Probing ^{31}Ne with intermediate energies protons

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Introduction

Reactions of unstable neutron-rich (exotic) nuclei with a proton target are of current interest since such reactions are at present the major means to sensitively probe the matter densities of exotic nuclei, especially the region of the nuclear surface. The Glauber multiple scattering model provides a fairly successful theoretical tool for investigating the nucleon-nucleus scattering at intermediate energies.

In a recent analysis [1], we have calculated the interaction cross section of neon isotopes $^{17\text{-}32}$Ne on ^{12}C at 240 MeV/nucleon within the framework of Coulomb modified correlation expansion for the Glauber model (CMGM) S-matrix. The results suggested that the use of Slater determinant description of colliding nuclei, involving harmonic oscillator single particle wave functions (hereafter referred to as HO densities), can be considered as a good starting point to predict the rms radii of exotic neutron rich nuclei. Keeping this in view, we now consider the analysis of the differential cross section of ^{31}Ne on hydrogen at 240 MeV/nucleon and 1.0 GeV/nucleon within the framework of CMGM. Though no experimental data are available to compare the theoretical predictions, our aim, in this wok, is to see how far the results with HO density of ^{31}Ne are comparable with those obtained with relativistic mean-field (RMF) density and the density of Minomo *et al.* [2] , and what could be said about the nature of densities at energies under consideration.

Formulation

According to the Glauber model, the scattering amplitude describing the elastic scattering of protons from a target nucleus is given by

$$F_{el}(\vec{q}) = \frac{iK}{2\pi}\int e^{i\vec{q}.\vec{b}}\left[1 - S_{el}(\vec{b})\right]d^2b, \qquad (1)$$

where $\vec{q}$ is the momentum transfer, $\vec{b}$ is the impact parameter, and $S_{el}(\vec{b})$ is the elastic S-matrix element, expressed as

$$S_{el}(\vec{b}) = (\psi_A|\prod_{i=1}^{A}[1 - \Gamma_{NN}(\vec{b} - \vec{s}_i)|\psi_A) \qquad (2)$$

where ψ_A is the target ground state wave function, $\vec{s}_i$ is the i^{th} nucleon coordinate in a plane perpendicular to the scattering (z) axis, and Γ_{NN} is the NN profile function, which is related to the NN amplitude $f_{NN}(\vec{q})$ as follows

$$\Gamma_{NN}(\vec{b}) = \frac{1}{2\pi ik}\int e^{-i\vec{q}.\vec{b}} f_{NN}(\vec{q})\, d^2q \qquad (3)$$

Further, following Ahmad [3], the required correlation expansion for the elastic scattering amplitude is given by

$$F_{el}(\vec{q}) = F_0(\vec{q}) + \sum_{l=2}^{AB} F_l(\vec{q}) \qquad (4)$$

The term F_0 in eq.(4) is the uncorrelated part of the scattering amplitude, involving all orders of scattering; this term depends upon the one body density of the target nucleus. The other terms involve the *l*-th body density of the target nucleus and may be regarded as providing corrections to the uncorrelated part.

With these considerations, the elastic differential cross section is calculated using the expression

$$\frac{d\sigma}{d\Omega} = \left|\boldsymbol{F_{el}(\vec{q})}\right|^2 \qquad (5)$$

Results and Discussion

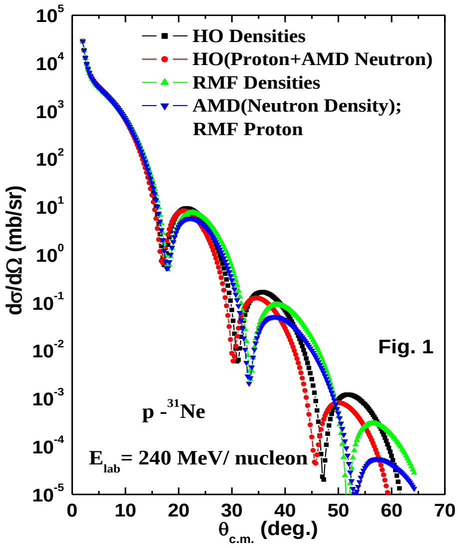
We have calculated the differential cross sections of ^{31}Ne on hydrogen target at 240 MeV/nucleon and 1.0 GeV/nucleon involving up to two body correlation term in the Glauber amplitude (eq.(4)). The inputs require in the calculation are **(i)** the NN scattering amplitude, **(ii)** the proton and neutron density distributions of the target nucleus, and **(iii)** the oscillator constant.

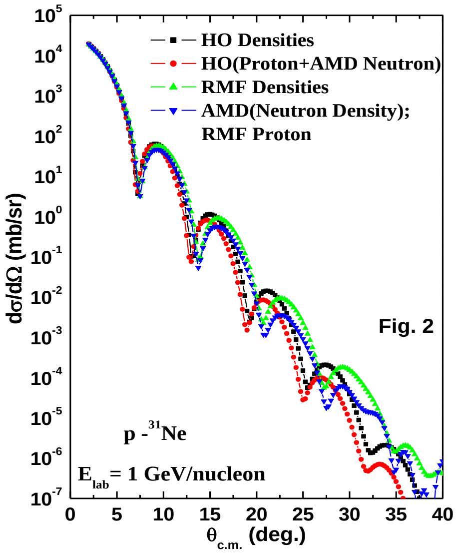
For the NN scattering amplitude, the simple Gaussian parametrization for the NN amplitude [1]

$$f_{NN}(\vec{q}) = \frac{k\sigma_{NN}}{4\pi}(i + \rho_{NN})e^{-\beta_{NN}q^2/2} \qquad (6)$$

has been frequently used. In eq. (6), σ_{NN} is the NN total cross section, ρ_{NN} is the ratio of the real to the imaginary parts of the forward NN amplitude and β_{NN} is the slope parameter. The present work needs the values of the parameters σ_{NN}, ρ_{NN} and β_{NN} at 240 MeV and 1.0 GeV. These values are taken from Ref. [4].

The oscillator constants for proton and neutron HO density distributions are fixed from the corresponding RMF proton and neutron rms radii of ^{31}Ne [5]. As a result, the present calculations have no adjustable free parameters. The results of the calculations are presented in Figs. 1 and 2. In these figures, we have predicted the cross sections with **(i)** HO densities for both protons and neutrons which gives the corresponding RMF (rms) radii (squares), **(ii)** HO densities for both protons and neutrons in which neutron distribution gives the corresponding rms radius of Minomo *et al.* [2] (circles), **(iii)** RMF densities (triangles), and **(iv)** RMF proton density and Minomo *et al.* [2] neutron density (inverted triangles). The difference between different forms of matter densities are visible throughout the angular range. However, the present calculations are unable to predict the suitable choice of the matter distributions unless we have the experimental data on p-^{31}Ne differential cross sections at energies under consideration.





References

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