Searching for shape coexistence in 124Te

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Shell model predicts shell closure at “magic” numbers of protons and neutrons

$^{124}\text{Te}$:

- Stable
- $Z=52$
  - Near closed proton shell
- $N=72$
  - Mid-shell for neutrons
Shape coexistence

Can be characterized by absolute B(E2) values, but other indications exist:

- Parabolic energy dependence as a function of neutron number in intruder bands.
- Transition energy difference
Why $^{124}$Te?

- $Z=52$
- Shape coexistence already established in $Z=48$ and $Z=50$ nuclei
- Lifetimes of many states are well known
  - absolute $B(E2)$s can be calculated once branching ratios are measured.
$^{123}_{\text{Te}}(n,\text{gamma})$
Neutron capture

- Thermal neutrons come in at very low energies
- Neutrons captured in compound nucleus reaction
- Daughter nucleus will be in an excited state near or at its neutron separation energy
  - The calculated neutron separation energy for $^{124}\text{Te}$ is 9.43 MeV
Why neutron capture?

- In order to investigate shape coexistence, must populate $0^+ \textbf{intruder states}$

- It is difficult to make a nucleus with zero angular momentum

- Neutron has a spin angular momentum of $\frac{1}{2}$
  - If the target nucleus has a small angular momentum, low-spin states will be populated
123Te(n,\gamma)

- Target nucleus has a ground state spin of $+\frac{1}{2}$, so $0^+$ states will be populated by neutron capture.

- Comparatively high neutron capture cross section (418.3 b).
  - 124Te has a thermal neutron capture cross section of 6.324 b.

- Long half life ($>9.2 \times 10^{16}$ years).
Scientific Research conducted at the ILL
FIPPS

8 CLOVERS EACH CONSISTING OF 4 HPGE DETECTORS

BEAM IS A HIGHLY COLLIMATED PENCIL NEUTRON BEAM
Data acquisition and sorting

- Detectors record the time and energy of gamma rays that hit them

- We set a timing window – for every gamma ray that hits the detector, any other hits registered within the time gate are considered “in coincidence” with it

- In Coincidence: occurring one after the other in a cascade

- From this we construct a symmetric matrix of gamma ray energies – “gating” on any gamma energy gives a histogram of counts vs energy that occur in coincidence with that gamma.
Preliminary results

Total projection of gamma-gamma coincidence matrix (logarithmic y-axis)

Total counts in projection: $\sim 14 \times 10^9$

This peak contains about $6 \times 10^8$ counts

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Preliminary results

Portion of a slice taken on the $1055 \, 0^+ \rightarrow 2^+$ transition
(linear $y$-axis)
Preliminary results

Portion of a slice taken on the $1055 \, 0^+ \rightarrow 2^+$ transition
(linear y-axis)
Preliminary results

Large discrepancy between ground state $2^+ \rightarrow 0^+$ transition and intruder $2^+ \rightarrow 0^+$ energy
Thank you!

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