

Precise Measurements of α_k for the 346.5 keV M4 Transition in $^{197}\text{Pt}^m$

Introduction

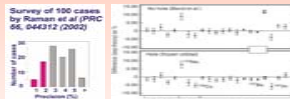
• In Internal Conversion, nuclear de-excitation energy is transferred directly to an atomic electron in the K, L, M, or higher shell; this electron then leaves the atom. Subsequently, an electron from an outer shell moves to fill the hole left by the departed electron; this results in characteristic x-ray emission.

• This process competes with gamma-ray emission.



• The Internal Conversion Coefficient (ICC) is the ratio of the total number of decays for a particular transition that proceed by internal conversion to those that proceed by gamma-ray emission.

• A 2002 survey by Raman, et al. noted that many ICC measurements were not known to a high precision; it also highlighted the discrepancy between competing theoretical tables of ICC values and the lack of agreement between experimental and theoretical measurements.



• Two primary theoretical tables of ICC values differed over how they considered the atomic vacancy (or "hole") left by the electron after it departed its orbital; the calculations of Hager and Seltzer considered this hole to be filled immediately ("no hole" approximation), while the later calculations of Band and Tzashkovskaya took the hole into account and considered the electron orbital to remain in the state they were before the electron left ("frozen orbital" approximation).

• New precision measurements by the Hardy Research Group of the ICCs for ^{193}Ir , ^{134}Cs , and ^{137}Ba demonstrated agreement with the "frozen orbital" approximation.

• A 1987 paper by I.N. Vishnevsky, et al. gave the ICC of the 346.5 keV M4 Transition in $^{197}\text{Pt}^m$ as: $\alpha_k = 4.02 \pm 0.08$. This measurement differed from both theoretical ICC tables; because of this, the Hardy Research Group opted to precisely re-measure the ICC of this nuclide.

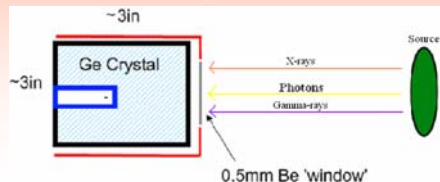
Experiment

Two sources of ^{196}Pt (97.43% \pm 0.02% pure) were used:

- S1: 0.7 mg of 10 mm diameter ^{196}Pt powder on thin Mylar backing; this was covered with 0.5 mil thick Mylar.
- S2: 1.53 mg of 10 mm diameter ^{196}Pt powder on thin Mylar backing; this was covered with 0.5 mil thick Mylar.
- Both sources were activated by thermal neutrons; S1 was activated for a period of two hours, while S2 was activated for a period of thirty minutes.

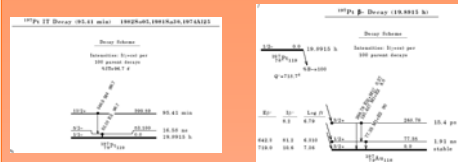
X-ray and gamma-ray emissions from both sources were recorded by a High Purity Germanium Detector, with an absolute efficiency of \pm 0.20%. 17 spectra were recorded for S1; 27 spectra were recorded for S2.

Apparatus

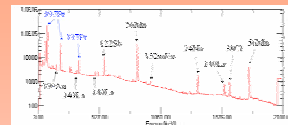


Impurity Analysis

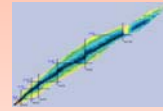
The activation of ^{196}Pt created both $^{197}\text{Pt}^m$ and $^{197}\text{Pt}^g$; $^{197}\text{Pt}^g$ IT decays to $^{197}\text{Pt}^m$, which beta decays to ^{197}Au , which is stable. In addition, the source contained trace quantities of ^{190}Pt and ^{192}Pt and larger quantities of ^{194}Pt and ^{198}Pt , as well as other nuclides from the environment and handling.



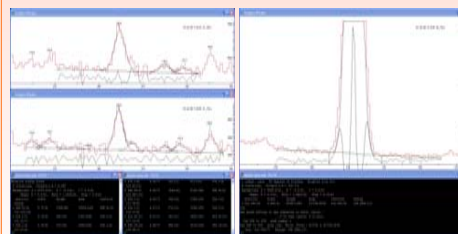
This led to a number of impurities in the activated source which contributed to the recorded x-ray and gamma-ray spectra. For a precision measurement, most of these impurity contributions cannot be ignored, and must be identified and subtracted from the spectra.



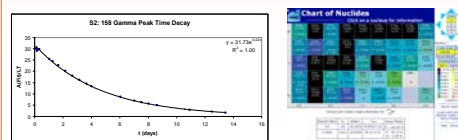
The NuDat and ENSDF tables contain valuable information on all known nuclides, including gamma-ray energies, intensities, and half-lives ($T_{1/2}$). These tables were used to understand the decay schemes of known impurities; they were also used to identify unknown impurities based upon gamma-ray energies and intensities.



A customized version of the RADWARE software suite, GF3_JCH, was used to examine the obtained spectra and obtain integrals of the area under gamma-ray peaks. These areas were then plotted sequentially in Microsoft ExcelTM; the data points were fitted to an exponential trend line of the form $y = Ae^{kx}$; the $T_{1/2}$ of the gamma-ray peak was then obtained using the formula $T_{1/2} = \ln(2)/\lambda$.



Comparison of gamma-ray energies, intensities, and $T_{1/2}$ with the values available in the ENSDF tables enabled the identification of the impurities from which unknown gamma-ray peaks originated.



Attenuation Coefficients

The presence of other media en route from the source to the detector, including the source itself, caused attenuation of the observed emissions. In order to correct for this attenuation, it was necessary to compute the attenuation correction factor for both sources. The attenuation is given by the formula $I = I_0 e^{-\mu x}$, where μ is the attenuation coefficient.

In order to determine the correction factor, it was necessary to consider the x-rays and gamma-rays from each source; it was also necessary to consider the Mylar cover around the source. The source consisted of platinum powder that was not uniformly thick; also, the diameter of the source varied at different points along its surface. The average thickness of each source was calculated to take this fact into account.

• S1: average thickness of 4.5 μm .

• S2: average thickness of 2.1 μm .

These differences in the physical properties of each source meant that the correction factor for each source was different. The calculations to determine the attenuation correction factors are depicted below.

Source No. 17 (S1) - 0.7 mg of ¹⁹⁶ Pt									
Energy (keV)	Intensity (%)	Attenuation Coefficient (μ)	Correction Factor	Energy (keV)	Intensity (%)	Attenuation Coefficient (μ)	Correction Factor	Energy (keV)	Intensity (%)
59.0	0.01	0.0001	1.0000	112.0	0.01	0.0002	1.0002	146.0	0.01
67.0	0.01	0.0001	1.0000	122.0	0.01	0.0002	1.0002	150.0	0.01
74.0	0.01	0.0001	1.0000	132.0	0.01	0.0002	1.0002	154.0	0.01
82.0	0.01	0.0001	1.0000	142.0	0.01	0.0002	1.0002	158.0	0.01
90.0	0.01	0.0001	1.0000	152.0	0.01	0.0002	1.0002	162.0	0.01
98.0	0.01	0.0001	1.0000	162.0	0.01	0.0002	1.0002	166.0	0.01
106.0	0.01	0.0001	1.0000	172.0	0.01	0.0002	1.0002	170.0	0.01
114.0	0.01	0.0001	1.0000	182.0	0.01	0.0002	1.0002	174.0	0.01
122.0	0.01	0.0001	1.0000	192.0	0.01	0.0002	1.0002	178.0	0.01
130.0	0.01	0.0001	1.0000	202.0	0.01	0.0002	1.0002	182.0	0.01
138.0	0.01	0.0001	1.0000	212.0	0.01	0.0002	1.0002	186.0	0.01
146.0	0.01	0.0001	1.0000	222.0	0.01	0.0002	1.0002	190.0	0.01
154.0	0.01	0.0001	1.0000	232.0	0.01	0.0002	1.0002	194.0	0.01
162.0	0.01	0.0001	1.0000	242.0	0.01	0.0002	1.0002	198.0	0.01
170.0	0.01	0.0001	1.0000	252.0	0.01	0.0002	1.0002	202.0	0.01
178.0	0.01	0.0001	1.0000	262.0	0.01	0.0002	1.0002	206.0	0.01
186.0	0.01	0.0001	1.0000	272.0	0.01	0.0002	1.0002	210.0	0.01
194.0	0.01	0.0001	1.0000	282.0	0.01	0.0002	1.0002	214.0	0.01
202.0	0.01	0.0001	1.0000	292.0	0.01	0.0002	1.0002	218.0	0.01
210.0	0.01	0.0001	1.0000	302.0	0.01	0.0002	1.0002	222.0	0.01
218.0	0.01	0.0001	1.0000	312.0	0.01	0.0002	1.0002	226.0	0.01
226.0	0.01	0.0001	1.0000	322.0	0.01	0.0002	1.0002	230.0	0.01
234.0	0.01	0.0001	1.0000	332.0	0.01	0.0002	1.0002	234.0	0.01
242.0	0.01	0.0001	1.0000	342.0	0.01	0.0002	1.0002	238.0	0.01
250.0	0.01	0.0001	1.0000	352.0	0.01	0.0002	1.0002	242.0	0.01
258.0	0.01	0.0001	1.0000	362.0	0.01	0.0002	1.0002	246.0	0.01
266.0	0.01	0.0001	1.0000	372.0	0.01	0.0002	1.0002	250.0	0.01
274.0	0.01	0.0001	1.0000	382.0	0.01	0.0002	1.0002	254.0	0.01
282.0	0.01	0.0001	1.0000	392.0	0.01	0.0002	1.0002	258.0	0.01
290.0	0.01	0.0001	1.0000	402.0	0.01	0.0002	1.0002	262.0	0.01
298.0	0.01	0.0001	1.0000	412.0	0.01	0.0002	1.0002	266.0	0.01
306.0	0.01	0.0001	1.0000	422.0	0.01	0.0002	1.0002	270.0	0.01
314.0	0.01	0.0001	1.0000	432.0	0.01	0.0002	1.0002	274.0	0.01
322.0	0.01	0.0001	1.0000	442.0	0.01	0.0002	1.0002	278.0	0.01
330.0	0.01	0.0001	1.0000	452.0	0.01	0.0002	1.0002	282.0	0.01
338.0	0.01	0.0001	1.0000	462.0	0.01	0.0002	1.0002	286.0	0.01
346.0	0.01	0.0001	1.0000	472.0	0.01	0.0002	1.0002	290.0	0.01
354.0	0.01	0.0001	1.0000	482.0	0.01	0.0002	1.0002	294.0	0.01
362.0	0.01	0.0001	1.0000	492.0	0.01	0.0002	1.0002	298.0	0.01
370.0	0.01	0.0001	1.0000	502.0	0.01	0.0002	1.0002	302.0	0.01
378.0	0.01	0.0001	1.0000	512.0	0.01	0.0002	1.0002	306.0	0.01
386.0	0.01	0.0001	1.0000	522.0	0.01	0.0002	1.0002	310.0	0.01
394.0	0.01	0.0001	1.0000	532.0	0.01	0.0002	1.0002	314.0	0.01
402.0	0.01	0.0001	1.0000	542.0	0.01	0.0002	1.0002	318.0	0.01
410.0	0.01	0.0001	1.0000	552.0	0.01	0.0002	1.0002	322.0	0.01
418.0	0.01	0.0001	1.0000	562.0	0.01	0.0002	1.0002	326.0	0.01
426.0	0.01	0.0001	1.0000	572.0	0.01	0.0002	1.0002	330.0	0.01
434.0	0.01	0.0001	1.0000	582.0	0.01	0.0002	1.0002	334.0	0.01
442.0	0.01	0.0001	1.0000	592.0	0.01	0.0002	1.0002	338.0	0.01
450.0	0.01	0.0001	1.0000	602.0	0.01	0.0002	1.0002	342.0	0.01
458.0	0.01	0.0001	1.0000	612.0	0.01	0.0002	1.0002	346.0	0.01
466.0	0.01	0.0001	1.0000	622.0	0.01	0.0002	1.0002	350.0	0.01
474.0	0.01	0.0001	1.0000	632.0	0.01	0.0002	1.0002	354.0	0.01
482.0	0.01	0.0001	1.0000	642.0	0.01	0.0002	1.0002	358.0	0.01
490.0	0.01	0.0001	1.0000	652.0	0.01	0.0002	1.0002	362.0	0.01
498.0	0.01	0.0001	1.0000	662.0	0.01	0.0002	1.0002	366.0	0.01
506.0	0.01	0.0001	1.0000	672.0	0.01	0.0002	1.0002	370.0	0.01
514.0	0.01	0.0001	1.0000	682.0	0.01	0.0002	1.0002	374.0	0.01
522.0	0.01	0.0001	1.0000	692.0	0.01	0.0002	1.0002	378.0	0.01
530.0	0.01	0.0001	1.0000	702.0	0.01	0.0002	1.0002	382.0	0.01
538.0	0.01	0.0001	1.0000	712.0	0.01	0.0002	1.0002	386.0	0.01
546.0	0.01	0.0001	1.0000	722.0	0.01	0.0002	1.0002	390.0	0.01
554.0	0.01	0.0001	1.0000	732.0	0.01	0.0002	1.0002	394.0	0.01
562.0	0.01	0.0001	1.0000	742.0	0.01	0.0002	1.0002	398.0	0.01
570.0	0.01	0.0001	1.0000	752.0	0.01	0.0002	1.0002	402.0	0.01
578.0	0.01	0.0001	1.0000	762.0	0.01	0.0002	1.0002	406.0	0.01
586.0	0.01	0.0001	1.0000	772.0	0.01	0.0002	1.0002	410.0	0.01
594.0	0.01	0.0001	1.0000	782.0	0.01	0.0002	1.0002	414.0	0.01
602.0	0.01	0.0001	1.0000	792.0	0.01	0.0002	1.0002	418.0	0.01
610.0	0.01	0.0001	1.0000	802.0	0.01	0.0002	1.0002	422.0	0.01
618.0	0.01	0.0001	1.0000	812.0	0.01	0.0002	1.0002	426.0	0.01
626.0	0.01	0.0001	1.0000	822.0	0.01	0.0002	1.0002	430.0	0.01
634.0	0.01	0.0001	1.0000	832.0	0.01	0.0002	1.0002	434.0	0.01
642.0	0.01	0.0001	1.0000	842.0	0.01	0.0002	1.0002	438.0	0.01
650.0	0.01	0.0001	1.0000	852.0	0.01	0.0002	1.0002	442.0	0.01
658.0	0.01	0.0001	1.0000	862.0	0.01	0.0002	1.0002	446.0	0.01
666.0	0.01	0.0001	1.0000	872.0	0.01	0.0002	1.0002	450.0	0.01
674.0	0.01	0.0001	1.0000	882.0	0.01	0.0002	1.0002	454.0	0.01
682.0	0.01	0.0001	1.0000	892.0	0.01	0.0002	1.0002	458.0	0.01
690.0	0.01	0.0001	1.0000	902.0	0.01	0.0002	1.0002	462.0	0.01
698.0	0.01	0.0001	1.0000	912.0	0.01	0.0002	1.0002	466.0	0.01
706.0	0.01	0.0001	1.0000	922.0	0.01	0.0002	1.0002	470.0	0.01
714.0	0.01	0.0001	1.0000	932.0	0.01	0.0002	1.0002	474.0	0.01
722.0	0.01	0.0001	1.0000	942.0	0.01	0.0002	1.0002	478.0	0.01
730.0	0.01	0.0001	1.0000	952.0	0.01	0.0002	1.0002	482.0	0.01
738.0	0.01	0.0001	1.0000	962.0	0.01	0.0002	1.0002	486.0	0.01
746.0	0.01	0.0001	1.0000	972.0	0.01	0.0002	1.0002	490.0	0.01
754.0	0.01	0.0001	1.0000	982.0	0.01	0.0002	1.0002	494.0	0.01
762.0	0.01	0.0001	1.0000	992.0	0.01	0.0002	1.0002	498.0	0.01
770.0	0.01	0.0001	1.0000	1002.0	0.01	0.0002	1.0002	502.0	0.01
778.0	0.01	0.0001	1.0000	1012.0	0.01	0.0002	1.0002	506.0	0.01
786.0	0.01	0.0001	1.0000	1022.0	0.01	0.0002	1.0002	510.0	0.01
794.0	0.01	0.0001	1.0000	1032.0	0.01	0.0002	1.0002	514.0	0.01
802.0	0.01	0.0001	1.0000	1042.0	0.01	0.0002	1.0002	518.0	0.01
810.0	0.01	0.0001	1.0000	1052.0	0.01	0.0002	1.0002	522.0	0.01
818.0	0.01	0.0001	1.0000	1062.0	0.01	0.0002	1.0002	526.0	0.01
826.0	0.01	0.0001	1.0000	1072.0	0.01	0.0002	1.0002	530.0	0.01
834.0	0.01	0.0001	1.0000	1082.0	0.01	0.0002	1.0002	534.0	0.01
842.0	0.01	0.0001	1.0000	1092.0	0.01	0.0002	1.0002	538.0	0.01
850.0	0.01	0.0001	1.0000	1102.0	0.01	0.0002	1.0002	542.0	0.01
858.0	0.01	0.0001	1.0000	1112.0	0.01	0.0002	1.0002	546.0	0.01
866.0	0.01	0.0001	1.0000	1122.0	0.01	0.0002	1.0002	550.0	0.01
874.0	0.01	0.0001	1.0000	1132.0	0.01	0.0002	1.0002	554.0	0.01
882.0	0.01	0.0001	1.0000	1142.0	0.01	0.0002	1.0002	558.0	0.01
890.0	0.01	0.0001	1.0000	1152.0	0.01	0.0002	1.0002	562.0	0.01
898.0	0.01	0.0001	1.0000	1162.0	0.01	0.0002	1.0002	566.0	0.01
906.0	0.01	0.0001	1.0000	1172.0	0.01	0.0002	1.0002	570.0	0.01
914.0	0.01	0.0001	1.0000	1182.0	0.01	0.0002	1.0002	574.0	0.01
922.0	0.01	0.0001	1.0000	1192.0	0.01	0.0002	1.0002	578.0	0.01
930.0	0.01	0.0001	1.0000	1202.0	0.01	0.0002	1.0002	582.0	0.01
938.0	0.01	0.0001	1.0000	1212.0	0.01	0.0002	1.0002	586.0	0.01
946.0	0.01	0.0001	1.0000	1222.0	0.01	0.0002	1.0002	590.0	0.01
954.0	0.01	0.0001	1.0000	1232.0	0.01	0.0002	1.0002	594.0	0.01
962.0	0.01	0.0001	1.0000	1242.0	0.01	0.0002	1.0002	598.0	0.01
970.0	0.01	0.0001	1.0000	1252.0	0.01	0.0002	1.0002	602.0	0.01
978.0	0.01	0.0001	1.0000	1262.0	0.01	0.0002	1.0002	606.0	0.01
986.0	0.01	0.0001	1.0000	1272.0					