Core Excitation Effects on $^{9}Be(^{17}F,^{16}O)X$ reaction at 70 MeV/n energy

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Introduction

Existence of halo nuclear structure in extremely neutron/proton rich nuclei attracted a lot of attentions of nuclear physicists after its major discovery [1]. Existence of halo is basically a threshold phenomenon in which the outermost valence nucleon tunnel out to larger distance and form a "core plus valence nucleon" structure and valence nucleon remains loosely bound to the core. These kind of novel nuclear structure is observed in neutron/proton rich nuclei lying on the neutron or proton drip lines. Neutron halos structure are observed in huge number of isotopes so far while Proton halos were probed less than neutron halos because of presence of Coulomb barrier. ^{8}B, ^{17}F, ^{17}Ne,^{26}P are some candidates of proton rich nuclei having halo/skin structure. Some of these are well known halo structure while some are still under investigations. The study of these isotopes is important because of their role in astrophysics and Stellar processes that is why their study has been a hot topic since their discovery. In particularly ^{17}F case, experimentally observed two binding energies of valence proton i.e. 600 keV and 105 keV corresponding to $J^{\pi}=3/2^{+}/5/2^{+}$ and $1/2^{+}$ states make it appealing to restudy. So the investigations of core (^{16}O) excited states has been interesting point to explain the structure of ^{17}F, also this isotope is interesting to study because of astrophysical $^{17}F(p\ ,\ \Upsilon)^{18}Ne$ reaction [2].

In this work we have analyzed effects of core excitation on nuclear breakup cross-section and Longitudinal Momentum Distribution(LMD) for $^{9}Be(^{17}F,^{16}O)X$ at 70 MeV/n incident energy. In halo nuclei breakup reactions, for simplicity, the core is assumed in its ground state while valence proton may lie anywhere as per shell model. However, in recent works the possibility of core to be in its excited states has also been reported in some cases [3-5].

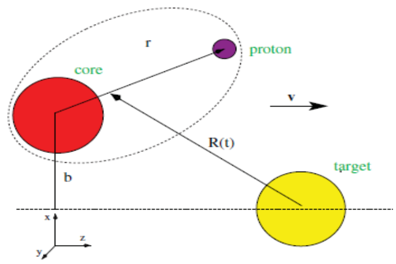


Fig.1. Geometry of the Problem

The breakup of single proton from ^{17}F has been studied within the frame work of Glauber Eikonal Model which is more appropriate for the knockout reactions at intermediate energies (around 50 MeV/n) and widely discussed in literature [6]. The simplest interaction is shown in Fig. 1. In this reactions the dominant breakup mechanism are stripping or absorption and diffraction dissociation, the contribution due to Coulomb mechanism is small since chosen target (^{9}Be) have small atomic number. All the calculations were done using a standard computation code i.e. MOMDIS [6] based on Glauber Eikonal model. Using this code we have calculated the Longitudinal Momentum Distribution of core fragment (^{16}O) after the valence proton detachment and breakup cross sections corresponding to above said nuclear mechanisms. In the calculations the projectile wave functions were calculated by solving Schrodinger wave equation with Wood-Saxon nuclear potential fitted to reproduce the effective binding energies while the core target and proton-target nuclear interactions were calculated by using ***t-ρ-ρ*** formalism.

Results

The calculated results are shown in Table-1, here the nuclear structure of ^{17}F is assumed ^{16}O plus proton model with S_p=0.6 MeV and for simplicity we assumed that as per shell model valence proton lies in 2s state. In the light of our previous work, we considered different excited state of core (^{16}O) [7] with the possibility of valence proton to be in $2s_{1/2}$ state. And so effective binding energy is $S_p^{eff} = S_p + E_c^x$ where E_c^x is core excitation energy. The obtained cross sections and LMD width corresponding to these configurations are shown in Table 1. It has been observed that with increase in core excitation energy i.e. effective binding energy the breakup cross section decreases by ~25% however the LMD width increases by ~17%.

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

E_c^x (MeV)	Core⊗Proton Configuration	σ_{total} (mb)	FWHM (MeV/c)
6.917	$2_1^+ \otimes 2s_{1/2}$	45.09	59.05
9.844	$2_2^+ \otimes 2s_{1/2}$	38.39	65.63
11.08	$3^+ \otimes 2s_{1/2}$	36.30	66.92
11.52	$2_3^+ \otimes 2s_{1/2}$	35.62	68.00
13.02	$2_4^+ \otimes 2s_{1/2}$	33.58	70.48

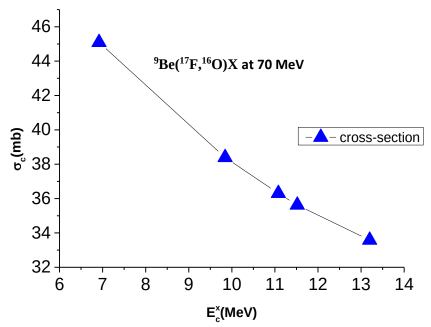
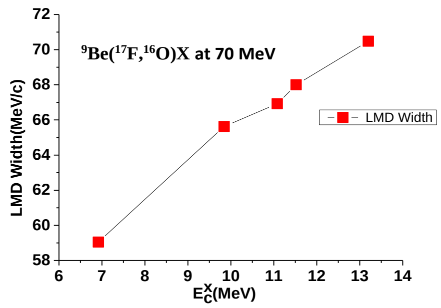


Fig 2.Variation of breakup cross-section with core excitation energy.

This may be seen in Fig. 2 and Fig. 3 that decrease in breakup cross-section and increase in LMD width is almost linear and follows almost a straight line. This behavior may be understood via the well-known uncertainty principle that with increment



in total binding energy of the projectile reduces its spatial extension i.e. haloness which eventually increases the width of momentum distribution and hence the reduces the breakup cross section.

Conclusion

For reaction $^9Be(^{17}F,^{16}O)X$ at beam energy 70 MeV/n, the effect of core excitation on cross-section and LMD width has been analyzed by considering only stripping and diffraction mechanism. It is found that breakup cross-section decreases with increase in excitation energy of core while width of longitudinal momentum distribution increases linearly. The results are in accord with our old calculations done for ^{27}P [8]. The observed changes in breakup cross section are ~25% however in LMD width it is ~17%. Thus, core excitation plays an important role in reaction mechanism which has to be taken seriously for better understanding of results.

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