PROPERTIES OF PARTIAL RADIATION WIDTHS IN ^{196}Pt

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A point of central importance in the study of radiative neutron capture is a precise determination of the statistical law which governs the fluctuations from resonance to resonance in the partial radiation width for a transition to a particular final state. Because such a radiative transition appears to procede by way of a single exit channel, this law is expected to be the same as that known to apply to neutron widths, i.e., the Porter-Thomas distribution[1] which describes the widths for a single-channel process. Unfortunately, experimental limitations in previous experiments have prevented a definitive determination of the distribution. However, the recent development of lithium-drifted germanium γ-ray detectors[2] with their excellent resolution and relatively high efficiency has made possible a measurement of greater precision for a significantly larger statistical sample. We wish to report the results of such a study of resonance capture in ^{195}Pt, which confirms the validity of the Porter-Thomas distribution for partial radiation widths and also furnishes new information of use in studying the nuclear structure of ^{196}Pt.

^{195}Pt is a particularly favorable target nucleus for such a study because of the large number of resonances at low energy with spin and parity 1^-. In these resonances intense electric dipole transitions can occur to the ground state (0^+), first (2^+), and second (2^+) excited states of ^{196}Pt, whose properties are well established. We have observed capture spectra for such resonances by irradiating a natural platinum target 5 mm thick in a neutron beam of the Saclay electron linac at a position 29 m from the neutron source. Gamma rays were detected in a Ge-Li detector of 6-cc sensitive volume, 10 cm from the target center. The resolution in γ-ray energy was limited by electronic drift to 15 keV at 8 MeV. The neutron energies were determined by measurement of their time of flight with a resolution which was 10 nsec/m at 700 eV. The data consisting of events characterized by two parameters, γ-ray pulse height and time of flight, were recorded and analyzed in 1024×4096 channel detail by means of a magnetic-tape multiparameter analyzer.

The capture spectra for four resonances in ^{195}Pt with spin and parity 1^- are shown in Fig. 1. In the region of γ-ray energy corresponding to transitions to states within 1.4 MeV of the ground state of ^{196}Pt, i.e., gamma-ray energies greater than 6.5 MeV, each of these spectra is dominated by one transition; the others are either weak or unobservable. They illustrate the large fluctuations from resonance to resonance known to characterize partial radiation widths. A precise determination of the law associated with these fluctuations has been attempted in at least three earlier experiments.[3-5] It has been customary to analyze data in terms of the family of χ^2 distributions with ν degrees of freedom, as proposed by Porter and Thomas.[1] The value $\nu=1$ corresponds to the Porter-Thomas distribution, while the value $\nu=2$ is a simple exponential. Previous results[3-5] indicated that the value of ν for partial radiation widths is small, in the range 1-3. The uncertainty can be attributed in part to the limited statistical samples considered and in part to uncertainties in the involved analysis requited to extract intensities from spectra in which individual transitions were not resolved.

In this experiment for a determination of ν, the analysis was restricted to the transitions to the ground state and first two excited states of ^{196}Pt at 0, 356, and 689 keV, respectively. Over this interval effects of change in detector efficiency were found to be negligible. The spectra were analyzed for 22 resonances in the interval 0 to 680 eV whose spin and parity is 1^-. The assignments of spin were made independently for 19 of these by transmission and total capture-cross-section measurements.[6] The additional three cases directly identified in this experiment should not introduce a significant statistical bias, since the transmission measurements indicate that only two other pos-

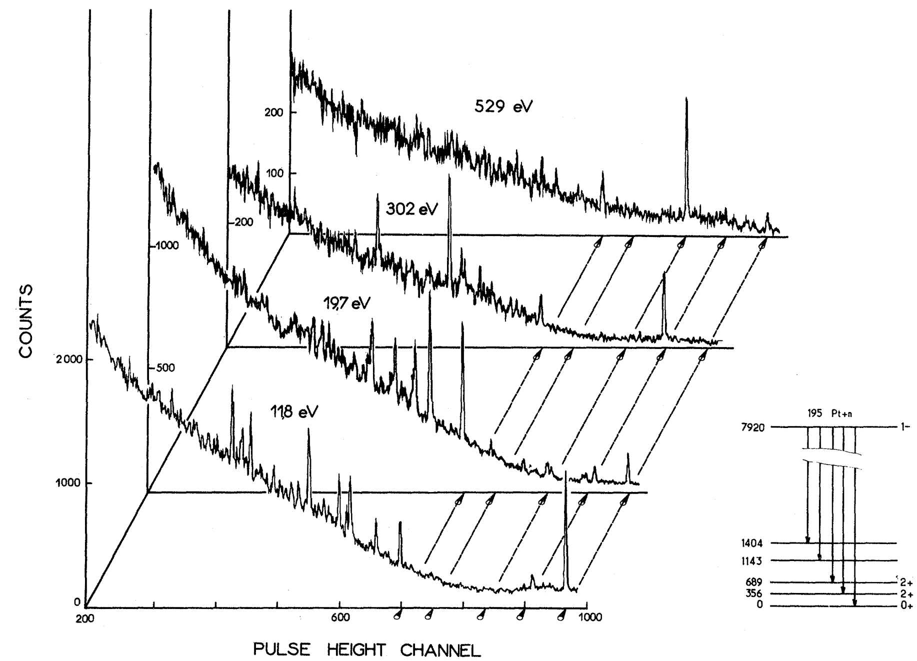

FIG. 1. Capture spectra for resonances in ^{195}Pt at 11.8, 19, 302, and 529 eV. The expected positions of the second escape peaks for the five transitions of highest energy are indicated.

sible 1^- resonances remain in the energy interval which could be added to the sample.

The number of neutrons captured in each resonance was assumed to be proportional to the total number of events with an energy greater than 1.6 MeV. The resulting distribution of the widths normalized to a mean value of 1 for the population of 66 members is shown in Fig. 2.

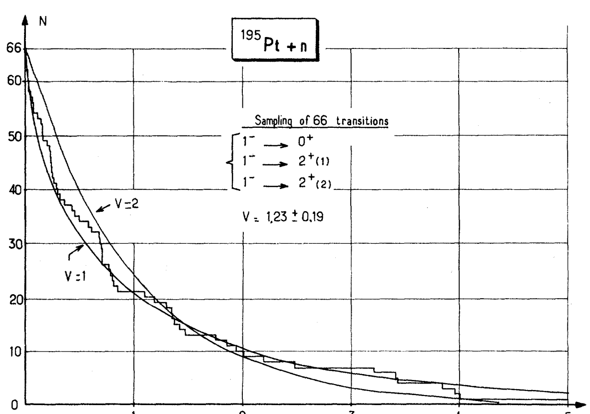

FIG. 2. Observed distribution of partial widths for 66 transitions. The number of transitions with relative widths greater than $\Gamma_i/\overline{\Gamma}_i$ is plotted against $\Gamma_i/\overline{\Gamma}_i$. The corresponding curves are shown for $\nu = 1$, the Porter-Thomas distribution, and $\nu = 2$, the simple exponential.

No attempt was made to correct the individual intensities for differences in the mean values of the three transitions. However, preliminary calculations indicate that corrections based on the observed mean values would not significantly alter our conclusions. A visual comparison with the curves shown for $\nu = 1$ and $\nu = 2$ reveals that the data agree with the Porter-Thomas distribution and definitely not with the exponential. The maximum likelihood value used in previous experiments to summarize the data is $\nu = 1.23 \pm 0.19$ for the 66 transitions. For the distribution corresponding to the sum of the three transitions in each resonance, it is $\nu = 3.57 \pm 1.00$. Thus, for ^{196}Pt, the process of decay by radiative transition is observed to be consistent with the picture of a single-channel process.

Because of the properties of the Porter-Thomas distribution, it is often difficult to extract extensive information on the nuclear structure of a nucleus from a study of thermal capture or of a few resonances. In such experiments, the absence of a transition of observable strength in a given energy region is not evidence for the absence of any electric dipole transition,

Table I. Data for primary transitions observed in ^{196}Pt following resonance neutron capture. $\overline{\Gamma}_i$ is the mean partial radiation width.

E_γ (keV)	Energy final state (keV)	$\overline{\Gamma}_i$ (meV) Expt.	Estim.[a]	Previous values Energy (keV)	Spin parity
7920	0	2.0	3.4	0	0^+
7562	358 ± 5	1.2	2.9	356	2^+
7231	689 ± 5	1.4	2.6	689	2^+
6777	1143 ± 5	0.7	2.1	...	
6516	1404 ± 5	1.1	1.9	...	

[a]Estimate based on radiative strengths reported by Bartholomew. See Ref. 8.

because of the possibility of large statistical fluctuations in the partial widths. However, because of the large number of resonances studied in our experiment, the error in the average relative intensities of the transitions is ±30%, most of which results from the statistical properties of the sample. Thus if experimental sensitivity is not the limiting factor in a given energy region, we should observe all the allowed transitions. This is the case for electric dipole transitions above 6.5 MeV in ^{196}Pt.

We have calculated the absolute mean partial widths for the five transitions observed in this energy range by using the absolute calibration of the 11.9-eV resonance reported by Carpenter.[7] The error in the absolute value which results predominantly from this value is ±35%. These widths are compared in Table I with values calculated from the average radiation strength for known high-energy transitions reported by Bartholomew.[8] In view of the errors and approximation nature of the calculated values, the agreement is satisfactory and the transitions can be assumed to be E_1.

Several conclusions concerning the level scheme of ^{196}Pt are implied by our observations. The failure to observe a transition of energy 6803 keV implies that the existence of a 2^+ state previously reported at 1117 ± 5 keV[9] is not correct. The 6777-keV transition indicates a level at 1143 keV with possible parameters 0^+, 1^+, or 2^+. The existence of a two-phonon vibrational triplet in this region is predicted by the collective model. Earlier attempts to observe this multiplet were not successful. However, our data suggest that the conclusion[9,10] that a complete triplet does not exist in ^{196}Pt is premature, and comparisons of the level sequence with predictions of the collective model should be deferred until the character of the levels at 1143 and 1404 keV are well established.

A more detailed report of this work including details of 17 new transitions in ^{196}Pt observed between 6516 and 5086 keV will be published in the near future.

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