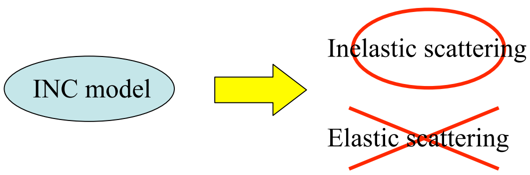
Developments of simulation model describing both elastic and inelastic scattering

Yoshinori Fukui, Hiroki Iwamoto, Yusuke Uozumi
Faculty of Engineering, Kyushu University

Introduction



・The calculation result remains uncertainty about recoil momentum of residual nuclei.

The method for describing elastic scattering

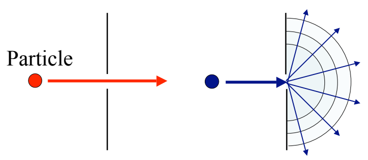
- Using classical potential
- Introducing stochastic quantization

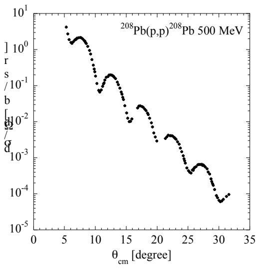
The applicability of these methods are verified.

Theories

Elastic scattering

→ Wave mechanics





Particle diffraction = Elastic scattering

INC model does not include wave mechanics.

→ It cannot describe elastic scattering.

Classical potential

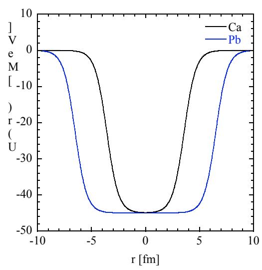
・This method expresses the time variation of momentum in terms of nuclear potential gradient.

Time variation of momentum

$$\frac{d\vec{p}}{dt} = -\nabla U(r)$$

$U(r)$: Woods-Saxon potential

$$U(r) = -\frac{V_0}{1+\exp\left(\frac{r-R}{a}\right)}$$



V_0 = 45 [MeV] : Potential depth

R : Nucleus radius

a = 0.54 [fm] : Diffuseness

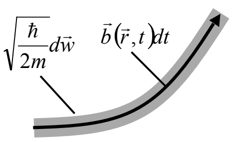
Stochastic quantization

・This method express the trajectory displacement in terms of quantum fluctuation.

・Specifically, the trajectory displacement is described by nonuniform random number based on empirical equation.

Stochastic differential equation

$$d\vec{r}(t) = \vec{b}(\vec{r}(t),t)dt + \sqrt{\frac{\hbar}{2m}}d\vec{w}(t)$$



$\vec{b}$: Mean forward velocity

$d\vec{w}$: Quantum fluctuation

$$\vec{b}(\vec{r},t) = \mathrm{Re}\left[\frac{\hbar}{m}\nabla \ln\psi(r,t)\right] + \mathrm{Im}\left[\frac{\hbar}{m}\nabla \ln\psi(r,t)\right]$$

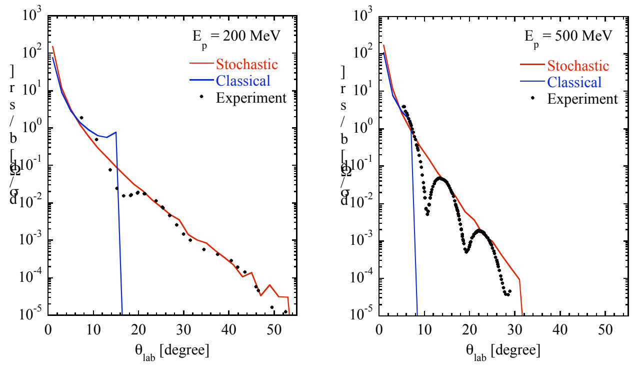
$$\langle dw(t)\rangle = 0$$

Simplified equation

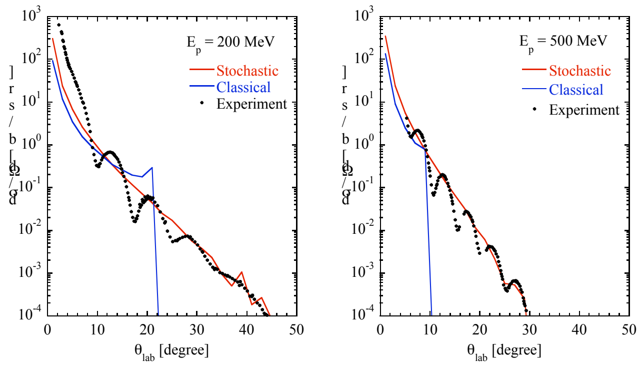
$$d\vec{r} \rightarrow (\vec{b}'+\vec{\omega}')\Delta t \equiv \vec{C}\Delta t$$

Results

Angular distribution of ^{40}Ca(p,p)^{40}Ca reaction



Angular distribution of ^{208}Pb(p,p)^{208}Pb reaction



Classical potential

・This approach cannot reproduce in a region of large angle.

Stochastic quantization

・This approach can roughly reproduce in terms of angular distribution.

・This approach cannot describe wave interference but it is sufficient results from a practical point of view.

Conclusion

・We accepted the stochastic quantization more useful than the another one from the results.

・This approach is unsatisfying and incorrect from a theoretical point of view.

・However, it has positive accepts from a practical point of view.

・Our further study will be directed toward testing its applicability to other regimes and performing calculations of recoil momentum of residual nuclei.