Elastic backscattering measurements and optical potential analysis for the systems $^{6,7}$Li + $^{58}$Ni, $^{116,120}$Sn, $^{208}$Pb at sub- and near – barrier energies

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Outline

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- Experimental setup
- The results: Determination of barrier distribution via elastic scattering
  - Optical potential analysis
- Conclusion: Optical Potentials
  - Reaction mechanisms
Motivation

Elastic backscattering measurements are valuable tools for:

- Probing the nuclear potential at sub and near barrier energies
- Probing reactions mechanisms connected with direct procedures

Excitation functions of $\sigma/\sigma_R$

Determination of barrier distributions
Motivation

Previous experiment

\[ \frac{E_{\text{lab}}}{V_{\text{bar}}} = 0.6 - 1.3 \]

Conclusion:

Backscattering technique is a more accurate technique to probe the optical potential than the conventional angular distribution

Current work

\[ \frac{E_{\text{lab}}}{V_{\text{bar}}} = 0.6 - 1.3 \]
Experimental setup

Details:
- \( R_{20} = 800 \text{ mm} \)
- \( R_{160} = 210 \text{ mm} \)
- \( R_{170} = 165 \text{ mm} \)
- \( d = 200 \mu\text{g/cm}^2 \)
Barrier distribution via elastic scattering

\[
\frac{\sigma_{el(170^{\circ})}(E)}{\sigma_{Ruth(170^{\circ})}} = \frac{N_B \cdot \Omega_F \cdot \sigma_{Ruth(30^{\circ})}(E)}{N_F \cdot \Omega_B \cdot \sigma_{Ruth(170^{\circ})}}
\]

\[
D_{el}(E) = -\frac{d}{dE} \sqrt{\frac{d\sigma_{el}(E)}{d\sigma_{Ruth}(E)}}
\]
Optical model analysis

Starting point: Imaginary potential

Main steps:

- Draw a straight line to define the imaginary potential above the Coulomb barrier.
- Define the energy point where a second line should be drawn.
- Define the slope of the second line.
- Define the last energy point, where the imaginary potential drops to zero.

Dispersion relation

\[ U(r, E) = V_0(r, E) + \Delta V(r, E) + iW(r, E) \]

\[ \Delta V = \frac{P}{\pi} \int_{E'}^{E} W(r, E') dE' \]
Optical model analysis

$^6$Li on different targets

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Optical model analysis

$^7$Li on different targets

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Reaction mechanisms

$^6,^7\text{Li}$ on different targets

Calculated by K. Rusek - EPJA Vol.48 (7), p.102, 2012
Conclusions

- **Optical potential**
  The backscattering technique is a valuable tool for predicting the optical potential at sub and near barrier energies.
  
  For weakly bound nuclei the imaginary potential persists either with an increasing trend ($^6\text{Li}$) or a flat behavior ($^7\text{Li}$) to sub-barrier energies near $E/V_{\text{bar}}=0.5$.
  
  For $^6\text{Li}$ the rising part has the larger slope for the heavier targets and the smaller slope for the lighter.
  
  These measurements indicate, especially for $^7\text{Li}$, that the dispersion relation connecting the imaginary and the real part of the optical potential may not be valid to weakly bound nuclei in accordance to initial predictions by Satchler.

- **Reaction mechanisms**
  Coupling to the continuum are strong and important.
Collaborators

- University of Ioannina, Greece
- INFN-LNS, Catania, Italy
- Dipartimento di Scienze Fisiche and INFN, Università di Napoli, Italy
- The Andrzej Soltan Institute for Nuclear Studies and Warsaw University, Poland
- CEA SACLAY, France
- Dipartimento di Fisica and INFN, Università di Padova, Italy
- National Institute for Physics and Nuclear Engineering (NIPNE), Romania
- University of Huelva, Spain