Core Excitation Effects in ^{9}Be (^{15}C, ^{14}C)X reaction

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Introduction

The existence of halo structure among the neutron/proton rich nuclei is a well-known phenomenon in which the nucleus exists in core plus valence nucleon structure. The valence nucleon is loosely bound to core, and form extended radii [1]. Study of these nuclei is important because of their connections with nucleosynthesis reactions and understanding the drip line nuclear physics [2]. Therefore, a lot of interest has been devoted to the study of these nuclei. The technical advancement in the development of RIB facilities gave a big burst to experimental work in this field and open new problems for the theoretician. The study of breakup reactions involving these exotic nuclei gives a direct way to study astrophysical nuclear reactions and explore the noval structure of the drip line species.

The study of breakup of these nuclei into its constituents has been an efficient tool to explore these nuclei. During the breakup reactions, for simplicity the core of the projectile is assumed in its ground state however valence nucleon may be in higher states. But in recent works, the possibility of core to be in its excited state is reported and played significant role in interpretation of experimental data [3]. So in the light of our previous work [4], we have investigated the nuclear breakup (through stripping and diffraction mechanism) of ^{15}C nuclei on light target (^{9}Be) at 103 MeV/n incident energies. The reported binding energy of valence neutron is S_n= 1.218 MeV, for J^{Π}=1/2^{+}. In this work we investigated the effects of core excitation on longitudinal momentum distribution (LMD) and nuclear breakup cross section which are very important observables in halo breakup reactions studies.

Here, the target nucleus is very light (small atomic number) so the breakup is dominantly cause by nuclear interaction (stripping and diffraction mechanisms) and contribution corresponding to Coulomb interaction is very small. The work is studied within the framework of Glauber eikonal model, using a standard FORTRAN code called MOMDIS [5]. Details of theoretical formalism are discussed in ref. [5]. We calculated LMD and cross sections. In the calculations the major ingredients has been the relative motion wave function of core and valence neutron, which were calculated numerically by solving Schrodinger wave equation using woods-Saxon potential whose depth is adjusted to get the experimental core excitation energy (Effective binding energy), the parameter r_0 taken as 2.67 fm and diffuseness a=0.6 fm for ^{15}C. For simplicity we have used spectroscopic factor C^2S =1. While core-target and neutron-target S-matrices were calculated using the $t_{\rho\rho}$ approximation.

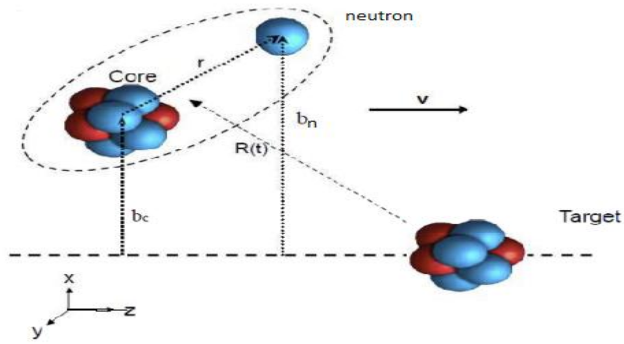

Fig.1 Geometry of the problem

Results

The calculations were performed by taking different excited states of the core from ref [6] and the obtained LMD width and breakup cross section corresponding to each core state are shown in Table-1,

Table-1: Calculated nuclear breakup cross-section (stripping and diffraction dissociation) and LMD width corresponding to different core excited states.

Core⨂Neutron configuration	Core excitation energy E_c^{ex} (MeV)	Effective neutron separation energy S_n^{eff} ($E_c^{ex}+Sn$) (MeV)	Total cross-section (σ_t=stri+dif) in mb	LMD width in MeV/c
$0^{+}\otimes S_{1/2}$	0	1.218	106.4	29.69
$0_1^{+}\otimes S_{1/2}$	6.589	7.807	42.05	57.24
$0_2^{+}\otimes S_{1/2}$	9.746	10.964	35.42	63.59
$0_3^{+}\otimes S_{1/2}$	11.306	12.524	33.15	66.18

The total cross section and LMD width are corresponding to stripping and diffraction mechanisms. It is clear from the table that with increase in binding energy i.e. ($E_c^{ex} + S_n$) the valence neutron tends more tightly bound to core which may be understood via the well known uncertainty principle that

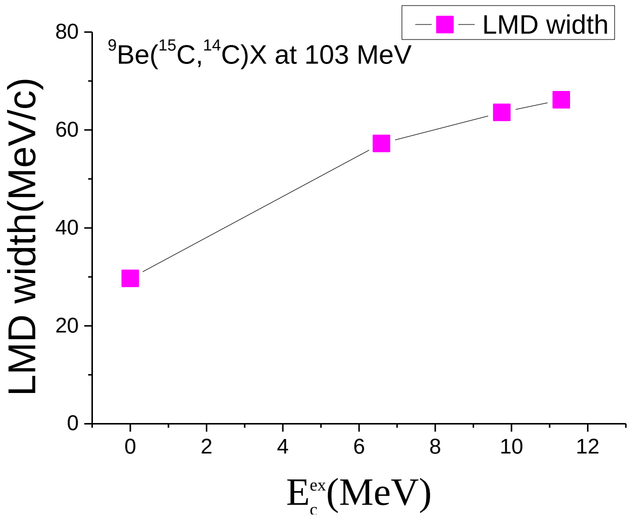

Fig-2 Increase in LMD width with core excitation energy.

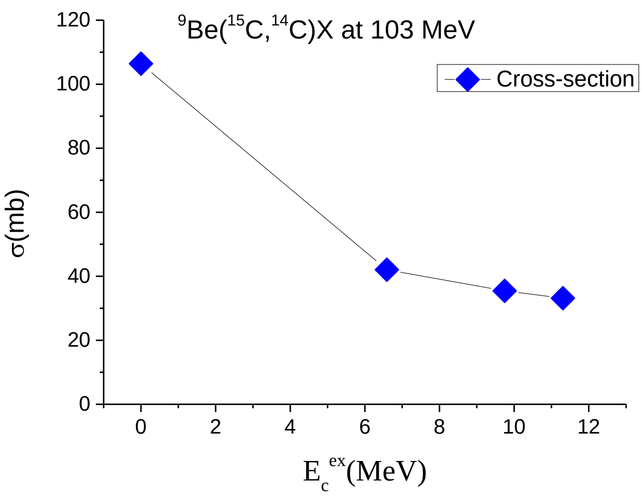

Fig-3 Decrease in nuclear breakup cross-section with core excitation energy

the increment in total binding energy of the projectile reduces its spatial extension which eventually increases the width of momentum distribution and hence abruptly reduces the breakup probability or cross section as may be seen in Table- 1 and Fig. 2 & Fig. 3.

Conclusion

The single neutron breakup reaction $^9Be(^{15}C, ^{14}C)X$ has been studied at 103 MeV/n and exclusively the core excitation effects on longitudinal momentum distribution width and total nuclear breakup cross-section has been investigated quantitatively using MOMDIS code [5]. It has been found that the Longitudinal Momentum Distribution (LMD) width increases almost twice with ten times increase in binding energy (see table-1). However, the breakup cross section decreases by one third to that of ground state binding energy. Therefore, we found that core excitation energy affects significantly the observables (LMD and nuclear breakup cross sections), so core excitations are to be consider seriously while interpretation of experimental results.

References

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