Microscopic spin–orbit potentials for $^3$He elastic scattering at intermediate energies

M. KATSUMA and Y. SAKURAGI

Osaka City University
The central part of optical potentials for $^3$He elastic scattering has been determined from optical model analyses up to $E_{\text{lab}} = 450$ MeV.

The spin–orbit part of optical potentials for $^3$He scattering is unknown due to lack of experiments using polarised $^3$He beams.

$$E_{\text{lab}} = 33 \text{ MeV} \ (\text{Birmingham}) \quad \text{only one data}$$

There is an experimental project using polarized $^3$He beams at $E_{\text{lab}} = 450$ MeV. (RCNP)

We analyse the $^3$He elastic scattering with the optical model using double folding potentials.
Our Analyses

Elastic scattering of $^3$He particles

$^3$He+$^{58}$Ni  $\quad$ 33 – 450 MeV  $\quad$ $d \sigma/ d \Omega$

$^3$He+$^{58}$Ni  $\quad$ $E_{\text{lab}}$ = 450 MeV  $\quad$ Ay

RCNP （preliminary results）
Volume integrals of real central potentials

A unique potential family of central part for real optical potentials in $^3$He elastic scattering has been decided.

- Low incident energies deep or shallow potentials
- Energies higher than 40 MeV/N the shallow potential becomes the best-fit potential.
Folding potentials

\[ V^N(r) = \int \rho_1(r_1) \rho_2(r_2) \, u_{NN}(s) \, dr_1 \, dr_2 \]

The effective Nucleon-Nucleon interaction (DDM3Y)

\[ u_{NN} = u_{CE}(s) + u_{SO}(s) \, L \cdot \sigma \]

Optical Potentials

\[ U(r) = N_R \, V_{CE}^N(r) + N_{LS} \, V_{SO}^N(r) \, L \cdot \sigma \]
\[ + V_C^C(r) + i \, W_{WS}(r) \]
$^{3}\text{He} + ^{58}\text{Ni}$ Elastic Scattering

$E_{\text{lab}} = 33.3 \text{ MeV}$

$E_{\text{lab}} = 37.4 \text{ MeV}$

$E_{\text{lab}} = 43.7 \text{ MeV}$

$E_{\text{lab}} = 51.4 \text{ MeV}$

$E_{\text{lab}} = 73.2 \text{ MeV}$

$E_{\text{lab}} = 83.5 \text{ MeV}$

$N_{R} = 1.0 \pm 0.08$
Elastic Scattering

$^3\text{He} + {}^{58}\text{Ni}$

$N_R = 0.968$

$E_{\text{lab}} = 33.3 \text{ MeV}$

$N_{LS} = 1.0$

$\frac{d\sigma}{d\Omega}$ (mb/steradian)

$\theta_{cm}$ (degree)
Elastic Scattering

$^3\text{He} + ^{58}\text{Ni}$

$E_{\text{lab}} = 450\text{ MeV}$

DF model

$d\sigma/d\Omega (\text{mb/sr})$

$\theta_{\text{cm}} (\text{deg.})$

$N_l = 1.0$

$A_y$ data: Kamiya et al. (Preliminary)
Elastic Scattering

$^3\text{He} + ^{58}\text{Ni}$

$E_{\text{lab}} = 450 \text{ MeV}$

$N_{LS} = 0.50$

$A_y$ data: Kamiya et al. (Preliminary)
We analyses elastic scattering for the $^3\text{He}+^{58}\text{Ni}$ system at incident energies from 33 MeV to 450 MeV with the double folding potentials using M3Y interaction.

- The cross-section data for $^3\text{He}$ elastic scattering are reproduced by our folding potential without the large modification of real central potentials, i.e. $N_R \sim 1.0$.

- The double folding model predicts large analyzing power compared with the recent experimental data at $E_{\text{lab}} = 450$ MeV (RCNP).

- The renormalization factor $N_{LS}$ of spin–orbit potentials is 0.5 to reproduce the experimental data.