Investigating the alpha-clustering on the surface of ^{120}Sn via $(p,p\alpha)$ reaction, and the validity of the factorization approximation

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The ^{120}Sn$(p,p\alpha)^{116}$Cd reaction at 392 MeV is investigated with the distorted wave impulse approximation (DWIA) framework. We show that this reaction is very peripheral mainly because of the strong absorption of α by the reaction residue ^{116}Cd, and the α-clustering on the nuclear surface can be probed clearly. This work have already published in Ref [1].

In the DWIA framework, the reduced transition amplitude is given by

$$\bar{T}^{nljm}_{\boldsymbol{K}_0\boldsymbol{K}_1\boldsymbol{K}_2} = \int d\boldsymbol{R}\sqrt{\frac{d\sigma_{p\alpha}}{d\Omega_{p\alpha}}(\theta_{p\alpha}(\boldsymbol{R}), E_{p\alpha}(\boldsymbol{R}))}F_{\boldsymbol{K}_0\boldsymbol{K}_1\boldsymbol{K}_2}(\boldsymbol{R})\,\varphi^{nljm}_{\alpha}(\boldsymbol{R}) \equiv \int dR\, I(R). \tag{1}$$

See Ref [1] for the definition of each component. We investigate also the validity of the so-called factorization approximation that has frequently been used so far, because in that approximation asymptotic momenta instead of local ones of the scattering particles are used to construct the relative momenta of p-α binary collision inside the nucleus, and such treatment is questionable especially for reactions with heavy target.

In Fig. 1 we show the triple differential cross section (TDX) with and without factorization approximation as a function of the recoil momentum p_R. Since s-wave bound state of α is considered in this calculation, TDX has a peak at around so-called quasi-free (QF) condition: $p_R = 0$. One may find in Fig. 1 that the factorization approximation works well. We show in Fig. 2 the absolute value of $I(R)$ at QF condition. It is clearly seen that the amplitude in nuclear interior region is significantly suppressed by strong absorption effect coming from the imaginary part of the optical potential, that is mainly from the optical potential of emitted α particle. It was also found that the kinematics of the particles in the nuclear interior region is significantly affected by the distortion, but it has little effect on the reaction observables as shown in Fig. 1, because the strong absorption effect also exists in that region.

It should be noted that the inaccuracy of factorization approximation may arise if a scattering particle feels a potential having a strong real part and a weak imaginary part; this can be realized, for instance, for nucleon scattering at lower energies.

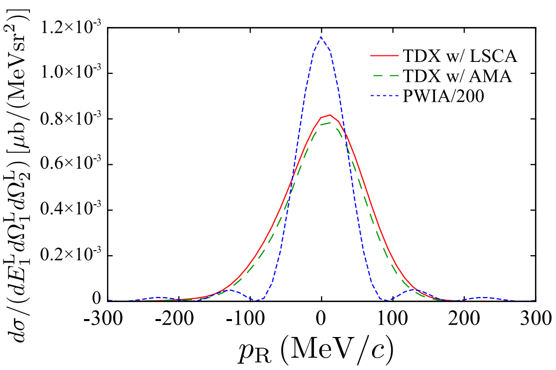

Figure 1: TDX as a function of the recoil momentum. The solid (dashed) line corresponds to the calculation without (with) the factorization approximation. The TDX calculated with the PWIA divided by 200 is also shown by the dotted line.

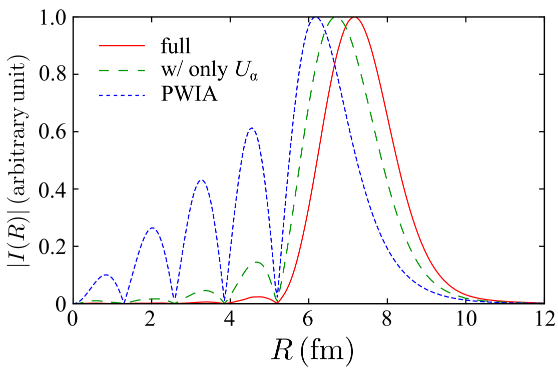

Figure 2: $|I(R)|$ at $p_R = 0$ (solid line), the same but calculated with only the α-^{116}Cd distorting potential U_α (dashed line), and the result with PWIA (dotted line). The results are normalized to unity at the peak position.

References

[1] K. Yoshida, K. Minomo and K. Ogata, Phys. Rev. C **94**, 044604 (2016).