Nuclear reaction cross-section of ^{22}C using Glauber Model and Relativistic Mean Field formulism

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The studies of exotic nuclei have been important theoretically as well as experimentally for nuclear physics community. One of the most exotic phenomena is the neutron halo, which is formed by the extremely weakly bound neutrons that decouple from the nuclear core. With the advancement in the radioactive ion beam facilities, it becomes possible to carry out many experiments and get more information regarding the structures of nuclei away from the stability line. The properties of the nuclei in the exotic mass regions are entirely different. For example, in the very neutron-rich Ne, Na, and Mg isotopes with N≈20, one of the most important issues is the vanishing of the shell gap, which causes a mixing of normal and intruder configurations, and has significant influence on the properties of those nuclei [1] The reaction cross sections of certain nuclei ^{6,8}He, ^{11}Li and ^{11,14}Be [2] have been found anomalously large. The matter radius of such nuclei is much larger than that of the neighboring nuclei. Recently, the measurement of nuclear reaction cross-section for ^{19,20,22}C [3] shows that the drip-line nucleus ^{22}C has halo structure. The ^{22}C has N = 16 which is new magic number in neutron-rich nuclei but, ^{21}C is unstable, which makes it Borromean type nucleus. Therefore, these are the points which motivates the study of ^{22}C nucleus. We use Galuber theory [4] to calculate the nuclear reaction cross-section and the differential cross-section,

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

where $'\mathrm{T(b)}'$ is the transparency function with impact parameter $'\mathrm{b}'$. The densities obtained from the axially deformed relativistic mean field (RMF) model for both target and projectile nuclei are used to calculate the nuclear cross-section and the differential cross-section,

TABLE I: The coefficients of Gaussian function.

$Nucleus$	c_1	a_1	c_2	a_2
^{12}C	-0.15936	0.63293	0.41531	0.30458
^{5}He	-1.20918	0.36343	1.40551	0.36338
^{21}C	-1.18702	0.25247	1.41022	0.22598

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

with $\omega^2 = x^2 + y^2$. The density is fitted to the Gaussian to get the co-efficients given in the Table I. The Glauber model with relavistic mean field density shows reasonably good agreement with the experimental observations. The nuclear reaction cross-section for ^{6}He + ^{12}C at E = 800 MeV/A is 725.367 mb, which is comparable well with experimental value σ_R= 722±6 mb. The defferential cross-section for ^{6}He + ^{12}C at energies 38.3 MeV/A and 41.6 MeV/A are shown in Fig.1. The results of the calculation are in good agreement with the experimental observations [5]. Although, at higher angle the cross-section is deviated slightly from the experimental finding, but the nature of the curve is similar. The cross section at higher angle seems to be under estimated the experimental data. The reaction crossr-section at the above mentioned energies and different projectile nuclei for ^{12}C target are given in Table. II. In the Table we have also given the corresponding one neutron removal cross-section for ^{6}He and ^{22}C projec-

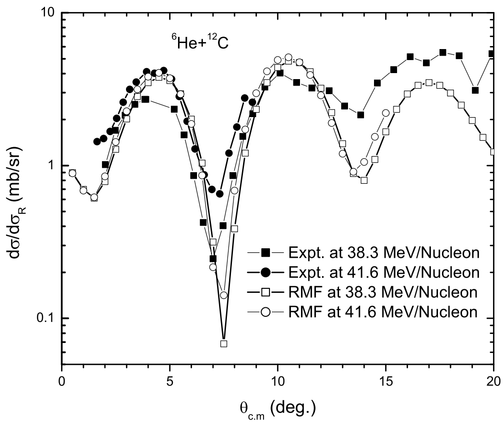

FIG. 1: The comparison of elastic differential cross-section at energies 38.3 MeV/A and 41.6 MeV/A with expt. data [5]

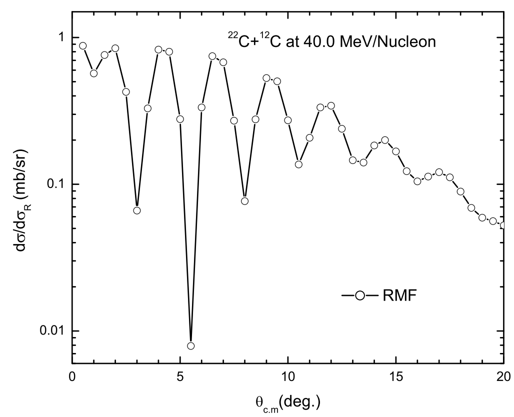

FIG. 2: The elastic differential cross-section at energy 40.0MeV/A using RMF density.

TABLE II: The comparision of cross section (mb), on Target ^{12}C with experimental datum [7]

Proj.	E(MeV/A)	σ_R	σ_R(Expt.)	σ_{-N}
^6He	38.3	1075.636	-	117.976
^6He	46.1	1034.722	-	115.505
^6He	800.0	725.367	722± 6	82.474
^{22}C	40.0	1645.677	-	20.576

TABLE III: The nucleon-nucleon cross section (σ_{NN}) and other parameters to calculate profile function

E(MeV/Nucleon)	σ_{NN}	α_{NN}	β_{NN}
38.3	14.42735	0.89143	0.51548
40.0	13.500	0.900	0.486
46.1	12.74401	0.90712	0.46193

tiles and, the available experimental value of reaction cross-section. The large cross-section indicates that the ^{22}C is halo nucleus. The Fig. 2, shows the differential cross-section for the ^{22}C + ^{12}C at energy 40.0 MeV/A. In the figure the large dip is at $\theta_{c.m.} \sim 5.0^0$. The nuclear reaction cross-section for this reaction at energy obtained 1645.677 mb. The parameters for nucleon-nucleon interactions such as σ_{NN}, α_{NN} and β_{NN} at various energy values are presented in the Table III. [6].

In conclusion, the cross section calculated with the RMF densities agrees excellently good agreement with experiments at lower angle and fairly good at higher angle. The large nuclear reaction cross section and small neutron removal cross section suggests halo structure of the drip-line nucleus ^{22}C.

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