Mapping the boundaries of the seniority regime and collective motion: Coulomb excitation studies of $N=122$ isotones $^{206}$Po and $^{208}$Rn

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Outline

- Physics background
- Proposed experiment
- Beamtime request
$N=122$ isotones in the trans-Pb region

\[ \pi 1h_{9/2} \rightarrow \sqrt{2}f_{5/2} \]

208Rn → 206Po
$N=122$ isotones in the trans-Pb region

- Around the $Z=82$ and $N=126$ shell closures level patterns resembling seniority $\nu=2$ structure have been observed.
- Relative high-$j$ proton single-particle orbital ($j=9/2$) dominate the structure - seniority $\nu$ can be regarded as a good quantum number.
- In the trans-Pb nuclei with $120 \leq N \leq 128$ the neutrons occupy high $n$, low $\ell$ orbitals and therefore they should have weaker interactions with the $1h_{9/2}$ protons. This implies that the seniority can be preserved.
In almost all even-even nuclei, $B(E2)$ values connecting the lowest yrast states increase both with increasing valence nucleon number and spin.

The $B(E2)$ values exhibit a parabolic trend across a major shell with higher spin $B(E2)$ values scaling with $B(E2;2^+\rightarrow0^+)$. In seniority scheme, $\Delta\nu=2$ transitions are parabolic maximising at mid-$j$ shell. Transitions with $\Delta\nu=0$, however, minimise their $B(E2)$ values at mid-$j$ shell. – A completely contrasting result to that of collective motion.
$B(E2)$ values in the seniority scheme

$2^+ \rightarrow 0^+, \Delta\nu=2$

$8^+ \rightarrow 6^+, \Delta\nu=0$

$f = n/(2j+1)$
$N=122$ isotones in the trans-Pb region

Level-energy systematics
$N=122$ isotones in the trans-Pb region

**$B(E2)$ values**

![Diagram showing $B(E2)$ values for isotones in the trans-Pb region with specific transitions marked for $^{206}$Po and $^{208}$Rn.](image)
$N=122$ isotones in the trans-Pb region

$B(E2)$ values

Open questions:

- The microscopic structure of the proposed $\Delta \nu=2\ 2^+$ states.
  - Seniority scheme predicts parabolic behaviour of the $B(E2)$ values across the $\pi h_{9/2}$ shell.
  - Neutron states?

- The proton-neutron interaction in this region should not be strong due to the large $\Delta n$ and $\Delta \ell$ between the available proton and neutron orbitals.
  - Different trend for the $B(E2)$ values across the $\pi h_{9/2}$ shell expected (flat as the p-n interaction weak).
Proposed experiments

- Objectives: to measure the $B(E2;0^+\rightarrow 2^+)$ values in the $N=122$ isotones $^{206}\text{Po}$ and $^{208}\text{Rn}$ through Coulomb excitation at ISOLDE.

- Post-accelerated beams of $^{206}\text{Po}$ and $^{208}\text{Rn}$ (3 MeV/u) will be Coulomb excited in the $^{116}\text{Cd}$ target at MINIBALL target position. De-exciting $\gamma$ rays will be detected with the MINIBALL $\gamma$-ray spectrometer in coincidence with outgoing particles detected in MINIBALL CD.
Proposed experiments

2.9 MeV/u $^{208}$Rn beam on 2 mg/cm$^2$ $^{116}$Cd target
Proposed experiments

Kinematics of $^{224}$Ra on $^{112}$Cd

L. P. Gaffney, IS465
Production and purity of the $^{206}$Po and $^{208}$Rn beams

- Rn as noble gas can be purified using the cooled transfer line (c.f. experiment IS465).
- Possible isobaric contaminants in the $^{206}$Po beam can be suppressed by using the RILIS laser ion source (c.f. experiment IS479).
- Composition of the beams will be monitored online.

**Conclusion:** Based on the observations in the earlier experiments, *no experimental difficulties* arising from the beam impurities are foreseen.
Count rate estimates and beam time request

- ISOLDE primary yields: $^{206}$Po $5 \cdot 10^6 \, \mu C^{-1}$ and $^{208}$Rn $2.1 \cdot 10^8 \, \mu C^{-1}$.

- Assume: 1% post-acceleration efficiency, 7% efficiency of MINIBALL, 2 mg/cm$^2$ target thickness, the CD angular coverage of $16^\circ \leq \theta \leq 53^\circ$ and \( \langle 0^+|\hat{O}(E2)|2^+ \rangle = 0.407 \, \text{eb} \) ($^{204}$Pb).

- Conservative estimate (2$^+$ to 0$^+$ transitions): 200 $\gamma$ rays in 3 shifts ($^{206}$Po), 700 $\gamma$ rays in an hour ($^{208}$Rn).

- In total **6 shifts** of beam time is requested.
Collaboration

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