Nonlinear relativistic mean field Theory: Impulse Approximation

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Introduction

The scattering reaction of nucleon and the composite particles, i.e. nucleus provides a fruitful source to determine the nuclear structure as well as nuclear interaction. One of the theoritical method to study such types of reaction is "Impulse Approximation". The first theoritical introduction to high energy elastic scattering reaction was given by Chew [1] almost six decades ago. Futher, it has been sucessfully explained by Glauber theory [2], unitarized impulse approximation [3] and popular experimental obsevation [4, 5], which briefly describe the scatterering obseravable with additional comparisions between theory and experiment.

An advanced formalism to study such reaction is the relativistic impulse approximation (RIA), which was developed by Horowitz et al. [6] for ^{40}Ca, ^{208}Pb at different energy. From the recent knowledge, the importance of nonlinear term in the meson-nucleon interaction [7], which motivate us to study the nucleon-nucleus reaction by using nonlinear relativistic mean field approach.

Theoretical Framework

We would like to introduced the "Relativistic impulse approximation", which basically follows mainly three steps of calculation: (a) first we generate the density of the target nucleus using non-linear $\sigma-\omega-$ model [7]. Here, the successful NL3 parameter set [8] is used, (b) in this second step we obtain the optical potential (both imaginary and real part of scalar and vector potential) from the RMF density by McNeil, Ray and Wallace (MRW) [10] parametrization. (c) lastly we integrate the potential for a large radius, i.e. a long range of radial component with Numerov algorithm [11] and the solution approximate with the non-relativistic Coulomb wave function [12]. From this, we get the scatterering amplitude and other observables, like differential cross section $\frac{d\sigma}{d\Omega}$, analysing power A_y and the spin observable Q.

Result and Discussion

First, we calculate the density of ^{40}Ca, ^{48}Ca, ^{90}Zr and ^{208}Pb in the frame-work of RMF approach, which is the key quantity to define the optical potential of the system. The density distribution $\rho(r)$ of ^{40}Ca, ^{48}Ca, ^{90}Zr and ^{208}Pb are plotted in FIG. 1.

With the density in hand, the electromagnetic contibution of the energetic proton (the projectile) create the optical potential using MRW parametrization. The real (Re) and imaginary (Im) part of the scalar and vector potentials for ^{40}Ca as a representative case at various energies are plotted in FIG. 2. From the potential curves, it is clear that the Re S is larger in magnitude compare to the Re V and also the Im S is more than Im V.

Lastly, we performed the third step of calculation which is mentioned above to get the solution for the scattering amplitude $f(\theta)$. From this $f(\theta)$, we find the differential crosssection $\frac{d\sigma}{d\Omega}$, analysing power A_y and the spin observable Q for various energetic proton at different angle of observation. The result for $\frac{d\sigma}{d\Omega}$ of ^{40}Ca,^{48}Ca, ^{90}Zr and ^{208}Pb at various energies are shown in FIG.3.

In summary, we found qualitative description of the density of ^{40}Ca, ^{48}Ca, ^{90}Zr and ^{208}Pb from RMF theory. Using these densities we derived the scalar and vector optical potentials for the energetic proton at various inci-

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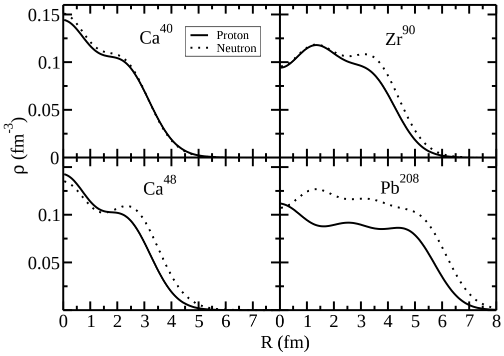

FIG. 1: The RMF density distribution of ${}^{40}Ca$, ${}^{48}Ca$, ${}^{90}Zr$ and ${}^{208}Pb$ as a function of radius using NL3 set.

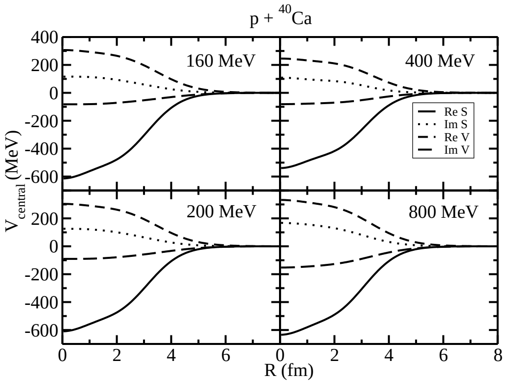

FIG. 2: The optical potential of ${}^{40}Ca$ for different energetic proton using MRW parametrization.

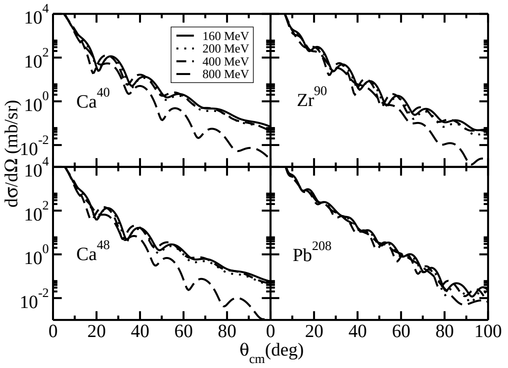

FIG. 3: The differential cross-section of ${}^{40}Ca$, ${}^{48}Ca$, ${}^{90}Zr$ and ${}^{208}Pb$ as a function of angle of observable.

dent energies. The differential cross-section, analysing power and the spin obsevable of the high energetic proton provides a good description of the nuclear structure and reaction. Most important result drawn from the spin observable which put a shining path to study towards the relativistic inelastic proton-nucleus scattering. Work in this direction is in progres.

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