Searching for low-energy shape coexistence in $^{80}$Ge

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Shape coexistence

Andreyev et al., Nature 403, 430 (2000)

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A recent experiment probed the structure of doubly magic $^{78}\text{Ni}$. An excited $2^+$ state was observed at only 0.31 MeV above the $2_1^+$, suggesting shape coexistence in this nucleus.

$^{78}$Ni is proposed to be a portal to the fifth island of inversion*. 

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Low-lying Coexistence in $^{80}$Ge

An ALTO experiment observed a state $0^+_2$ state in $^{80}$Ge at 639 keV, through a conversion electron peak at 628 keV.

A coincidence was also observed between the 628-keV conversion electron peak and a 1764-keV $\gamma$-ray, from a proposed 2403 keV state.

The binding electron of the $K$-shell electron in $^{80}$Ge is 11 keV

Gottardo, A. et al., PRL 116, 182501 (2016)
GRIFFIN for $\beta$-decay spectroscopy

Quality of the dataset

Experimental details:

- $^{80}\text{Ga}$ $\beta$-decay to $^{80}\text{Ge}$
- Run time: 51 hrs
- 78% $^{80}\text{Rb}$ contaminant
- 22% $^{80}\text{Ga}$ at $2 \times 10^4$ pps
- $6^-\ 80\text{gs Ga}$: 53%
- $3^-\ 80\text{m Ga}$: 46%

Garcia, F. H. et al., *PRL* 125, 172501 (2020)
Contradictory Results

The GRIFFIN experiment used PACES for conversion electron detection.

**ALTO $^{1628}$: \( \sim 0.08\% \)**

**GRIFFIN 2\( \sigma \) limit: <0.02\%**

Gottardo, A. et al., *PRL* 116, 182501 (2016)
Garcia, F. H. et al., *PRL* 125, 172501 (2020)
Searching for transitions

Limits were calculated to determine detection sensitivity.

**ALTO** $I_{1764}/I_{1772}$: 0.3

**GRIFFIN** $I_{1764}/I_{1772}$ 2σ limit: 0.003

Gottardo, A. et al., *PRL* 116, 182501 (2016)

Garcia, F. H. et al., *PRL* 125, 172501 (2020)
The broad peak at 1764 keV is in fact four different transitions (red), observed in different gates (blue);
Theoretical considerations

Large-scale shell model calculations were performed, and were able to reasonably predict intruder configurations in neighbouring isotopes.

Garcia, F. H. et al., *PRL* 125, 172501 (2020)
Current status and the future of $^{80}\text{Ge}$ data

Analysis is still ongoing. The dataset is quite rich.

Highlights:
- ~77 newly observed transitions
- 10 previously observed transitions placed
- ~41 newly observed excited states

Next steps:
- β-feeding analysis for tentative spins
- Angular correlations for spin assignment
- Lifetime measurements of the $2^+$ and $4^+$
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Thank you
80Ge experiment comparisons

GRiffin
- ISOL: p⁺ reactions
- Yield: 2.4×10⁴ pps
- 80gs Ge: 53% / 80m Ge: 46%
- 15 HPGe
- ϵ (1.3 MeV): 8%
- 5 Si(Li)
- 10 plastic scintillators

Gottardo et al.
- Photofission
- Yield: ~ 10⁴ pps
- 1 HPGe
- ϵ (1.3 MeV): 0.7%
- 1 Si(Li)
- 1 plastic scintillator

Verney et al.
- Photofission
- Yield: 9.4×10³ pps
- 80gs Ge: 48% / 80m Ge: 52%
- 2 HPGe
- ϵ (1.3 MeV): 1.4%
A major concern that presented itself during the analysis was the quantity of each of the ground state and isomer of $^{80}$Ge in the beam.

The 6(−) g.s. and 22.4 keV 3(−) isomer in $^{80}$Ga are known to $\beta$-decay. ENSDF only shows the 3(−) isomer $\beta$-decaying, but there is a high lying ($8^{+}$) in $^{80}$Ge that has a non-zero $\beta$-feeding intensity. This can only be fed by the ground state in $^{80}$Ga.
To prove we had a comparable isomeric mixture, we chose two independent states to examine:

- $(2^+)$ 1573-keV state fed only by the $3(−)^{80m1}$Ga
- $(8^+)$ 3445-keV state fed only by the $6(−)^{80gs}$Ga

We compared the $\beta$-feeding intensities in our experiment and those in ENSDF and discovered a decrease of 0.66 in feeding of the 1573-keV state and an increase of 1.55 to the 3445-keV state.

Given the ENSDF set contains a beam composition of 62% of the $(3−)$ isomer, we calculate a value of 41% of the same component.

Based on the data in the paper, ALTO observed 52% of $^{80m1}$Ga in their beam.
The authors also employed theoretical models to show lowering of the $0_2^+$ in context of different energy contributions.

The theoretically calculated value was in good agreement with their experimentally observed value.

Gottardo, A. et al., *PRL* 116, 182501 (2016)