Study of the neutron-rich region in vicinity of $^{208}\text{Pb}$ via multinucleon transfer reactions

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Towards neutron-rich heavy nuclei

- **aim**: to exploit the multinucleon transfer reaction mechanism in the production of the neutron-rich heavy binary partners
- **focus**: region **south-east** of the doubly-magic $^{208}\text{Pb}$ nucleus in the Segré chart
- we employed this reaction mechanism in the $^{94}\text{Rb} + ^{208}\text{Pb}$ reaction studied with the MINIBALL $\gamma$-array at ISOLDE

$^{94}\text{Rb} + ^{208}\text{Pb}$ cross section distribution [mb] calculated by GRAZING

Program GRAZING [http://www.to.infn.it/~nanni/grazing]
The $^{94}$Rb+$^{208}$Pb experiment

Beam: $^{94}$Rb at 6.2 MeV/A, delivered by HIE-ISOLDE
Target: $^{208}$Pb, 1 and 13 mg/cm$^2$ thickness

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Experimental results

- prompt γ-rays within Δt ~ 250 ns
- isomer contribution
- background: strong presence of $^{94}\text{Rb}$ ($\tau_{1/2} \sim 3$ s) β-decay chain

**E-θ matrix:** separation of Rb-like and Pb-like reaction fragments

**E-θ cuts:** fragments used for the angular distribution construction
Angular distributions

\[ \frac{\sigma}{\sigma_R} \] was obtained gating on fragments without \( \chi \) in coincidence

- experimental distribution: elastic + inelastic + transfer
- normalization at the most forward \( \theta \) → Rutherford scattering
Inelastic and neutron transfer channels

“Thin” (1 mg/cm²) target

- fragment-γ coincidence with Rb-like products
- γ-rays emitted in-flight → Doppler correction with resolution of 1.2% at 1.5 MeV
Inelastic and neutron transfer channels

\[ ^{207}\text{Pb}(-1n) \quad ^{208}\text{Pb} \quad ^{209}\text{Pb}(+1n) \]

- Selective population
  - yrast states
  - \(^{208}\text{Pb} \): strong 3\(^{-}\) octupole excitation
  - \(^{207,209}\text{Pb} \):
    - \(\rightarrow\) single-particle states
    - \(\rightarrow\) particle (hole) and 3\(^{-}\) coupling scheme
Inelastic and neutron transfer channels

“Thick” (13 mg/cm²) target

- $\gamma$-$\gamma$ coincidences → structure of excited states and isomers
- $^{210}$Pb: $10^+ \rightarrow 8^+ (\tau_{1/2} = 201 \text{ ns}) \rightarrow 6^+ (\tau_{1/2} = 92 \text{ ns}) \rightarrow 4^+ \rightarrow 2^+ \rightarrow 0^+$

$\tau_{1/2}$ from R. Broda et al, Phys. Rev. C 98, 024324 (2018)
Inelastic and neutron transfer channels

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Inelastic and neutron transfer channels

$^{210}\text{Pb}(+2n)$

Ongoing analysis: cross section extraction

- extraction of excited states yields
- cross check via $\gamma$-$\gamma$ coincidences
- normalization factor:
  - angular distribution of $3^{-} \rightarrow 0^{+}$ in $^{208}\text{Pb}$
  - comparison with reaction models (DWBA)
Inelastic and neutron transfer channels

\(^{210}\text{Pb}(+2n)\)

Ongoing analysis: cross section extraction

- extraction of excited states yields ✓
- cross check via \(\gamma-\gamma\) coincidences ongoing
- normalization factor:
  - \(\rightarrow\) angular distribution of \(3^{-}\rightarrow 0^{+}\) in \(^{208}\text{Pb}\) ✓
  - \(\rightarrow\) comparison with reaction models (DWBA)
Perspectives

- degrees of freedom that influence the evolution of MNT reaction (transfer strength)
- the optimal experimental conditions for the production of neutron-rich heavy nuclei (different systems, bombarding energies)

The preliminary results show larger cross sections of channels where neutrons are added to the $^{208}\text{Pb}$ target. MNT reactions with the neutron-rich unstable beam is an efficient reaction mechanism for the production of the neutron-rich heavy nuclei.
Thank you!

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