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The Half Life of the 53 keV Level in ^{197}Pt

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ABSTRACT

The half life of the recently proposed 53 keV level in ^{197}Pt has been measured to 18.5 ± 1.5 nsec using the delayed coincidence technique. This level, which is identified with the $f_{5/2}$ single particle state, decays directly to the $p_{1/2}$ ground state in ^{197}Pt. The reduced E2 transition probability for this 53 keV transition has been deduced and compared with the results obtained for the corresponding transitions in other Pt, Hg, and Pb isotopes and with the theoretical predictions by Sorensen and by Wahlborn and Martinson.

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1. INTRODUCTION

For many years a problem has existed in understanding the decay mode of the 97 min isomeric level in ^{197}Pt. An observed 346 keV M4 transition was later shown to be responsible for the main deexcitation of this isomeric state, generally believed to be the $13/2^+$ state expected in the odd mass platinum isotopes. This 346 keV M4 transition can, however, only take away four units of angular momentum and thus the transition will end on a $5/2^-$ level, while the ground state was expected to have a spin and parity of $1/2^-$ or possibly $3/2^-$. This dilemma has recently been solved when Emery and Sehgal [1] found the L_2 and L_3 conversion electrons from a 53 keV transition in coincidence with the 346 keV isomeric transition. The L subshell conversion electron intensities of the 53 keV transition were shown to be consistent with an E2 multipolarity, but it was not possible to definitely exclude an M1 admixture (< 60 %). There is, however, nothing in the known experimental facts that speaks against the level sequence in ^{197}Pt being $i_{13/2} \rightarrow f_{5/2} \rightarrow p_{1/2}$, which would be in accordance with systematics. To add to the information on the decay properties of the ^{197}Pt isomer we have measured the half life of the proposed 53 keV level. This has also a special interest as Sorensen [2], using the pairing plus quadrupole Hamiltonian for spherical nuclei, has calculated the reduced E2 transition probabilities for the $f_{5/2} \rightarrow p_{1/2}$ transition in some of the odd-A platinum isotopes. Transition rates of this kind have also recently been evaluated by Wahlborn and Martinson [3] assuming a quasi-particle model of the nucleus.

2. EXPERIMENTAL PROCEDURE

2.1 Source preparation

All sources were prepared from isotopically enriched ^{196}Pt metal*) which was mechanically worked into a fine powder. When pure alcohol was added the smallest grains went into a suspension which was

*) The enriched material was obtained from Stable Isotopes Division, Oak Ridge National Laboratory, Tennessee. Ths isotopic composition was ^{190}Pt < 0.05 %, ^{192}Pt 0.05 %, ^{194}Pt = 6.57 %, ^{195}Pt = = 26.18 %, ^{196}Pt = 65.55 % and ^{198}Pt = 1.7 %.

centrifuged on to a thin Mylar source backing. Several sources of 5 mm diameter and 0.1 - 0.3 mg/cm^2 thickness were prepared by this method. These sources were then irradiated in the R2-0 reactor at Studsvik with an average thermal neutron flux of 10^{13} n/cm^{2}sec.

2.2 Instrumentation

The basic instrument used in these measurements is a long lens electron-electron coincidence spectrometer very similar to the one described earlier by Gerholm and Lindskog [4]. The time to pulse height converter used in this experiment utilized the internal sweep of an oscilloscope. Its electrical design is a slightly modernized version of the one described by Thieberger [5]. The time calibration was made using the internal delay of the oscilloscope itself, which in turn had been compared with a 10 Megacycle crystal oscillator. To check the overall performance of the electronic system we measured the half life of the well known 482 keV level in ^{181}Ta, for which we found $T_{1/2}$ = (10.6 ± 0.3) nsec, in good agreement with previous investigations [6].

2.3 Half life measurement

The half life measurement was performed by measuring the delayed coincidence time distribution between the 346 and 53 keV transitions. The 346 K conversion electrons were fed to the external sweep trigger of a Tectronix 545 oscilloscope, while the 53 L conversion electrons were fed to the specially built sampling unit [5]. A typical example of an observed time distribution is shown in fig. 1. Several such decay curves were measured and analyzed by a least squares fit to a function essentially consisting of a single exponential decay plus a constant background [7]. As a mean value out of six measured delayed coincidence time distributions we obtained a half life for the 53 keV level in ^{197}Pt of $T_{1/2}$ = 18.5 ± 1.5 nsec.

3. DISCUSSION

From our measured half life $T_{1/2}$ = 18.5 ± 1.5 nsec, the transition energy 52.95 ± 0.05 keV [1] and the total conversion coefficient α = 110 ± 10 (obtained from the tables of Rose [8] and including a 30 %

reduction of the M shell conversion coefficient [9] due to the screening effect of the inner electrons), we obtain the reduced E2 transition probability for the 53 keV transition in ^{197}Pt to $B(E2)\downarrow = (6.6 \pm 0.8) \times 10^{-50}$ e^2 cm^4. When this value is compared with the single-particle estimate (see fig. 2) the 53 keV transition is found to be enhanced by a factor of ten.

Wahlborn and Martinson [3] have introduced a frame of reference built on a quasi-particle model which incorporates some more realistic features than the simple single-particle shell model. According to this description the reduced E2 transition probability can be written

$$B(E2,\ j \rightarrow j')_{qp} = C(E2,\ j \rightarrow j')\ P_-^2 (1+\eta)^4 (\epsilon + x_2)^2$$

Here P_- is a pairing factor, $(1+\eta) = (\frac{A}{A_o})^{1/3}(1 + \frac{\delta r_o}{r_o})$, where A_o equals 207 and $\frac{\delta r_o}{r_o}$ takes into account a possible deviation of the radius r_o, and finally $\epsilon + x_2$ is an effective charge with $\epsilon = 1$ for an odd proton transition. For single-particle transitions x_2 is expected to be of the order of 1, while collective transitions should give x_2 values of the order of 10. The C-factor mainly consists of a standard radial matrix element. In the case of the 53 keV E2 transition in ^{197}Pt the following values are valid: $C(E2,\ 5/2 \rightarrow 1/2) = 8.3 \times 10^{-3}$ e^2 barns, $P_-^2 = 5.3 \times 10^{-2}$ and $1 + \eta = 0.95$. These values together with our experimental value of $B(E2,\ 5/2 \rightarrow 1/2) = (6.6 \pm 0.8) \times 10^{-2}$ e^2 barns gives $x_2 = 12.6$. This high value of x_2 shows that this E2 transition is mainly of collective character. This is in agreement with what has been observed in the corresponding transitions in other odd-A platinum and mercury isotopes [3].

In the calculations by Sorensen [2] the collective contribution has been explicitly included. Our experimental result is in excellent agreement with the reduced E2 transition probabilities predicted from these calculations. To see if this result has general validity we have gathered together in fig. 2 the known experimental data for the cases which are assumed to be $2f_{5/2} \rightarrow 3p_{1/2}$ transitions. The predicted $B(E2)\downarrow/2J_f + 1$ values are usually confirmed by the experiments within

a factor of 2. In the case of the Pb isotopes, however, where the theory suggests a drastic change when adding pairs of neutrons, experiments show a smoother behavior.

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CAPTIONS TO FIGURES

Fig. 1 Delayed time distribution obtained by taking coincidences between the 346 K and 53 L conversion electrons. From the slope the half life of the 53 keV level in ^{197}Pt was found to be 18.5 ± 1.5 nsec.

Fig. 2 $B(E2)\downarrow/2J_f + 1$ in units of 10^{-50} e^2cm^4 given as a function of different odd neutron nuclei. The following notations are used:

o	Experimental value obtained from half life measurement
x	Experimental value obtained from Coulomb excitation
———	Sorensen predictions [2]
– – –	Single particle estimate [10]

^{195}Pt, ^{197}Hg, ^{199}Hg, ^{203}Pb and ^{207}Pb: Data taken from [3]

^{195}Hg: Data taken from [11]. If the measured half life of 0.79 ± 0.07 nsec does not belong to the 53.4 keV level in ^{195}Hg, the value of $B(E2)\downarrow/2J_f + 1$ given in the figure is only a lower limit

^{197}Pt: Present investigation

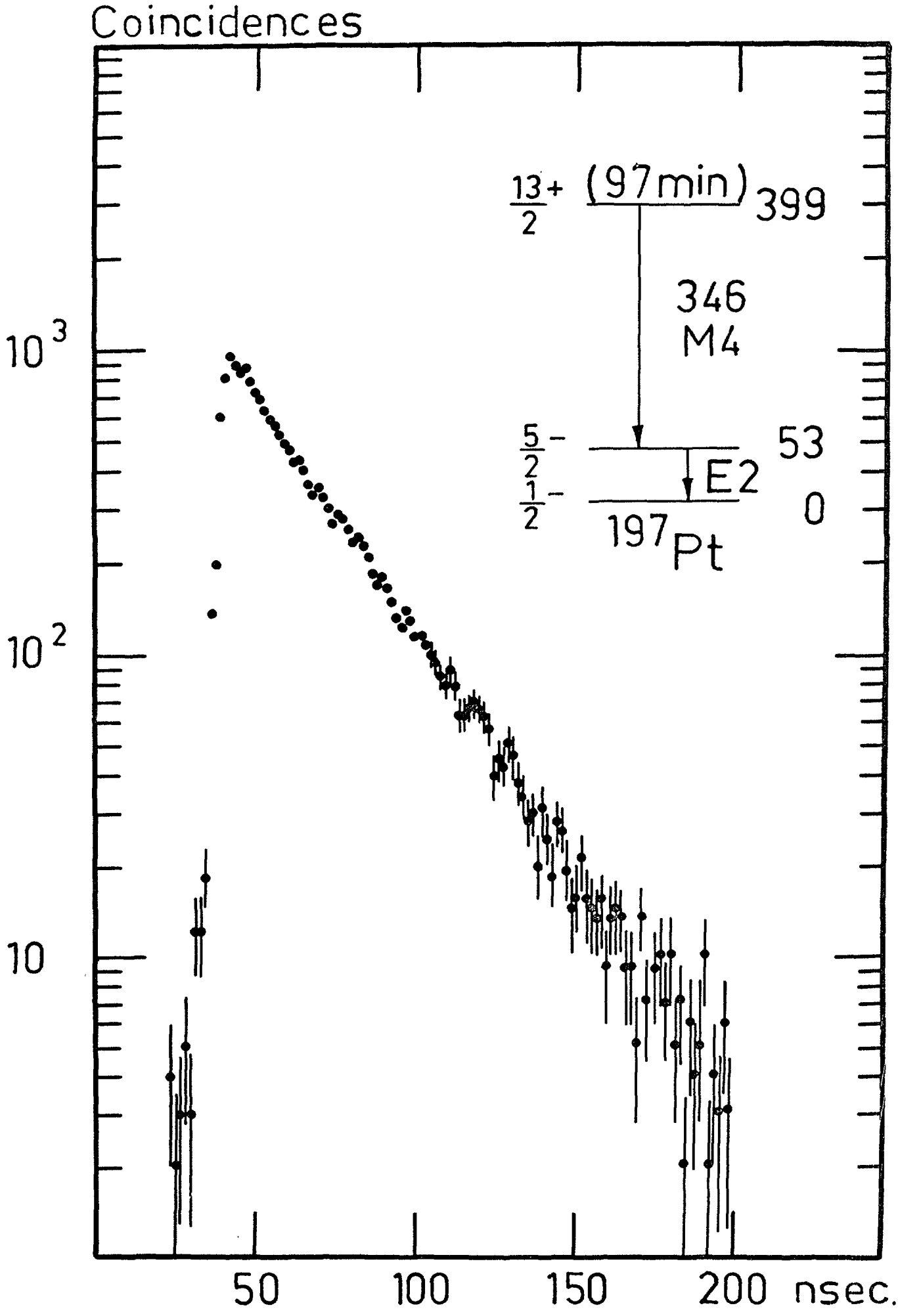
Coincidences
10^3
10^2
10
50
100
150
200 nsec.
$\frac{13}{2}^+$ (97min) 399
346
M4
$\frac{5}{2}^-$ 53
E2
$\frac{1}{2}^-$ 0
^{197}Pt

Fig. 1

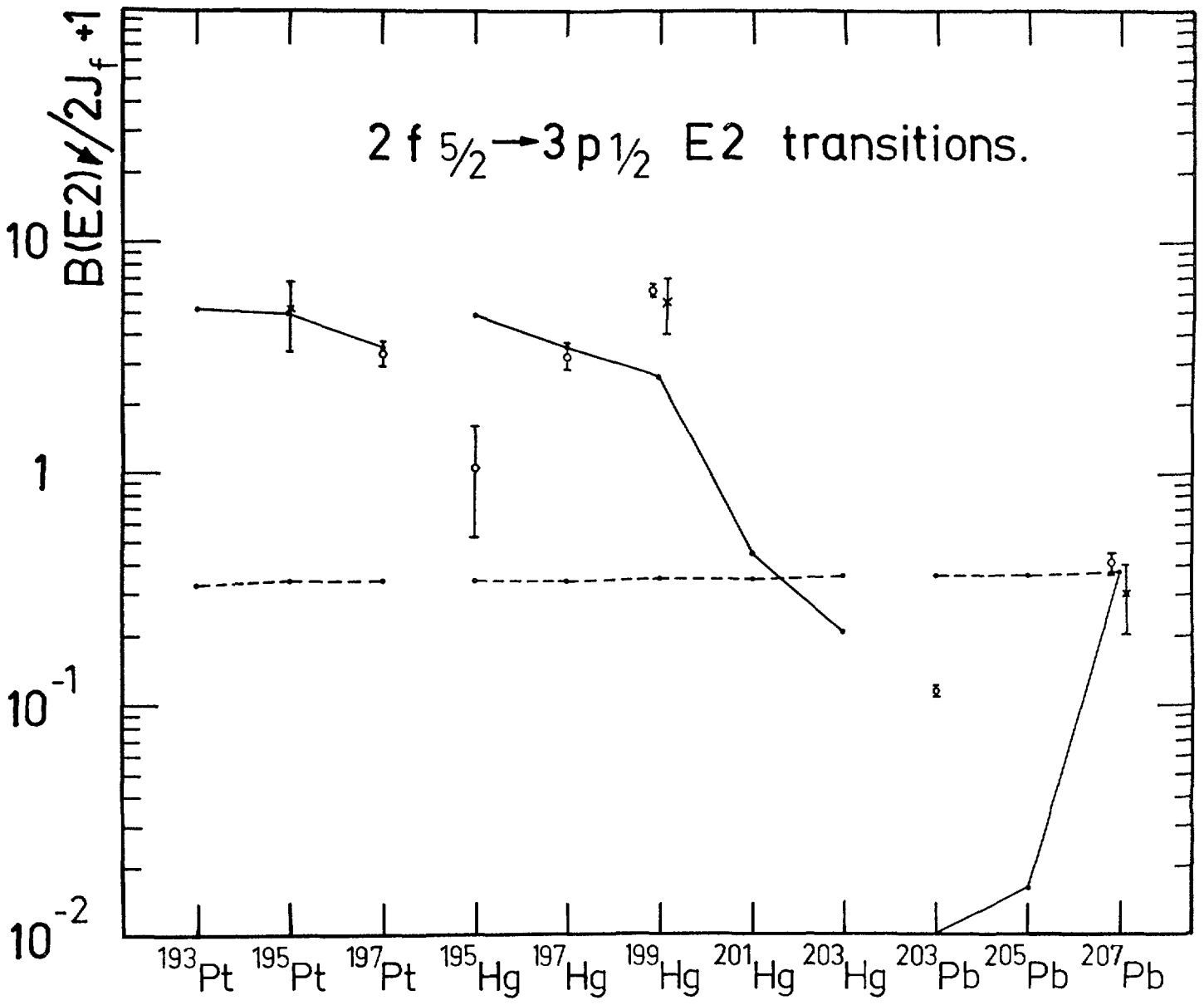
2 f 5/2 → 3 p 1/2 E2 transitions.
B(E2)↓/2J_f+1
10
1
10^-1
10^-2
193Pt
195Pt
197Pt
195Hg
197Hg
199Hg
201Hg
203Hg
203Pb
205Pb
207Pb

Fig. 2

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