Analysis of LMD data of fragments coming from $^{9}Be(^{11}Be,^{10}Be)X$ and $^{9}Be(^{15}C,^{14}C)X$ stripping reactions

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The earliest experiments performed by using radioactive ion beams have confirmed the existence of nucleon halo among some loosely bound nuclei, lying in the close proximity of drip lines, which is characterized by a core with usual nuclear density and one or two valence nucleons at a far off distance outside the core. Owing to their very low binding energy the breakup of halo nucleus into core and valance nucleon(s) is an important reaction channel and is used to explore various ground state properties of these nuclei. The stripping reaction in which the valence nucleon (s) of the projectile is absorbed by the target leaving the core unaffected is an important probe to obtain information about the properties of single particle nuclear state. Hence a lot of theoretical as well as experimental work has already been done to study the stripping reactions involving weakly bound halo nuclei [1-10].

On the theoretical front, the most frequently adopted approach to describe the stripping reaction is based on the eikonal approximation developed primarily by Glauber which works well for small scattering angle and for small momentum transfer during collision [11]. However, for explaining large angle scattering processes involving high momentum transfer the appropriate correction terms are needed to be incorporated in the eikonal theory [12].

In the present work we have studied the effects of first order correction term, introduced by Wallace [12], on the longitudinal momentum distribution (LMD) of the core fragments coming out from $^{9}Be(^{11}Be,^{10}Be)X$ and $^{9}Be(^{15}C,^{14}C)X$ stripping reactions at 60AMeV and 54AMeV incident energies respectively. The explicit expression for the stripping cross section differential in the momentum of the core may be written as [3]

$$\frac{d\sigma_{n,str}}{dk_{cz}} = \frac{1}{(2\pi)(2L_0+1)}\sum_{M_0}\int d^2\vec{r}_\perp \int d^2\vec{b}\left[1-\left|S_n(\vec{b}_n)\right|^2\right]\left[\left|S_c(\vec{b}_c)\right|^2\right] \times \left|\int dz \exp\left[-ik_{cz}z\right]\Psi_{L_0M_0}(\vec{r})\right|^2$$

Thus the major ingredients required for the calculation of the LMD are the profile functions and the ground state wave function of the projectile. The ground state wave function of the projectile is separated into radial and angular part and is written as

$$\Psi_{L_0,M_0}(\vec{r}) = R_{L_0}(r)\mathrm{Y}_{L_0,M_0}(\Omega)$$

Where, $R_{L_0}(r)$, the radial part of wave function is obtained by solving the Schrodinger equation in Woods-Saxon potential. The neutron and core profile functions $S_n(\vec{b}_n)$ and $S_c(\vec{b}_c)$ are related to the corresponding phase shift functions which are determined, in the eikonal approximation, by the longitudinal integrals of the core and neutron interaction with target along straight line trajectories and are written as

$$\chi_{i0}(b_i) = -\frac{1}{\hbar\upsilon}\int_{-\infty}^{\infty} dz\ V_{iT}(\sqrt{b_i^2+z^2})$$

with υ as the beam velocity and V_{iT} as the nucleon-target or core-target optical potential.

Equivalently, the expression for the phase shifts may be written as

$$\chi_{i0}(b_i) = -2K\varepsilon_i\int_0^{\infty} dz U_{iT}(r)$$

with $\varepsilon_i = \frac{V_{i0}}{K\upsilon}$ and V_{i0} and $U_{iT}(r)$ are the strength and form factor for the spherically symmetric potential. The first eikonal correction term which accounts for the deviations of particle trajectory from constant speed rectilinear motion can be written in the form [12]

$$\tau_{i1}(b) = -K\varepsilon_i^2\int_0^{\infty} dz\left(2 + r\frac{d}{dr}\right)U_{iT}^2(r)$$

so that the resulting S- matrices become

$$S_i^{(1)}(b_i) = \exp\left[\imath(\chi_{i0}+\tau_{i1})\right].$$

Using this expression of profile function, considering first order correction, we have calculated the LMD of ^{10}Be and ^{14}C coming from $^{9}Be(^{11}Be,^{10}Be)X$ and $^{9}Be(^{15}C,^{14}C)X$ reactions at 60MeV/A and 54MeV/A incident beam energies respectively and results are

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given in Figs.1 and 2. As mentioned earlier, the radial part of the wave function used in the calculations, are generated by solving the Schrodinger equation in Woods-Saxon potential. The range and the diffuseness parameters of the potential are kept fixed at 2.54fm and 0.7fm for ^{11}Be and at 2.60fm and 0.5 fm for ^{15}C nucleus. The depths of potentials are adjusted to reproduce the binding energies of the projectiles. The binding energy of ^{11}Be and ^{15}C nuclei are 0.504MeV and 1.218MeV and the corresponding potential depths come out to be 61MeV and 68.3MeV respectively. The calculated LMDs are compared with the corresponding experimental data taken from Refs. [4,6] as shown in Figs.1 and 2. In both cases the widths of the LMD obtained through calculations are found to be slightly smaller than that of experimental widths.

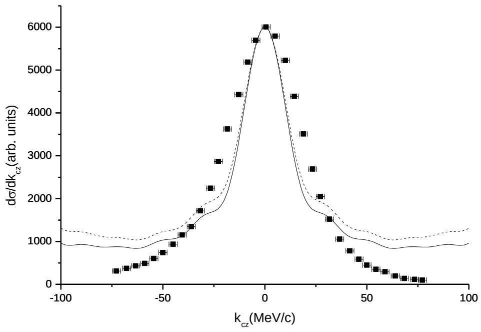

Figure 1. Longitudinal momentum distribution of ^{10}Be emerging from ^{9}Be(^{11}Be,^{10}Be)X at 60AMeV beam energy. The dotted and solid lines represent the results obtained by using Zero order eikonal approximation and by zero order + first order correction eikonal approximation. The data points are taken from Ref. [4]

It may be ascribed to the fact that we have considered pure s-wave configuration for the ground state of both the projectiles. Since there is no centrifugal barrier in case of pure s-wave, the spatial extension is enhanced and consequently momentum width is reduced. Further it may be clearly noticed from the figures that the effect of leading correction term to the eikonal approximation may be seen only in the tail region of the momentum distribution. In the tail region the momentum transfer is large and hence the eikonal approximation which is well founded for small momentum transfer demands correction term. Further in the tail region the inclusion of correction term improves, though to a small extent, matching between the data and prediction.

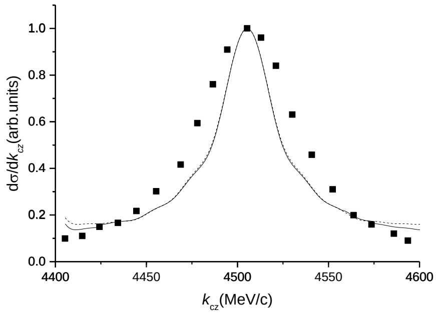

Figure 2. Same as Fig.1 but for ^{9}Be(^{15}C,^{14}C)X reaction at 54AMeV beam energy. The data points are taken from Ref. [6]

In conclusion, we have investigated the effects of leading order correction to eikonal approximation in analysing the LMD data of ^{10}Be and ^{14}C fragments coming from ^{9}Be(^{11}Be,^{10}B)X and ^{9}Be(^{15}C,^{14}C)X stripping reactions and found that it alters the tail of momentum distribution and improves matching between data and predictions in this region.

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