Reaction Cross Section for Ne Isotopes

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I. INTRODUCTION

The development of accelerator technique for Radioactive Ion Beams (RIBs) help to study numerous experimental as well as theoretical measurements for nuclei far from β - stability line. Experimental methods and theoretical analysis have been widely used to collect information about the nuclear size, valence nucleon distribution and halo structure. The measurement of various cross sections like reaction cross section, neutron removal cross section and momentum distribution are some of the established tools for exploring unstable nuclei.

Island of inversion (IOI) is one of the most important current subjects in nuclear physics. This was first applied by Warburton to a region of very neutron-rich nuclei from ^{30}Ne to ^{34}Mg [1]. Discovery of the halo structure is another important progress of research on unstable nuclei. A halo structure of ^{31}Ne was reported by the experiment on the one-neutron removal reaction [2]. Experimentally this is the heaviest halo nucleus.

In the present contribution, first we calculate the bulk properties, such as binding energy (BE), root mean square charge radius r_{ch}, matter radius r_m and quadrupole deformation parameter β_2 for $^{18-32}$Ne isotopes in the Relativistic mean field (RMF) and effective field theory motivated RMF (E-RMF) formalisms . Then we analyze the total nuclear reaction cross section σ_R for the scattering of ^{20}Ne and $^{28-32}$Ne from a ^{12}C target at 240 MeV/nucleon by using the RMF model. Thus the objective of the present study is to calculate the bulk properties as well as a systematic analysis of σ_R over a range of neutron rich nuclei in the frame work of Glauber model [3].

II. THEORETICAL FRAMEWORK

The ingredient to calculate the nuclear observables is the nuclear density. It becomes important to select the appropriate density before finding the ground state observables. These are the most crucial and required quantities for our calculations of the bulk properties as well as nuclear cross sections. Deformation makes the change in the density profile. Due to the elongation, surface diffuse and the root-mean- square (RMS) radius becomes effectively large and eventually enhances σ_R. Thus the amount of deformation is important [4]. A deformed RMF calculation can be found in Ref. [5].

The successful applications of RMF and E-RMF formalisms for finite nuclei as well as the infinite nuclear matter are well documented and details can be found in Ref. [6] for the RMF theory and the E-RMF in Ref. [7]. The RMF in conjunction with Glauber model is a useful theoretical tool of analysing σ_R [6]. The RMF and E-RMF formalisms using Glauber model show a good agreement with experimental data for both NL3 and G2 parameter set during measurements of the σ_R and elastic differential scattering cross sections [6]. The theoretical formalism to calculate the total nuclear reaction cross section using the Glauber approach, has been given by R. J. Glauber [3] and data for σ_R can be obtained from Ref. [6]. The σ_R at high energies is expressed as

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

Where $T(b)$ is the transparency function with impact parameter b.

TABLE I: Binding energy (BE), charge radius (r_c) and quadrupole deformation parameter β_2 for $^{18-32}$Ne isotopes obtained from RMF(NL3*) and E-RMF(G2) formalisms compared with experimental data. The BE is in MeV and charge radius in fm.

Nucleus	BE			r_c			β_2	
	RMF	E-RMF	Expt.	RMF	E-RMF	Expt.	RMF	Expt.
^{18}Ne	131.8	135.3	132.1	2.963	3.055	2.972	0.238	0.027
^{20}Ne	156.7	156.6	160.6	2.972	2.986	3.00	0.537	0.034
^{22}Ne	175.7	174.2	177.8	2.94	2.903	2.954	0.502	0.023
^{24}Ne	189.1	190.2	191.8	2.88	2.879	2.903	−0.259	0.014
^{26}Ne	200.0	202.7	201.5	2.926	2.886	2.927	0.277	
^{28}Ne	208.3	211.7	206.9	2.965	2.925	2.963	0.225	
^{30}Ne	215.2	218.2	211.3	2.992	2.965		0.046	
^{31}Ne	216.3	220.0	211.6	3.027	2.974		0.228	
^{32}Ne	218.7	221.2	213.2	3.069	2.982		0.369	

III. RESULT AND DISCUSSION

First we calculate the bulk properties, such as binding energy (BE), root mean square charge radius r_{ch}, matter radius r_m and quadrupole deformation parameter β_2 for the $^{18-32}$Ne isotopes in the RMF and E-RMF formalisms. The results of our calculations are presented in TABLE I which are in good agreement with the experimental data. The variation of total nuclear reaction cross section σ_R with mass number for Ne isotopes is shown in Figure 1. It shows our calculated results some how overestimate the experimental data [8]. The origin of this discrepancy may be due to the spherical densities considered in the calculations. To see more detail a work toward this direction are needed.

IV. SUMMARY AND CONCLUSION

In summary, the bulk properties of $^{18-32}$Ne isotopes have been calculated using the RMF (NL3) and E-RMF (G2) formalisms. The calculated results are in good agreement with the experimental data. However, the variation of σ_R with mass number for these isotopes some how overestimate the data. Here, the theoretical calculations do not follow the experimental trend as the input density is spherically symmetry. Thus considering deformed density a further study is now in progress.

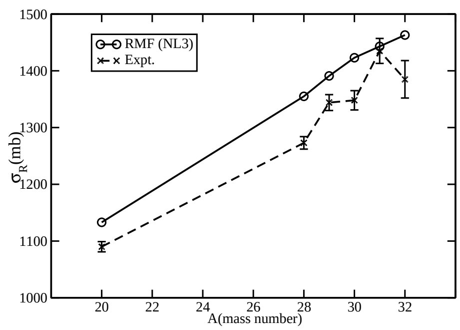

FIG. 1: Reaction cross sections for scattering of Ne isotopes on ^{12}C target at 240 MeV/nucleon.

References

[1] E. K. Warburton, et al., *Phys. Rev. C* **41**, 1147 (1990).

[2] T. Nakamura, et al., *Phys. Rev. Lett.* **103**, 262501 (2009).

[3] R. J. Glauber, *Lectures on Theoretical Physics*, **Vol.1**, p.315 (1959).

[4] T. Sumi et al., *Phys. Rev. C* **85**, 064613 (2012).

[5] M. K. Sharma and S. K. Patra, (*in this Symposium)*.

[6] S. K. Patra, R. N. Panda, P. Arumugam and Raj K. Gupta, *Phys. Rev. C* **80**, 064602 (2009).

[7] R. J. Furnstahl, B. D. Serot, and H. B. Tang, *Nucl. Phys. A* **615**, 441 (1997).

[8] M. Takechi et al., *Nucl. Phys. A* **834**, 412c (2010).