Investigating the Structure of $^{46}$Ca through the Beta Decay of $^{46}$K Utilizing the New GRIFFIN Spectrometer

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Evolution of Shell Structure

Aim to study the evolution of shell structure towards more neutron-rich nuclei.

The calcium isotopes are ideal for studies of shell closures in medium mass nuclei.

J. Blachot, Nuclear Data Sheets 111, 717 (2010)
A Little About $^{46}$Ca

Two previous beta decay experiments from late 1960’s

The Experiment

Use the Beta Decay of $^{46}\text{K} \rightarrow ^{46}\text{Ca}$ $Q = 7716$ keV

$^{46}_{19}\text{K} \rightarrow ^{46}_{20}\text{Ca} + \beta^- + \bar{\nu}_e$

$^{46}\text{K}$ $\beta^-_{(2-)}$ 95s

$4 \times 10^5$ pps beam

$\sim 40$ hours of data collection

GRIFFIN Configuration
- 15 HPGe Clover Detectors
- 5 Si(Li) Detectors (PACES)
- 10 scintillators (SCEPTAR)
- Moving tape system
Gamma-Gamma Coincidences

Energy (keV)
Observed Excited States

Q = 7716 keV

- Added 12 new excited states
- Placed 160 new gamma-ray transitions
Observed Excited States

Q = 7716 keV

Gate on 1075 keV Gamma

Energy (keV)

Counts

1346

2421

1075

1346

0

2

0+

0+

Scatter
Gate on 1075 keV Gamma
Gate on 1075 keV Gamma
Gate on 1075 keV Gamma
Absolute Efficiency of GRIFFIN

Sources: $^{133}\text{Ba}$, $^{152}\text{Eu}$, $^{60}\text{Co}$, $^{56}\text{Co}$

Eighth-order polynomial fit

Reduced-$\chi^2$: 1.17
Beta Feeding into the 0+ State

Beta Decay Selection Rules

<table>
<thead>
<tr>
<th>Forbiddenness</th>
<th>ΔJ</th>
<th>Δπ</th>
<th>log ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superallowed</td>
<td>0⁺ → 0⁺</td>
<td>No</td>
<td>2.9-3.7</td>
</tr>
<tr>
<td>Allowed</td>
<td>0, 1</td>
<td>No</td>
<td>4.4-6.0</td>
</tr>
<tr>
<td>First Forbidden</td>
<td>0,1,2</td>
<td>Yes</td>
<td>6-10</td>
</tr>
<tr>
<td>Second Forbidden</td>
<td>1,2,3</td>
<td>No</td>
<td>10-13</td>
</tr>
<tr>
<td>Third Forbidden</td>
<td>2,3,4</td>
<td>Yes</td>
<td>&gt;15</td>
</tr>
</tbody>
</table>

Energy (keV) | 1966 Feeding | 1968 Feeding
---|---|---|
6625 | 2.1 | NOB |
6295 | 1.5 | NOB |
5080 | 25  | 28  |
4520 | 0.6 | NOB |
4454 | NOB | 3   |
3630 | 5   | 8   |
3580 | 3   | NOB |
3020 | 0   | 11  |
1345 | 63  | 50  |
Relative B(E2) Transition Strengths

\[ B(E2) \propto \frac{BR}{E_{\gamma}^5 \cdot t_{1/2}} \]

\[ \text{Rel.}B(E2) = \frac{BR_{2005} \cdot t_{1/2}}{E_{2005}^5} \cdot \frac{E_{4426}^5}{BR_{4426} \cdot t_{1/2}} \]

More Relative B(E2) values to come once more spins and parities are assigned.

J. Blachot, Nuclear Data Sheets 111, 717 (2010)
Future Work

1. Determine intensities of placed gamma-ray transitions.
2. Investigate beta feeding for each excited state.
3. Assign angular momenta and parity for each excited state.
4. Compare results to theory.

Thank You!

- Dr. Corina Andreoiu
- Dr. Adam Garnsworthy
- Dr. Jenna Smith
- GRIFFIN Collaboration

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