Nuclear reaction cross section for drip-line nuclei in Glauber formalism using relativistic mean field densities

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In recent years, the study of exotic nuclei attracts considerable theoretical and experimental attention. The isotope of ^{24}O has N=16, which is a new magic number in the neutron rich nuclei [1]. The ground states of ^{23}O is unbound, also conventionally expected isotopes ^{25}O, ^{26}O and ^{28}O are found unbound, which limit the drip line for O isotopes at ^{24}O, which is a doubly magic nucleus. In addition to this, the change of shell structure and the weak binding at the limit of stability exhibit some fascinating phenomena. One of them is the formation of one/two neutron halo. The recent discovery of ^{40}Mg and ^{42}Al [2] which are well beyond the neutron dripline by various mass formulae, challenge the predictive power of theoretical calculations for a definite neutron dripline. This recent measurement increase our interest to study the properties of such nuclei. We investigate in this work the nuclear reaction cross section σ_R of Mg and Al isotopes from stable to dripline region using the well known Glauber model [3] with the conjunction of relativistic mean field densities.

The reaction cross section σ_R is defined as [3]:

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

where 'T(b)' is the transparency function with impact parameter 'b'. The densities obtained from the axially deformed relativistic mean field (RMF) model with NL3* set of force is used to calculate the nuclear reaction cross section. The axially deformed density is represented as:

$$\overline{\rho}(\omega) = \int_{-\infty}^\infty \rho(\sqrt{w^2 + z^2})dz, \qquad (2)$$

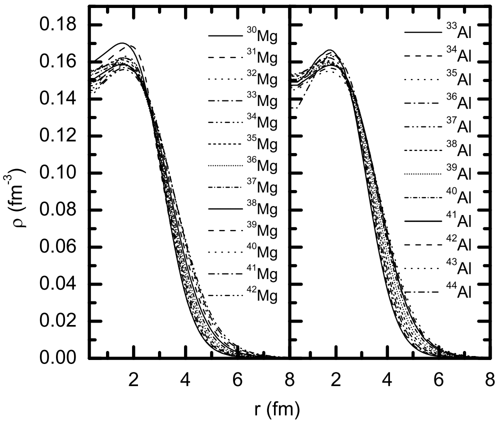

FIG. 1: The radial density plots of Mg and Al isotopes for RMF(NL3*).

with $\omega^2 = x^2 + y^2$.

Figure 1 shows the radial density plot for $^{30-42}Mg$ and $^{33-44}Al$ with RMF(NL3*) densities. The densities of higher isotopes of Mg and Al are showing depression at the center with increase of mass number A and have a longer tail. These densities are obtained after fitting into two Gaussian in terms of their coefficients c_i and a_i. The values of the Gaussian coefficients are listed in Table I. The other inputs require for calculation of profile function are the energy dependent parameters σ_{NN}, α_{NN} and β_{NN}. These values are taken from Ref. [4] wherever available otherwise an interpolated values of these parameters are used in the calculations. These are σ_{NN} = 4.311690 (fm^2), α_{NN} = -0.1439280 and β_{NN} = 0.2171934 (fm^2) at energy 900 MeV/A.

Table III compares the calculated values of reaction cross section of Mg isotopes with ex-

TABLE I: The RMF(NL3*) densities after fitting gaussian in terms of their coefficients c_i and ranges a_i.

Nuclei	c_1	a_1	c_2	a_2
^{12}C	-0.169195	0.577368	0.418511	0.300552
^{30}Mg	-2.85085	0.207626	2.95863	0.190729
^{31}Mg	-3.07236	0.214901	3.19436	0.197462
^{32}Mg	-3.14121	0.215721	3.27192	0.198145
^{33}Mg	-3.14637	0.211096	3.27551	0.193894
^{34}Mg	-2.72369	0.186362	2.82369	0.170924
^{35}Mg	-2.63207	0.17827	2.7282	0.16354
^{36}Mg	-2.58396	0.171635	2.67618	0.157531
^{37}Mg	-2.6057	0.168656	2.69665	0.154832
^{38}Mg	-2.65101	0.16633	2.7405	0.152757
^{39}Mg	-2.70506	0.164315	2.79411	0.151012
^{40}Mg	-2.72653	0.161259	2.8146	0.148298
^{41}Mg	-1.9176	0.143155	1.99748	0.129699
^{42}Mg	-4.08053	0.135833	4.15992	0.129709
^{33}Al	-3.30197	0.215088	3.42956	0.197664
^{34}Al	-3.29727	0.210286	3.42323	0.193247
^{35}Al	-1.30998	0.235532	1.37557	0.181819
^{36}Al	-2.77458	0.179283	2.87145	0.164565
^{37}Al	-2.68485	0.171731	2.77782	0.157672
^{38}Al	-2.68058	0.167474	2.77188	0.153851
^{39}Al	-2.68361	0.163411	2.77449	0.150276
^{40}Al	-2.65962	0.158524	2.74834	0.145895
^{41}Al	-2.6448	0.154438	2.73197	0.142219
^{42}Al	-2.61286	0.151115	2.69952	0.13913
^{43}Al	-2.56627	0.147747	2.6527	0.135973
^{44}Al	-3.09818	0.165568	3.1971	0.15212

TABLE II: The calculated values of σ_R using RMF(NL3*) densities.

Nuclei	$E(MeV/A)$	σ_R RMF(NL3*)	σ_R Expt. [5]
^{32}Mg	900	1515	1331±24
^{33}Mg	900	1541	1320±23
^{34}Mg	900	1657	1372±46
^{35}Mg	900	1706	1472±70

perimental observations. Our results are appeared slightly over estimated than the experimental values. Fig. 2 shows the variations of total reaction cross section as a function of projectile energy E_{proj} over the range of 30-2200 MeV/A. The σ_R having large value at small E_{proj} and start decreasing with increase of the E_{proj} upto $\sim$ 300 MeV/A. i A slight increase in σ_R appears at about 300 − 750 MeV/A and beyond it is constant. The σ_R

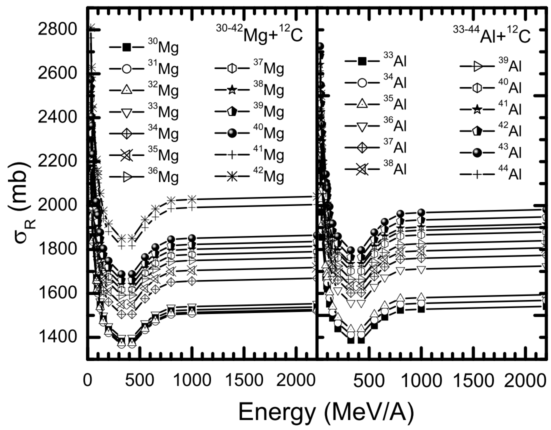

FIG. 2: Variation of reaction cross section with projectile energy E_{proj} for Mg and Al isotopes with ^{12}C target.

for isotopes of Mg and Al increases with increase of isotopic mass number (A).

In summary, we calculate the reaction cross section of some of the Mg and Al dripline nuclei in the frame-work of Glauber model using RMF densities. We compared our results with the observed experimental data wherever possible. In general, the results are well comparable with experimental results.

References

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