Reaction dynamics for some halo nuclear systems using Glauber model with relativistic mean field densities

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Introduction

The study of nuclear structure of exotic nuclei, specially the ones away from the β-stability are of current interest. Such nuclei with weak binding lie at the limit of stability and exhibit many fascinating phenomena. One of them is the formation of one or more nucleon halo structure in light mass region. It is well established that the halo nuclei like ^{11}Li, ^{11}Be and ^{19}C [1] show anomalously large interaction cross sections and matter radius than that of their neighboring nuclei. Some recent investigations have predicted the one neutron halo nature of ^{29}Ne and ^{31}Ne [2, 3]. The isotope ^{31}Ne has neutron number N=21, which breaks the shell closer structure as a consequence of deformation associated with the strong intruder configuration and hence this nucleus is widely investigated. We investigate here some of the halo candidates like ^{11}Be, ^{15}C, ^{19}C and ^{31}Ne using reaction dynamics. For this purpose, we have used the well known Glauber model approach [4] with two body system (core+one nucleon). The Glauber model works excellently at intermediate energy range. So total reaction cross sections and elastic differential cross sections have been investigated at projectile energy (E_{proj}) 100 MeV/nucleon for further understanding of these exotic halo systems. The reaction cross sections (σ_R) have been calculated by using the expression

$$\sigma_R = 2\pi \int_0^\infty b[1 - T(b)]db, \qquad (1)$$

where 'T(b)' is the Transparency function with impact parameter 'b'. The main ingredient of Glauber model are the densities of projectile and target nuclei which are taken from the well known relativistic mean field (RMF) formalism with NL3* parameter set [8].

TABLE I: The Gaussian coefficients c_1, a_1, c_2, a_2 of the core of the projectile and target nuclei for RMF(NL3*) densities.

Nuclei	c_1	a_1	c_2	a_2
^{12}C	-0.169195	0.577368	0.418511	0.300552
^{10}Be	-1.17648	0.379063	1.34262	0.337854
^{14}C	-1.21549	0.398868	1.40356	0.331961
^{18}C	-1.10166	0.289345	1.25595	0.245773
^{30}Ne	-2.90293	0.22326	3.04881	0.204765

TABLE II: The nucleon-nucleon cross-section σ_{NN} and other parameters like α_{NN} and β_{NN} used to calculate the profile function.

Energy (AMeV)	σ_{NN} fm^2	α_{NN}	β_{NN} fm^2
49.3	10.32921	0.9419416	0.3880949
100.0	5.295	1.435	0.322
240.0	3.266868	0.6800303	0.097843707
730.0	4.174130	-0.082869336	0.189661
950.0	4.318554	-0.2078482	0.2142974
960.0	4.319103	-0.2213738	0.2134798

These axially deformed densities of core of projectiles and target nuclei are converted into Gaussian form in terms of their coefficients c_i's and a_i's using expression.

$$\rho(r) = \sum_{i=1}^{2} c_i exp[-a_i r^2]. \qquad (2)$$

After conversion, these densities are listed in TABLE I in terms of Gaussian coefficients. The another important ingredients for reaction cross sections are some energy and isospin dependant parameters σ_{NN}, α_{NN} and β_{NN}, which are listed in TABLE II after estimation from Ref. [5] by spline interpolation. The calculated values of σ_R's for considered nuclei are listed in TABLE III along with the experimental data wherever available. This table suggest that the calculated σ_R for chosen set of halo nuclei find reasonable comparison with the experimental data.

TABLE III: The comparison of cross section in (mb) on C target for various projectiles along with the experimental values which are avialable [2, 6].

Projectile	E_{proj}(AMeV)	σ_R(RMF)	Σ_R(Expt.)
^{11}Be	950	918	942±8
^{15}C	730	989	945±10
^{19}C	960	1471	1231±28
^{31}Ne	240	1364	1435±22

Fig. 1 show the elastic differential cross section for ^{11}Be+^{12}C at energy 49.3 MeV/nucleon using RMF(NL3*) densities along with experimental data [7]. From Fig. 1, we conclude that the RMF densities produce remarkable agreement of elastic differential cross section with experimental data. The calculated values of σ_R's for ^{11}Be, ^{15}C, ^{19}C and ^{31}Ne halo projectiles with ^{12}C target at E_{proj} 100 MeV/nucleon are 993, 1078, 1562 and 1568 mb, respectively. The Fig. 2 predicts the elastic differential cross sections for ^{11}Be, ^{15}C, ^{19}C and ^{31}Ne projectile using ^{12}C target at energy 100 MeV/nucleon. The large dips are appeared for considered halo cases in between $\theta_{c.m} \sim$(2-3)^0

In conclusion, we have observed that both total reaction cross sections and elastic differential cross sections using RMF(NL3*) densities show excellent agreement with the experimental data and hence we have also predicted these values for considered halo cases at energy 100 MeV/nucleon.

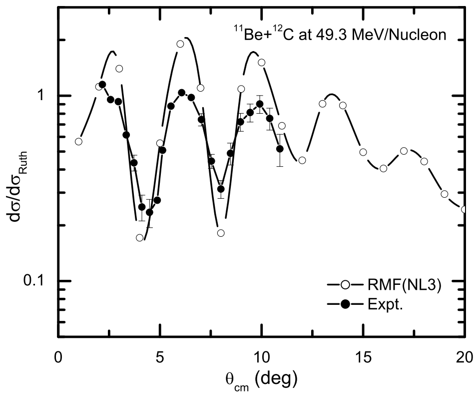

FIG. 1: The angular differential cross sections for ^{11}Be projectile over ^{12}C using RMF(NL3*) densities along with experimental data [7].

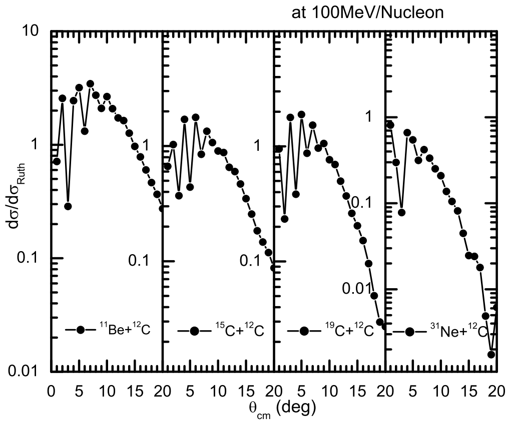

FIG. 2: The angular differential cross sections for ^{11}Be, ^{15}C, ^{19}C and ^{31}Ne projectiles over ^{12}C at E_{proj} 100 MeV/ nucleon.

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