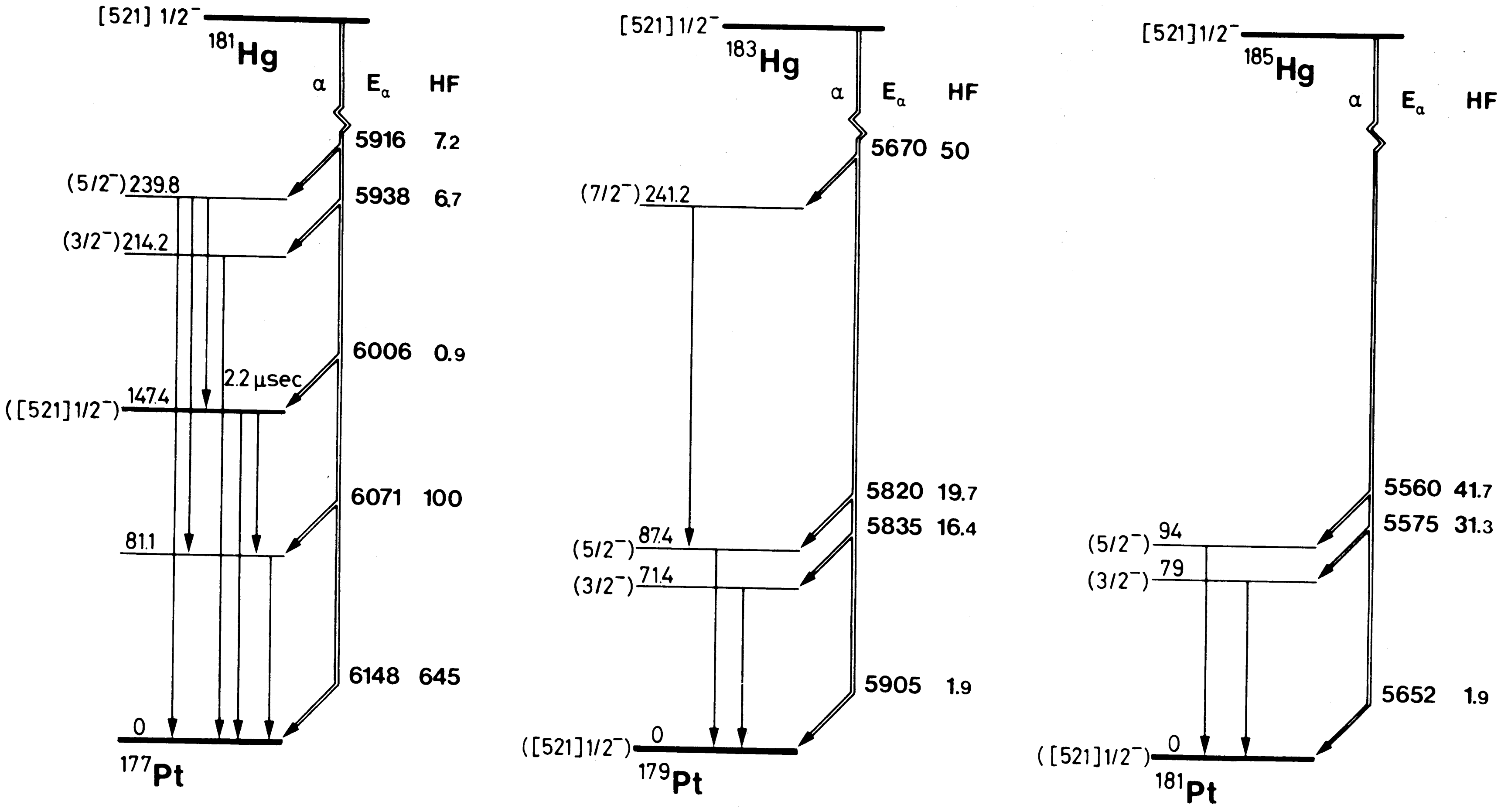

CHANNEL
1600
1650
1700
6.006
5.938
5.916
^{182}Hg
6.071
6.148
10^4
10^3
10^2
10^1
COUNTS PER CHANNEL
5.90
6.00
6.10
6.20
E_α (MeV)
68026

Fig. 4



Pt Kα
Pt Kβ
80.9 keV
92.4 keV
147.4 keV
158.7 keV
214.2 keV
239.8 keV
GATE 5916 keV
GATE 5938 keV
GATE 6006 keV
GATE 6071 keV
COUNTS
100
300
200
100
300
200
100
100
100
200
ENERGY, keV

Fig. 5



[521] 1/2⁻
181Hg
α
Eα
HF
5916 7.2
5938 6.7
6006 0.9
6071 100
6148 645
(5/2⁻) 239.8
(3/2⁻) 214.2
2.2 µsec
([521]1/2⁻) 147.4
81.1
0
177Pt
[521]1/2⁻
183Hg
5670 50
5820 19.7
5835 16.4
5905 1.9
(7/2⁻) 241.2
(5/2⁻) 87.4
(3/2⁻) 71.4
([521]1/2⁻) 0
179Pt
[521]1/2⁻
185Hg
5560 41.7
5575 31.3
5652 1.9
(5/2⁻) 94
(3/2⁻) 79
([521]1/2⁻) 0
181Pt

Fig. 6

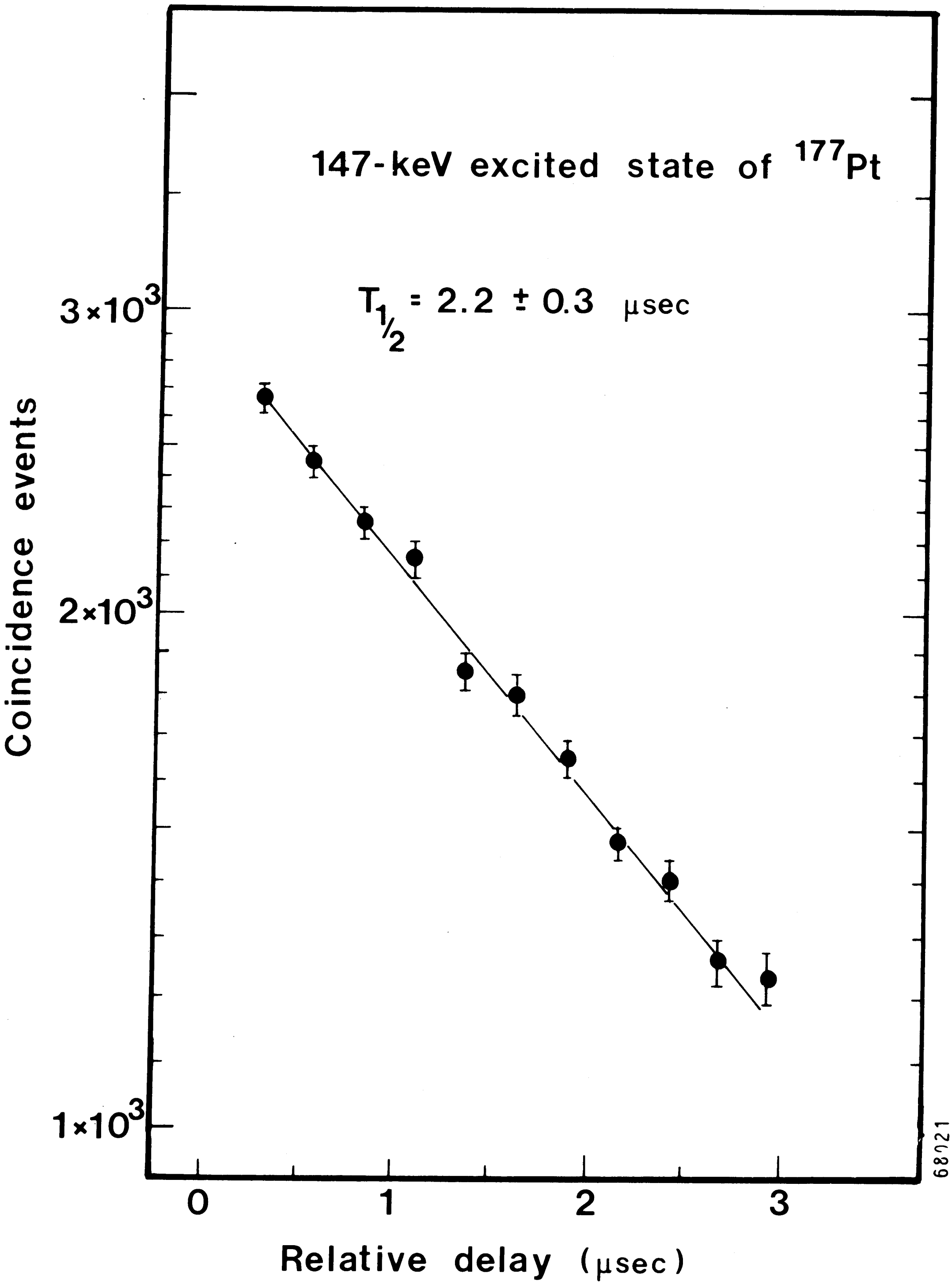

147-keV excited state of 177Pt
T1/2 = 2.2 ± 0.3 μsec
3×10³
2×10³
1×10³
Coincidence events
0
1
2
3
Relative delay (μsec)
68021

Fig. 7

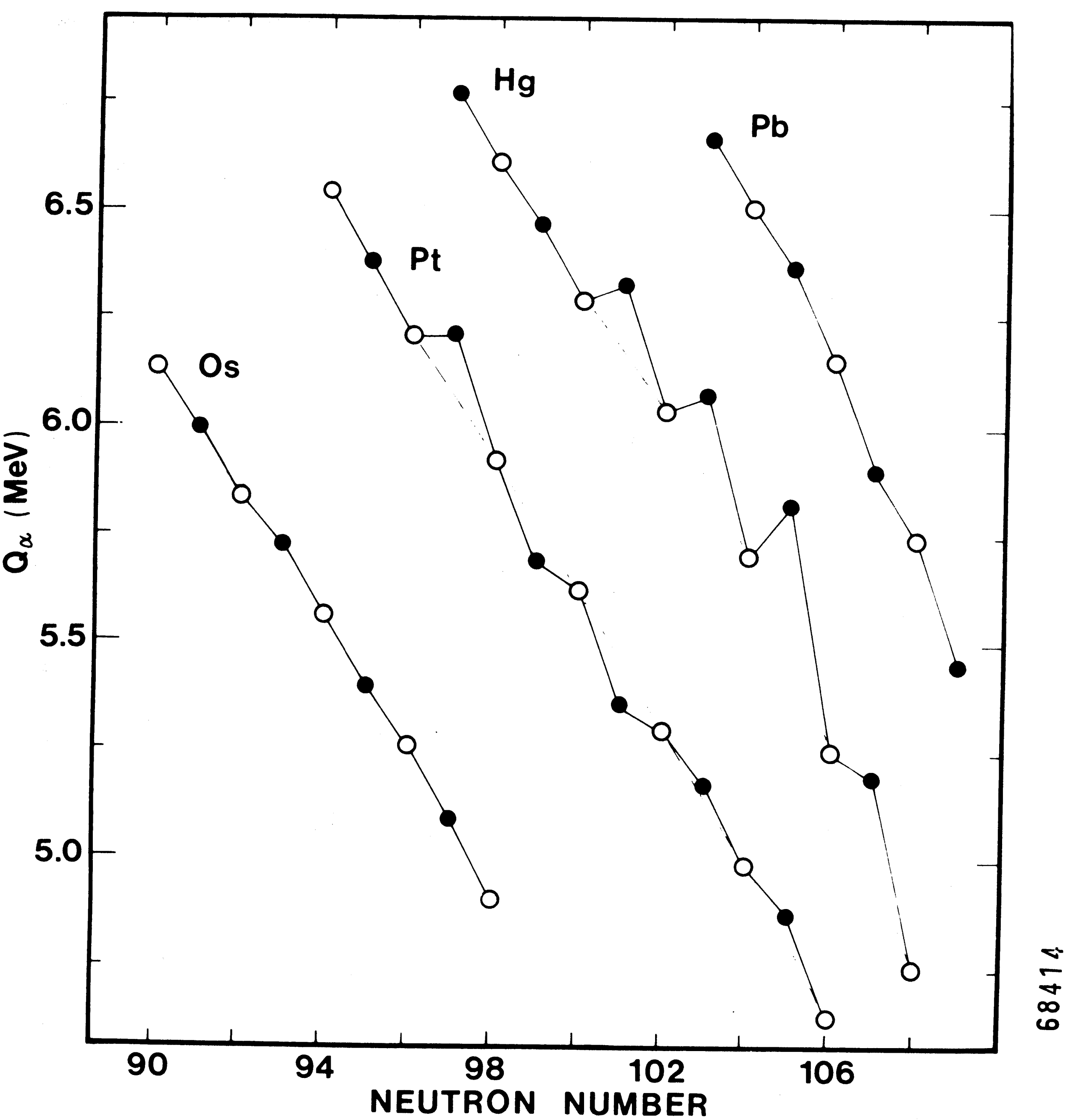
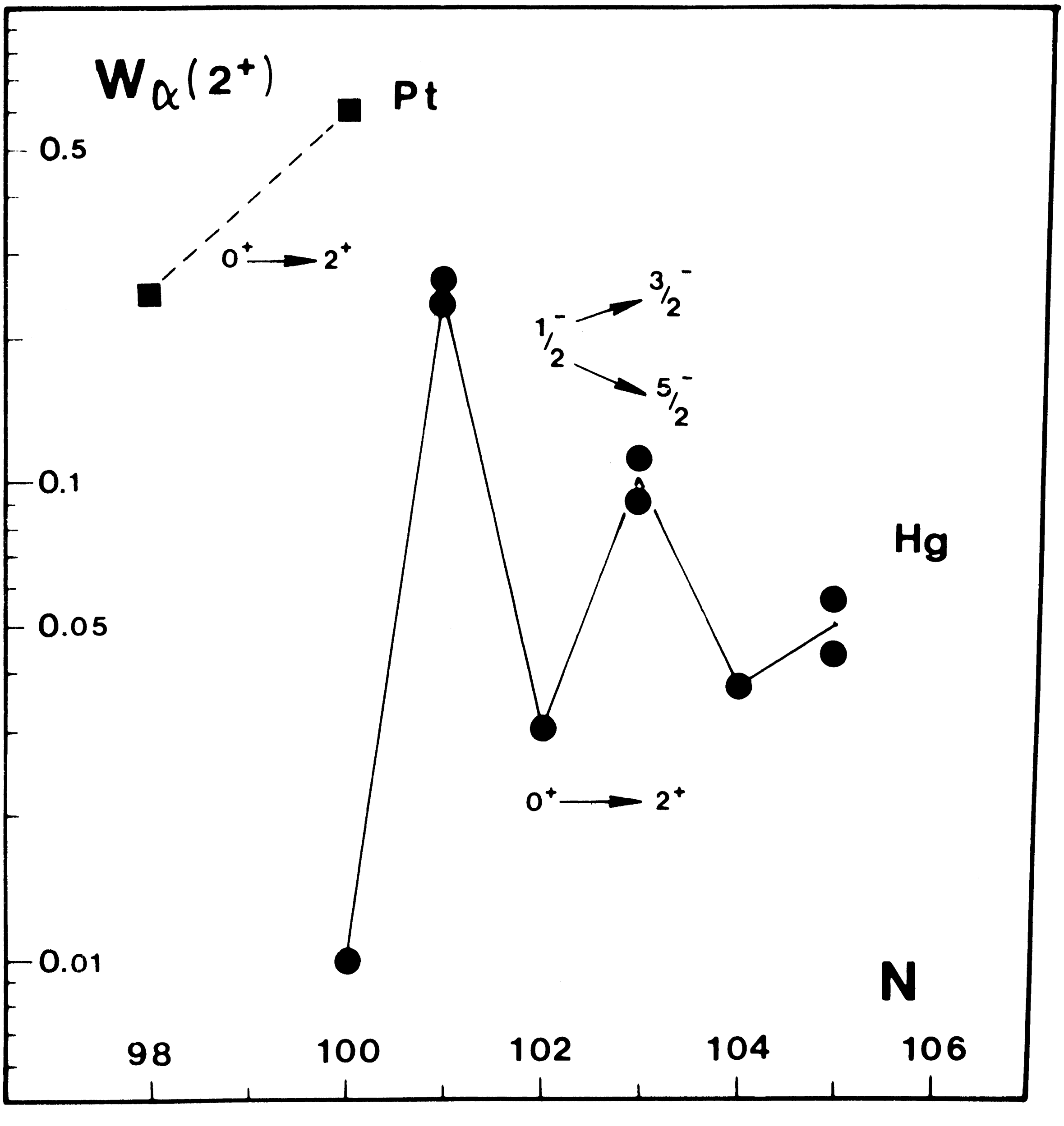

Hg
Pb
Pt
Os
6.5
6.0
5.5
5.0
Qα (MeV)
90
94
98
102
106
NEUTRON NUMBER
68414

Fig. 8



$W_\alpha(2^+)$
Pt
0.5
$0^+ \rightarrow 2^+$
$1/2^- \rightarrow 3/2^-$
$1/2^- \rightarrow 5/2^-$
0.1
Hg
0.05
$0^+ \rightarrow 2^+$
0.01
N
98
100
102
104
106

Fig. 9