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Internal Conversion Electron Spectroscopy @LNL
Internal Conversion Coefficients

- Experimentally we obtain:
  \[ \alpha_K(\Omega L) = \frac{I_K(\Omega L)}{I_\gamma(\Omega L)} \cdot \frac{\eta_\gamma^\text{abs}}{\eta_e^\text{abs}} \]

- Compare the experimental \(\alpha_K(\Omega L)\) value with the theoretical \(\alpha_K(\Omega L)\) values for different multipolarities to find a correct parity of the level.

Assign level parity
Electric Monopole Transitions (E0) $\Delta J=0$

- E0 Transition Probability:
  \[ B (E0; J \rightarrow J') = \frac{1}{2J + 1} |\langle J' || E0 || J \rangle|^2 \]

- Monopole Transition Strength:
  \[ \rho^2 (E0; J \rightarrow J') = \frac{|\langle J' || E0 || J \rangle|^2}{e^2 R^4} \]

Simple two levels model:

Shape of excited states and mixing between them
**Electric Monopole Transitions (E0) \( \Delta J=0 \)**

- Experimentally we obtain:
  
  \[
  q^2_K(E0/E2) = \frac{I_K(E0)}{I_K(E2)}
  \]

- For \( J_i=J_f=0 \)

- For \( J_i=J_f\neq 0 \)

\[
\alpha_K = \frac{\alpha^h_K(M1) + (1 + q^2_{j_{i_f}}) \cdot \delta^2 \cdot \alpha^h_K(E2)}{(1 + \delta^2)}
\]
Electric Monopole Transitions (E0) $\Delta J=0$

- Experimentally we obtain:
  \[ q_K^2(\text{E0}/\text{E2}) = \frac{I_K(\text{E0})}{I_K(\text{E2})} \]

- For $J_i=J_f=0$
  \[ q_K^2(\text{E0}/\text{E2}) = \frac{I_K(\text{E0})}{I_K(\text{E2})} \]

- For $J_i=J_f\neq 0$
  \[ \alpha_K = \frac{\alpha^{th}(\text{M1}) + (1 + q_{j_i,j_f}^2) \cdot \delta^2 \cdot \alpha^{th}(\text{E2})}{1 + \delta^2} \]

- If the E2 transition rate is known:
  \[ \rho^2(\text{E0}) = q_K^2(\text{E0}/\text{E2}) \times \frac{\alpha_K(\text{E2})}{\Omega_K(\text{E0})} \times W_\gamma(\text{E2}) \]
74Se Recent Investigations

Se Recent Investigations


- In E. A. McCutchan et. al, Phys.Rev. C 87, 014307 (2013) the low-lying states are described as a set of near-spherical vibrational levels mixing strongly with a spectrum of prolate states.
**74Se Experiment**

- Performed at Legnaro National Laboratory last year

- Levels of interest were populated in the EC/β⁺ decay of ⁷⁴Br produced via the fusion evaporation $^{60}\text{Ni}(^{16}\text{O},pn)^{74}\text{Br}$ reaction

- The ground state of ⁷⁴Br has a half-life of 24.5 m and the isomeric state a half-life of 46 m

- Off-line acquisition: activation and measurement time of 31 min

- Bombarding and measurement cicles were controlled by our acquisition system
**74Se Experimental Setup**

- One HPGe detector
- Magnetic electron spectrometer
  - Magnetic coils
  - Si(Li) detector
- Spectrometer efficiency is constant from 150 keV to 1600 keV (≈ 1%)
- Spectrometer transmission $\Delta p/p$ ≈ 18%
\[ 3^+ \rightarrow 2^+ \]
\[ 2^+_1 \rightarrow 0^+_1 \]
\[ 4^+_1 \rightarrow 2^+_1 \]
\[ 0^+_2 \rightarrow 0^+_1 \]

---

- E0 transitions — Mixing between 0\(^+\) states and between 2\(^+\) states

- \( \alpha_K \) — Assign levels parity
E0 transitions → Mixing between 0\(^+\) states and between 2\(^+\) states

\[ q^2 (0_2^+ \rightarrow 0_1^+) = 0.28(8) \quad (q^2 = 0.203(14)) \]

\[ \alpha_K (4_1^+ \rightarrow 2_1^+) = 0.00080(6) \quad (\alpha_K = 0.000830(12)) \]
Spes Experimental Room
SLICES (Spes Low-energy Internal Conversion Electrons Spectrometer)

- Si(Li) detector
- HPGe detector
- Moving tape
- Plastic Scintillator
- Magnetic transport system
SLICES Si(Li) detector

- Development in collaboration with the Jülich (Germany) research center
- Diameter = 70 mm (active area ~ 3900 mm$^2$)
- Thickness = 6.8 mm
- Segmented in 32 independent sectors
- Requested FWHM(@~1MeV) ~ 3 keV
SLICES Si(Li) detector

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SLICES Efficiency

Distances: Source-Magnets = 50 mm, Magnets-Detector = 40 mm
SLICES Tests

[Graph showing temperature changes over time for different sensors labeled PT3, PT4, PT5, PT7]
SLICES Tests

1500 seconds +1000 Volt, 6 μs

low-energy part

warm
cold
SLICES Tests

975 keV
1500 seconds
+1000 Volt, 6 μs

high-energy part

warm

cold

energy [keV]

counts (linear)
SLICES Tests

FWHM(@975 keV) \sim 3.4 \text{ keV}
## SLICES Tests

<table>
<thead>
<tr>
<th>Strips</th>
<th>Live Time</th>
<th>τ</th>
<th>FWHM (@975 keV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>1500s</td>
<td>6μs</td>
<td>3.4keV</td>
</tr>
<tr>
<td>A</td>
<td>1500s</td>
<td>6μs</td>
<td>3.7keV</td>
</tr>
<tr>
<td>A</td>
<td>1500s</td>
<td>3μs</td>
<td>2.4keV</td>
</tr>
</tbody>
</table>
To Do List

SLICES

- Finalize the cooling system
- Finalize the mechanical structure design
- Test completed detector with proper sets of magnet
- Commissioning @LABEC in Florence
- Study the first SPES low-energy beams (the most intense expected beams are Cs, Rb, Sr, Br, ...)

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Naomi Marchini
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$^{74}\text{Se}$

- Finalize the analysis
  - Obtain $\rho^2(E0)$ values
  - Obtain $\alpha_k$ coefficients
Thank you for the attention

\textbf{\textsuperscript{74}Se Collaboration}

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\textbf{SLICES Collaboration}

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Selenium Isotopes (Z=34)

Several theoretical investigations confirm:

- For Z~N Se isotopes an oblate shape for the ground state with a strong configuration mixing for the low-lying excited levels, coexisting with a exited prolate configuration.

- For the heavier Se isotopes a prolate ground state is expected to coexist with an excited oblate configuration.

Why Electron Spectroscopy?

- Obtain the $\alpha_k(\Omega L)$ Internal Conversion Coefficients
  
  \[\downarrow\]
  
  Assign level Parity
  
  - Study of Electric Monopole Transitions (E0)
    
    \[\downarrow\]
    
    Study the possible Shape Coexistence and level Mixing