Precise Measurement of α_T for the 39.76-keV $E3$ Transition in ^{103}Rh

A Further Test of Internal Conversion Theory

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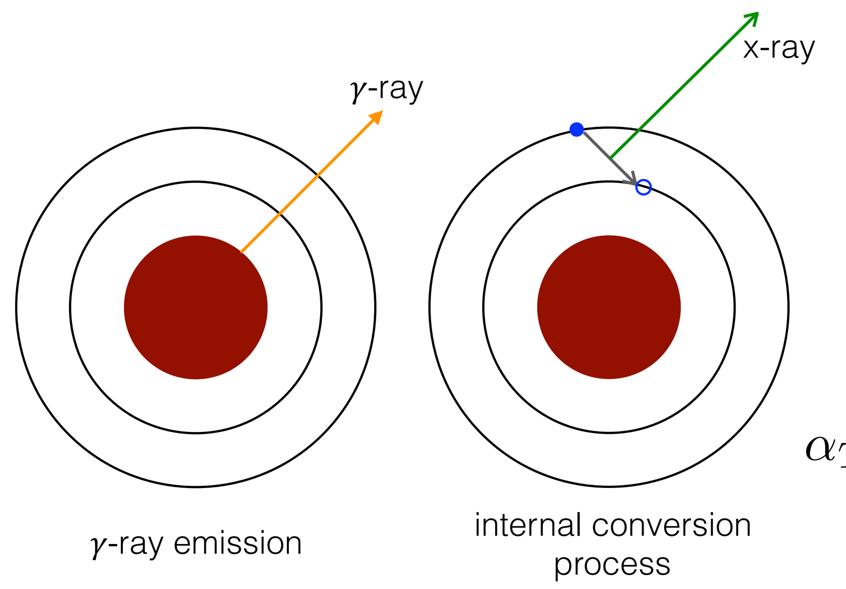
Theory - What is Internal Conversion?

Internal Conversion is a process that occurs when an excited atom decays. When the atom decays, either a γ-ray is emitted or the energy from the nucleus is transferred to an inner-orbital electron, knocking the electron from the atom. Internal conversion is this process of transferring energy to an electron.

When the inner-orbital electron is bumped out of the atom, a higher energy electron jumps down to fill its place, emitting a characteristic x-ray in the process.

The ratio of the probability of internal conversion to the probability of γ-emission is called the Internal Conversion Coefficient, α_T.

Our experimental method equates the probabilities to intensities letting us measure the x-ray and γ-peaks to determine α_T.



$$\alpha = \frac{P_e}{P_\gamma} = \frac{I_e}{I_\gamma}$$

$$P_e = \frac{1}{\omega}P_x \rightarrow I_e = \frac{1}{\omega}I_x$$

$$\alpha_T = \left(\frac{1}{\omega_K}\frac{N_x}{N_\gamma}\frac{\epsilon_\gamma}{\epsilon_x} - \alpha_K\right)\frac{1}{P_{EC,K}} - 1$$

Motivation

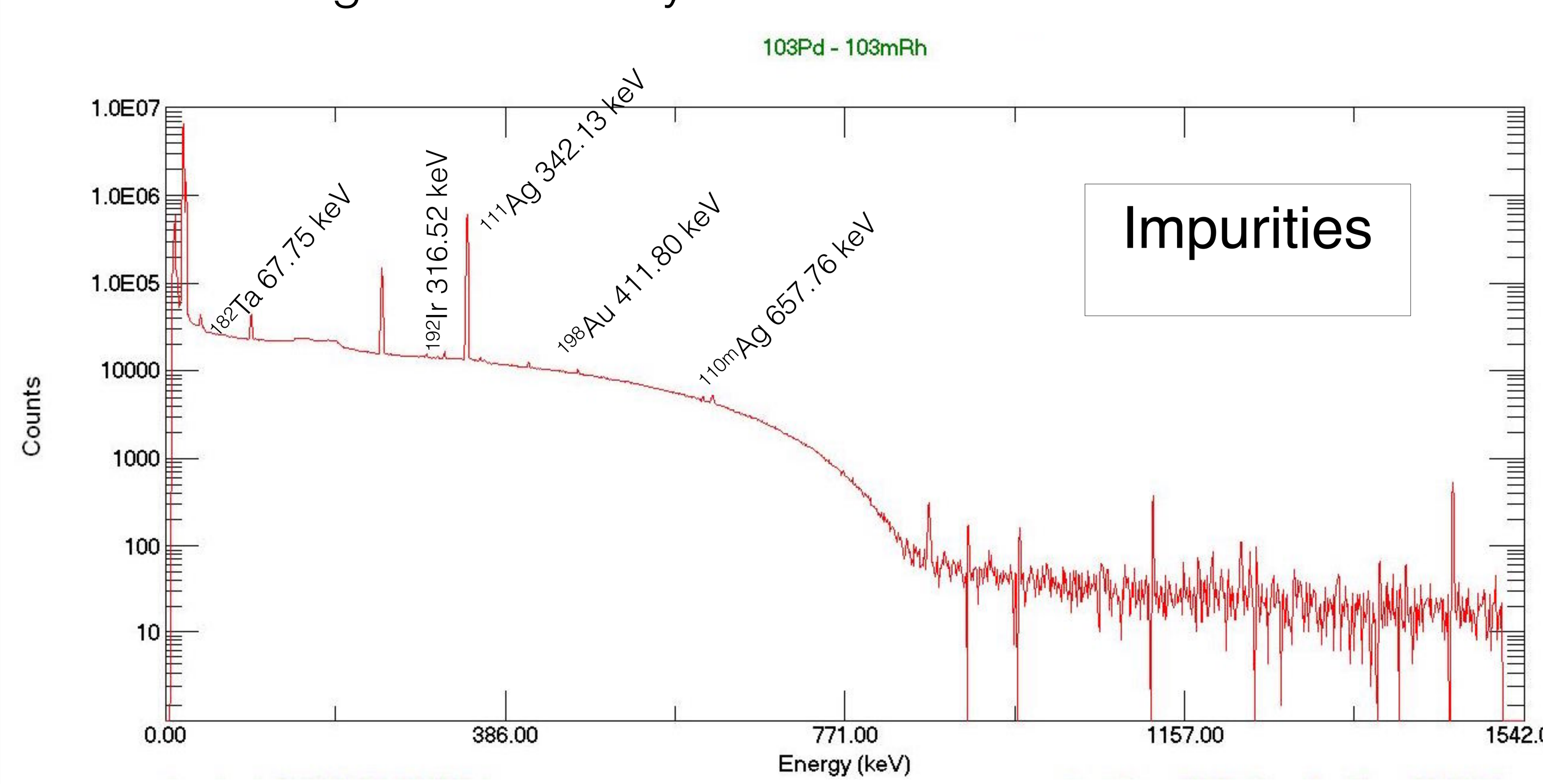
- ICC's can be theoretically calculated using two methods, yielding different results:
  - Considering the atomic vacancy
  - Assuming atomic vacancy is filled too rapidly to effect the ICC value
- There are no other experiments that measure Internal Conversion Coefficients to less than 1% precision
- Our previous measurements demonstrate that the atomic vacancy must be considered in theoretical calculations
- Our aim with this work is to extend the applicability of that statement to Z=45, the lowest atomic number we have yet to measure.
- This experiment is a continuation of our series of high-precision α measurements.

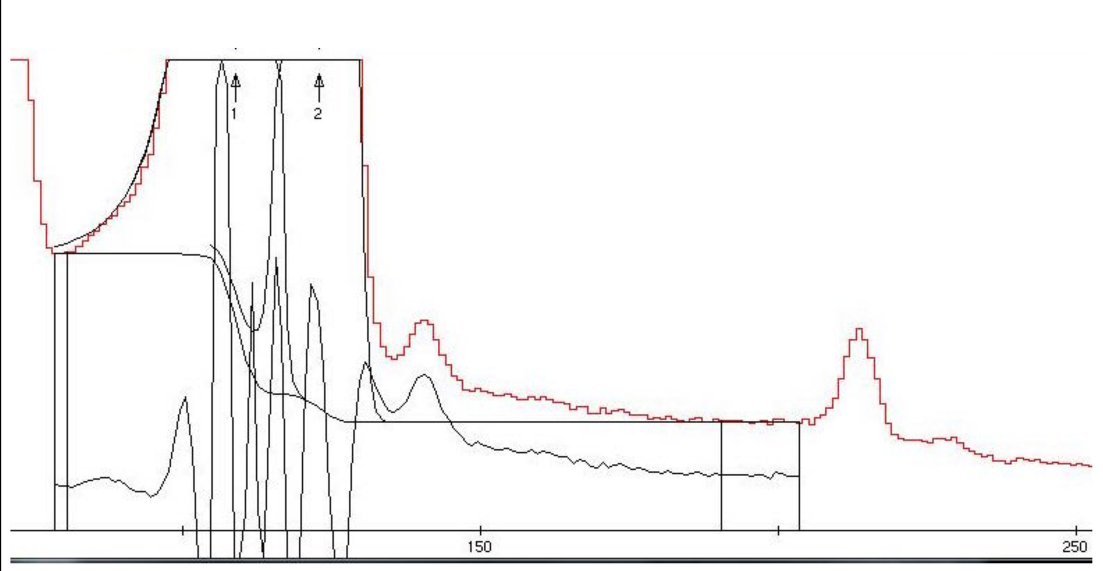
Our Measurement

- We activated a source of ^{103}Pd through thermal neutron activation in the TRIGA reactor at Texas A&M University
- ^{103}Pd decays through electronic capture to ^{103}Rh with a half-life of 16.991 days.
- Source "cooled down" for three weeks before we began our gamma spectroscopy allowing for short-lived radioactive impurities to decay away
- Decay spectra were taken using our precisely efficiency calibrated HPGe Detector.
- Three series of spectra were recorded for a total of 24 days of spectra taken over a total of 81 days after activation.

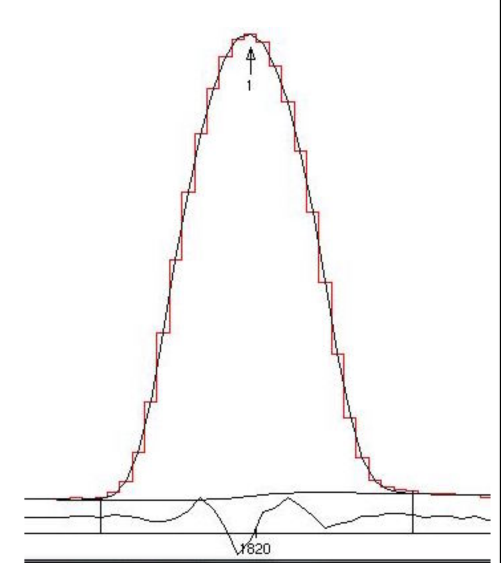
Impurity Analysis

- Insight into what impurity isotopes might affect our x-ray and gamma peaks of interest
- Impurities found:
  - ^{111}Ag, ^{110m}Ag, ^{182}Ta, ^{192}Ir, ^{198}Au, random coincidence summing of ^{103}Pd x-rays





x-ray package fit



342-keV γ fit

Impurity Corrections

- We fit the peaks of the γ-rays, x-rays and impurities using the gf3 program in the Radware package.
- ^{111}Ag impurity contributed to our x-ray package. We were able to correct for the x-ray impurity using:

$$A(Cd\ K_x) = \frac{A(342\gamma)}{\epsilon_{ph}(342\gamma) \times I(342\gamma)} \times \epsilon_{ph}(23.6keV) \times I(23.6keV)$$

- Our 40-keV gamma peak was confirmed to be the product of random coincidence summing of Kα-Kα x-rays resulting from the counting rate of the HPGe detector.
- Using the ratio between Kα and Kβ x-rays, we found the Kα-Kα peak area through the Kα-Kβ peak at 42-keV.
  - The 42-keV peak was first corrected to account for an impurity of ^{182}Ta

Preliminary Results

$$\alpha_T = \left(\frac{1}{\omega_K}\frac{N_x}{N_\gamma}\frac{\epsilon_\gamma}{\epsilon_x} - \alpha_K\right)\frac{1}{P_{EC,K}} - 1$$

$$N_x = 86444813(9574)$$

$$N_\gamma = 87397(2203)$$

$$\omega_K = 0.809(4)$$
$$\epsilon_\gamma = 1.0103$$
$$\epsilon_K = 0.9042$$
$$\alpha_K = 131.3(39)$$
$$P_{EC,K} = 0.8589$$

Theory (with hole)[1]	Theory (no hole)[1]	Our Result
1404	1389	1437(44)

Our result is consistent with our previous calculations which demonstrated that the atomic vacancy must be considered in ICC calculations.

Further work on this project aims to decrease the uncertainty on our value caused by the trouble with the random coincidence summing of x-rays.

Acknowledgements/References

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[1] T. Kibédi, et al., Nucl. Instr. and Meth. A 589 (2008) 202-229