Precise measurement of α_K for the 65.7 kev M4 transition in ^{119m}Sn

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Overview

- Internal Conversion
- Theories
- Detection
- Background Shielding
- Spectral Analysis of ^{119m}Sn
- Impurity analysis
- K x-ray and γ-ray analysis
- α_K Calculations
- Preliminary Results
- Summary

Internal Conversion

- When a nucleus is an excited state, it can decay to a lower energy state by gamma (γ) emission.

- Internal conversion is the process by which the a transition liberates an atomic electron rather that a photon
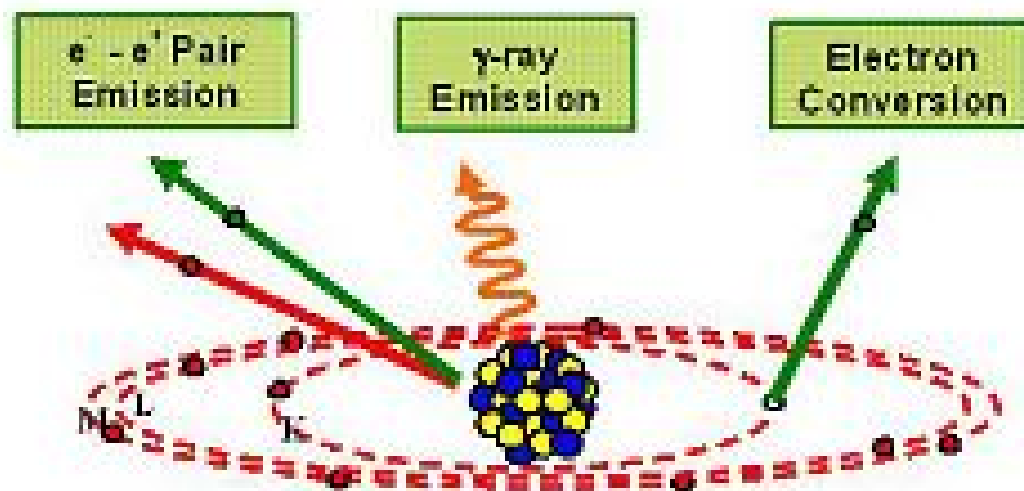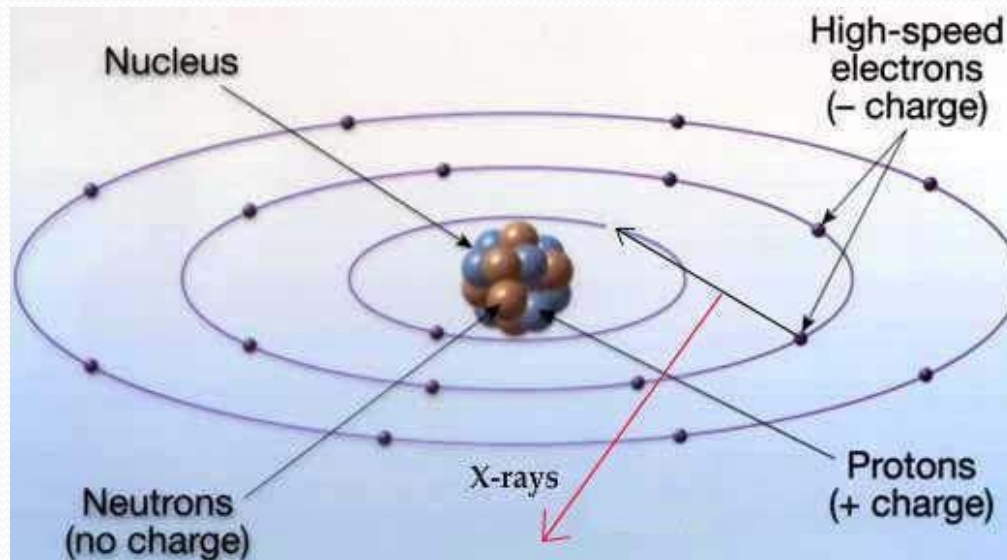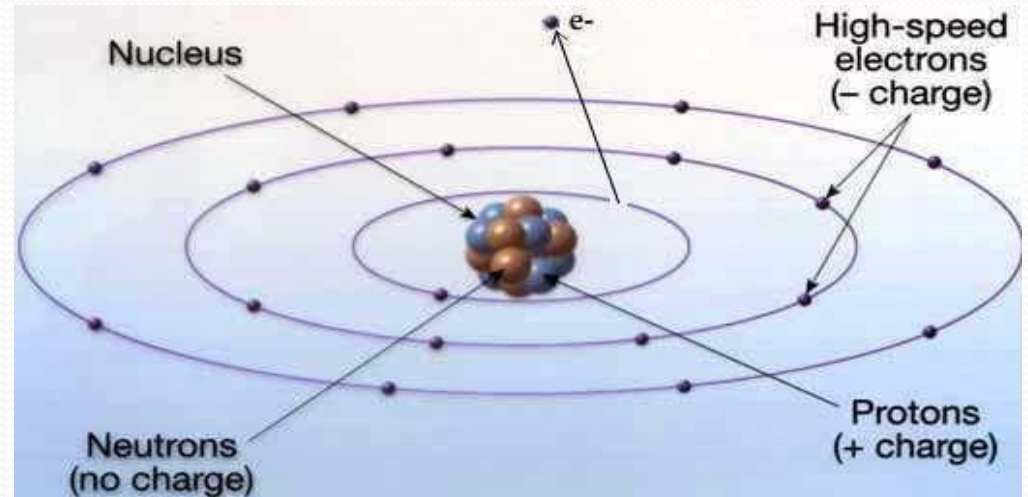
Internal Conversion

- Internal conversion can also occur without the emission of γ-ray.

- In this process the de-excitation energy is transferred to one of the atomic electrons, and this electron is ejected from the atom

- Conservation of energy requires that the kinetic energy of the emitted electron be the difference in the energy of the nuclear state and the electron binding energy, $T_e = E\gamma - B_n$.

Internal Conversion

• Whenever an electron is ejected out, it creates a vacancy that need to be filled.


• A electron from an outer shell moves down to fill this vacancy and an x-ray is emitted.

Theories

- We have determined that some of the Internal conversion coefficients (α) are relatively imprecise.

- We investigate internal conversion to test the theory of whether the vacancy in the atomic shell gets filled or not.

- Measuring the α_K for the 65.7 keV transition in ^{119m}Sn allows us to test the importance of including the atomic vacancy in the calculation of the ICC since, in this case, $\alpha_K = 1618$ if the vacancy is included and $\alpha_K = 1543$ if it is not.

Detection

- We use a High Purity Germanium crystal detector (HPGe) that is capable of detecting x-rays and γ-rays at ~8 keV and up

- The efficiency of the detector is ±.15% from 50-1800 keV
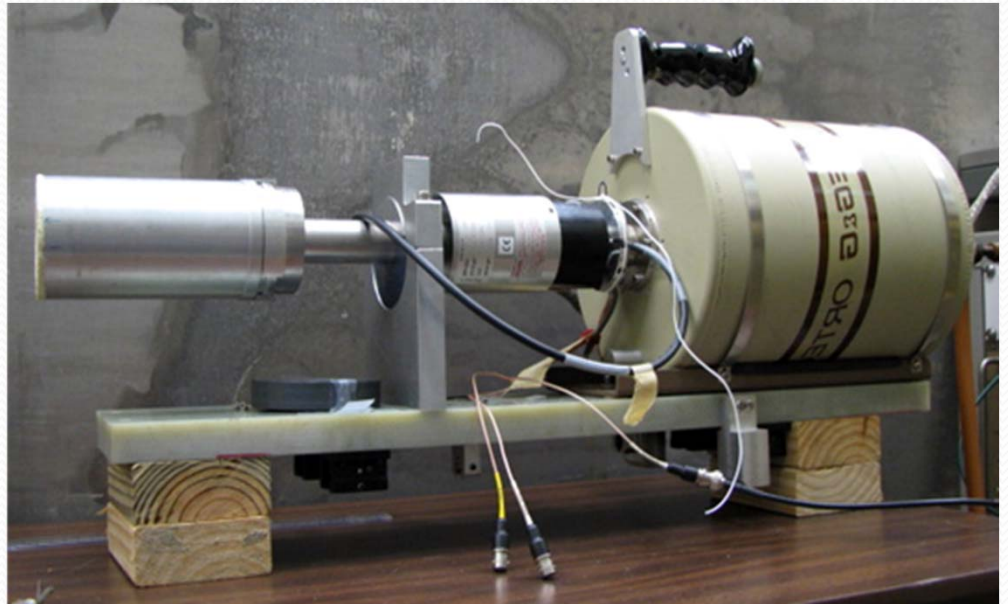
Background Shielding   Source

- In our efforts to reduce the amount of background radiation we use three outer Pb cylinders, one inner Cu cylinder, and a Cu back shield. The Cu was used to absorb x-rays from the Pb

- Each cylinder has a thickness of ~4 mm and a length of ~175 mm.

- We manage to reduce the amount of background radiation by a factor of 5.

•For our experiment we used ^{119m}Sn, which had been produced by neutron activation of enriched ^{118}Sn at the Texas A&M TRIGA reactor.

•For the preliminary measurements we activated for only 16 hours. The source was relatively weak, so we measured it at 79 mm as well as 151 mm where the efficiency of the detector is known from the front of the detector.
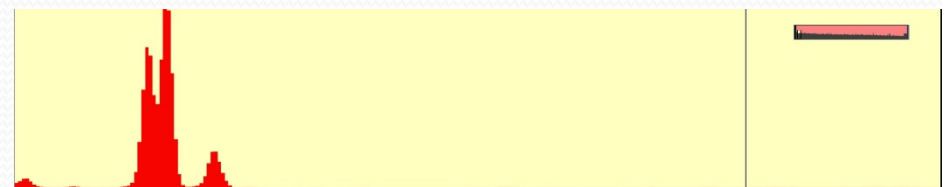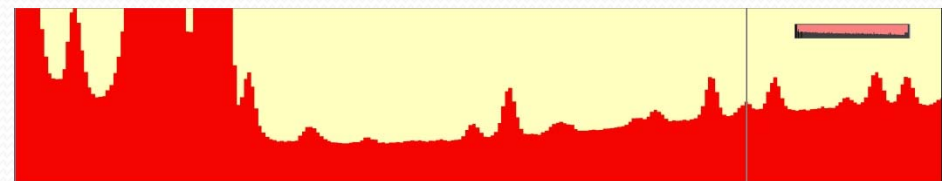
Spectral Analysis

•For spectrum analysis, we used software called Maestro, which allowed us to view the counts as a function of energy.

•Using Maestro, we obtained the area under the curve for two K x-ray peaks at 25.12 keV and 29.57 keV, and the γ-ray peak at 65.7 keV. Background radiation was also taken into account and subtracted

•Through the process of neutron activation, activities such as ^{117m}Sn, ^{113}Sn, and ^{182}Ta were also created and these impurities were subtracted from our peaks of interest.

119Sn_jul13_22_7
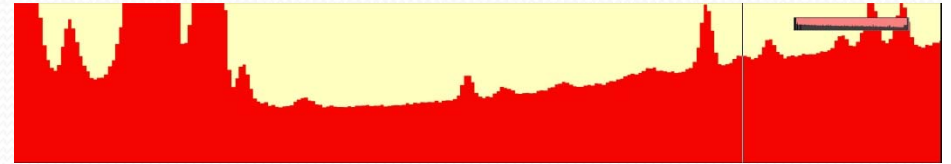
119Sn_jul26_23_1

25.12 keV
28.17 keV
65.7 keV

Spectra Analysis   Calculations

Area	25.12 keV (counts), K_α	29.57 keV (counts), K_β	65.7 keV (counts), 66_γ
151.0mm	2620714	615023	3106
79.0mm	7513840	1721786	9888

$$I_{SnK_x} = \frac{Area(K_x)}{Efficiency(K_x)} = \frac{Area(K_\alpha)}{Eff(K_\alpha)} + \frac{Area(K_\beta)}{Eff(K_\beta)}$$

$$I_{66_\gamma} = \frac{Area(66_\gamma)}{Efficiency(66_\gamma)}$$

Impurity Analysis

Corrected	^{117M}Sn (counts) at 158.5 keV	^{113}Sn (counts) at 391.96 keV	^{182}Ta (counts) at 68.0 keV
151.0mm	80600	12659	11320
79.0mm	118860	30040	24575

- The detector calibration is well known at 151 mm but the rate is higher at 79 mm. We used Monte Carlo calculations to obtain the relative efficiencies at the closer distance.

Efficiency	79.0mm	151.0mm
25.19 keV	2.8773(14)%	0.9519(14)%
28.57 keV	2.9451(14)%	0.9773(14)%
65.66 keV	3.0696(14)%	1.0224(14)%
67.75 keV	3.0623(14)%	1.0201(14)%
158.56 keV	2.4859(14)%	0.8562(14)%
361.69 keV	1.3917(14)%	0.4714(14)%

Preliminary Results

• The results for different distances were later combined with others to give the result 1600(300).

$$\alpha_K = \frac{1}{\omega_K} \frac{I_{SnK_x} - I_{Imp1}}{I_{66_\gamma} - I_{Imp2}}$$

• ω_K =0.860(4), Fluencies Yield

	^{117m}Sn [Imp 1]	^{113}Sn [Imp 2]	^{182}Ta [66γ]
Percent Corrected	~2.2%	~0.6%	~20.6%

	I Sn $_{Kx}$	I 66$_\gamma$	I Sn $_{Kx}$ (Imp 1)	I 66$_\gamma$ (Imp 2)	α_K (corrected)
At 79.0mm	313592951	267532	389850000	267000	1698
At 151.0mm	3382338	3038	3268000	2521	1507

Preliminary Results

- Although Maestro is quite user friendly, it is limited in the evaluation of peak areas. It does not allow a precise fit to the background under each peak. This also affects the precision with which background peaks can be subtracted.

- The location we used for our measurement left much to be desired. The detector was located on top of the shielding blocks above the MARS spectrometer and, when that device was in use, the background activities increased.
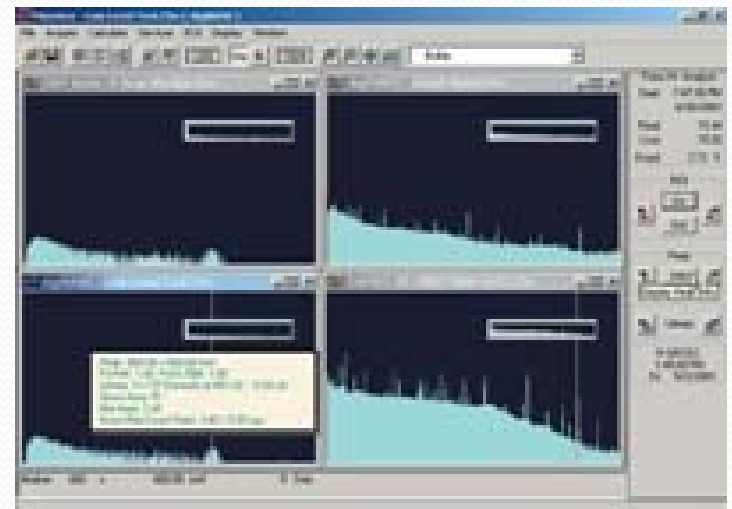
Conclusion

- Despite its large uncertainty, our result points the way to a more precise measurement in future.

- A new ^{119m}Sn source is being prepared with a much longer neutron activation. We will also use a different location for the measurement.

- The Radware code will be used to do the data analysis. This software allows the user to fit individual peaks and background in a more precise and reproducible way.

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