Proton vs neutron halo breakup in $^9Be(^{17}F,^{16}O)X$ at 40-240 MeV/n energies

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Introduction

Halo nuclei have been studied universally due to their huge role in stellar reactions and astrophysical processes [1]. Large interaction cross-section and narrow momentum distribution width and low nucleon separation energy are some key characteristics among these exotic nuclei. These days there are large number of proton rich and neutron rich nuclei lying close to the drip line and having halo or skin structure. Among these exotic nuclei, proton halos are less pronounce as compared to neutron halos due to the presence of Coulomb Barrier. But still there are large number of proton rich nuclei like ^8B, ^{26}P, ^{27}S, ^{17}F etc. which were observed to have halo structure while some of these are still under investigation[2]. ^{17}F is one of the such suspicious nuclei having halo character in its excited state, which need special investigation to explore its nuclear structure as pointed in [3, 4].

Here, in the light of Ref.[5, 6], we have investigated theoretically $^9Be(^{17}F,^{16}O)$X breakup reaction at $40MeV/n$ to $240MeV/n$ by assuming ^{17}F to be in its ground and excited state. The single nucleon removal cross section as well as longitudinal momentum distribution(LMD) of residual fragment is calculated using MOMDIS code based on Glauber eikonal model [7].

Formalism and Discussion

The ground state of ^{17}F with $J^\pi = 5/2^+$ is assumed to have ^{16}O core and a weakly bound proton with separation energy $S_p = 0.6MeV$ and excited state ^{17}F with $J^\pi = 1/2^+$ having proton separation energy $S_p = 0.106MeV$ [8]. The core is presumed in ground state and valence proton is supposed to be in either in $1d_{5/2}$ or $2s_{1/2}$ state for $J^\pi = 5/2^+$ or $J^\pi = 1/2^+$ projectile state respectively. All the calculations are performed by using standard MOMDIS code based on Glauber Eikonal Model suitable for intermediate energy[7]. The necessary required gradients like projectile radial wavefunction and S-matrices for the core-target and nucleon-target interaction are also calculated from MOMDIS code. Here we have also imposed the idea of replacing proton by an equivalent deeply bound neutron as discussed detail in Ref.[6].

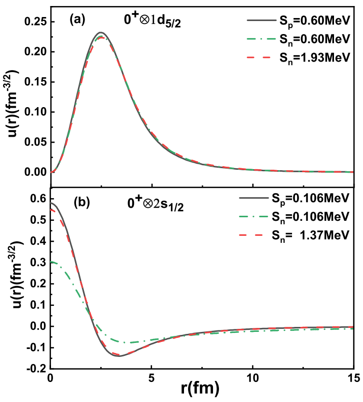

FIG. 1: ^{17}F Radial wavefunction for a)$1d_{5/2}$ state and b)$2s_{1/2}$ state.Solid line corresponds to valence nucleon as proton and dash curve for valence nucleon as its equivalent neutron in both the plots.

Results

The calculated single nucleon breakup cross section from ^{17}F($5/2^+$)on ^9Be target at different incident energies and respective FWHM of LMD of residual core ^{16}O fragment are

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TABLE I: Calculated single nucleon removal cross-section and LMD width for ^{17}F in ground state ($J^{\pi} = 5/2^{+}$).

$Core\otimes$	$40MeV/n$		$80MeV/n$		$120MeV/n$		$240MeV/n$	
nucleon	$\sigma_{-1p}(mb)$	FWHM	$\sigma_{-1p}(mb)$	FWHM	$\sigma_{-1p}(mb)$	FWHM	$\sigma_{-1p}(mb)$	FWHM
$^{16}O+p$	42.51	214.88	43.21	222.73	39.53	234.77	35.54	245.31
$^{16}O+n$	42.71	210.98	42.85	218.54	39.18	230.21	34.95	239.54

TABLE II: Calculated single nucleon removal cross-section and LMD width for ^{17}F in excited state ($J^{\pi} = 1/2^{+}$).

$Core\otimes$	$40MeV/n$		$80MeV/n$		$120MeV/n$		$240MeV/n$	
nucleon	$\sigma_{-1p}(mb)$	FWHM	$\sigma_{-1p}(mb)$	FWHM	$\sigma_{-1p}(mb)$	FWHM	$\sigma_{-1p}(mb)$	FWHM
$^{16}O+p$	106.81	57.76	101.30	58.58	80.36	59.12	62.37	59.77
$^{16}O+n$	106.9	61.57	100.2	62.25	79.67	62.66	62.09	63.12

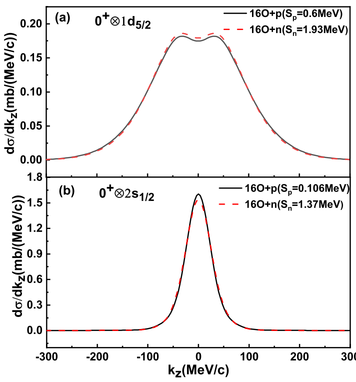

FIG. 2: LMD curves of ^{16}O from breakup of ^{17}F at 40MeV/n for (a) $1d_{5/2}$ state and (b) $2s_{1/2}$ state. Solid line corresponds to valence nucleon as proton and dash curve for valence nucleon as its equivalent neutron in both the plots.

shown in Table 1. Here, first row represents the results corresponding to the valence proton and second row for fitted equivalent valence neutron with binding energy 1.93 MeV. Similar results are shown in Table 2 for ($1/2^{+}$) of ^{17}F with equivalent neutron having binding energy of 1.37 MeV.

For the sake of clearity, Longitudinal Momentum Distribution(LMD) curves for $^{16}O+p$ and $^{16}O+n$ configurations at 40 MeV/n beam energy for $d_{5/2}$ and $s_{1/2}$ state are shown in Fig 2 which reflects that proton replacement with equivalent neutron works well and reproduce cross-section and LMD width very well.

Conclusion

Here we have calculated one-nucleon removal cross-section and residual core Longitudinal Momentum Distributions in nuclear breakup mechanism in both proton and equivalent neutron breakup cases from ^{17}F at $40-240MeV/n$ beam energies. It is observed that for both d and s state the equivalent neutron reproduces the proton breakup cross-section and longitudinal momentum distribution very well for all energies and is consistent as reported in Ref[6].

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