**Reaction Cross Sections of the Deformed Halo Nucleus \( ^{31}\text{Ne} \)**


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### Halo Nuclei

- Large interaction cross section \( \sigma_i \)
  - \( ^{12}\text{Be} \)
  - \( \text{large nucleus} \rightarrow \text{all nuclei except } ^{12}\text{Be} \)
  - Large radius for \( ^{11}\text{Be} \)

### Halo Nucleus

- Large Coulomb breakup cross section

### Mean Field Picture

- Naive spherical shell model
  - Nilsson diagram

### Motivations

In the Nilsson model, the rotational excitation energy of the core nucleus is neglected. In reality, however, \(^{30}\text{Ne}\) has the first \( 2^+ \) excited state at 0.801 MeV.

### Particle-Rotor Model

- \(^{31}\text{Ne} \): (deformed core \(^{30}\text{Ne} \) + n)
- Axial quadrupole deformation of the core
  - The core nucleus has a rotational band.

#### Deformed Woods-Saxon potential:

\[
V(r) = \frac{Z}{r} + V_0 \exp[-(r - R_0)/R_s] + V_0 \exp[-(r - R_0)/R_s] + (r - R_0)/R_s
\]

#### Energy:

\[
H = H_0 + V(r)\Omega_0^2(R_0)\Omega_0^2(R_0)
\]

#### Nilsson diagram:

\[
\Psi_{\Omega} = \sum_{l \Omega} \Psi_{l \Omega} \Omega_{\Omega \Omega}
\]

#### Ground State:

\[
H_{\Omega} = 0 \quad (\text{adiabatic limit})
\]

- Nilsson diagram \( \psi_0 \) : \( K \) is a good quantum number

#### The non-adiabatic effect of \( E_{\omega \rho} \neq 0 \)

### Results

- Probability of each component in the ground state wave function
  - \( \beta = 0.2, \Omega = 3/2^- \)
  - \( \beta = 0.55, \Omega = 3/2^- \)
  - \( \text{In PRM calculations the relevant quantity to the halo structure is the } \Omega \text{ component.} \)

#### Reaction cross sections for \(^{31}\text{Ne} \)

- The reaction cross sections \( \sigma_i \) for \(^{30,31}\text{Ne} \) as a function of the one-neutron separation energy \( S_\beta \)
- Comparison to the experimental interaction cross section \( \sigma_i \)

#### Summary

- Ground state properties of the deformed halo nucleus \(^{31}\text{Ne} \)
  - particle-rotor model (PRM)
  - the finite rotational excitation energy of the core nucleus
- Reaction cross sections for \(^{30,31}\text{Ne} \) on the \(^{12}\text{C} \) target → Glauber theory

#### Reaction cross sections

Calculations of reaction cross sections with the Glauber theory which describes high-energy nucleus-nucleus collisions

- Eikonal approximation : scattering in the forward angle
- Adiabatic approximation : neglect the intrinsic excitation energy for the large incident energy

\[
\sigma_{\text{Glauber}} = \frac{1}{\pi} \sum \frac{a_{\text{rot}}^2 S_{\Omega} \rho \sigma_{\text{rot}}} {\rho + S_{\Omega} \rho}
\]

- \( \rho \): initial state wave function (ground state) with particle-rotor model