Four-body dynamics in ^{6}Li scattering

S. Watanabe[1], T. Matsumoto[2], K. Ogata[3], and M. Yahiro[2]
[1]*RIKEN Nishina Center, Wako, Saitama 351-0198, Japan*
[2]*Department of Physics, Kyushu University, Fukuoka 812-8581, Japan*
[3]*Research Center for Nuclear Physics (RCNP), Osaka University, Ibaraki, Osaka 567-0047, Japan*

We investigate reaction dynamics of ^{6}Li elastic scattering on the heavy targets T = ^{208}Pb or ^{209}Bi. It was reported that the standard three-body continuum-discretized coupled-channels method (three-body CDCC) based on the $d + \alpha$ + T model cannot reproduce the measured cross section at around the Coulomb barrier energy ($\sim$ 30 MeV) [1]. We then apply four-body CDCC based on the $n + p + \alpha$ + T model and clarify the reaction dynamics [2].

In present four-body CDCC, the Schrödinger equation is solved in the model space P spanned by the ground and discretized-continuum states of ^{6}Li: $P = \sum_{\gamma=0}^{N} |\Phi_\gamma\rangle \langle\Phi_\gamma|$, where Φ_γ represents the γ-th eigenstate, and the $\gamma = 0$ and $\gamma = 1$–N correspond to the ground and discretized-continuum states, respectively. In order to investigate the breakup mechanism, we restrict the model space P. For this purpose, we first specify whether the breakup state Φ_γ ($\gamma = 1$–N) is the $d\alpha$-dominant or $np\alpha$-dominant breakup state by calculating the squared overlap between Φ_γ and the d ground state $\phi^{(d)}$: $\Gamma_\gamma^{(d\alpha)} = \left|\langle\phi^{(d)}|\Phi_\gamma\rangle\right|^2$. If $\Gamma_\gamma^{(d\alpha)}$ is larger (smaller) than 0.5, the state is defined as a $d\alpha$-dominant state $\Phi_\gamma^{(d\alpha)}$ ($np\alpha$-dominant state $\Phi_\gamma^{(np\alpha)}$). With the $d\alpha$- and $np\alpha$-dominant state above, the CDCC model space P can be decomposed into the three parts $P = P_0 + P_{d\alpha} + P_{np\alpha}$, where

$$P_0 = |\Phi_0\rangle \langle\Phi_0|\,,\ P_{d\alpha} = \sum_\beta |\Phi_\beta^{(d\alpha)}\rangle \langle\Phi_\beta^{(d\alpha)}|\,,\ P_{np\alpha} = \sum_\delta |\Phi_\delta^{(np\alpha)}\rangle \langle\Phi_\delta^{(np\alpha)}|\,. \tag{1}$$

In the following discussion, we calculate cross sections by switching on and off the subspaces $P_{d\alpha}$ and $P_{np\alpha}$.

Figure 1 shows ^{6}Li + ^{208}Pb scattering at 39 MeV. The solid and dotted lines correspond to the full and 1ch calculations, respectively. These are nothing but the calculations in P and P_0, respectively. The difference comes from breakup effects and the full calculation reproduces the experimental data well by virtue of breakup effects [2, 3]. Now, we switch on only the subspace $P_{np\alpha}$ or $P_{d\alpha}$ from P_0 in order to investigate the breakup mechanism. The dot-dashed line represents the calculation of $P_0 + P_{np\alpha}$ and it is close to 1ch calculation (dotted line). On the other hand, the dashed line corresponds to the calculation of $P_0 + P_{d\alpha}$ and it simulates the full calculation (solid line) almost perfectly. It should be noted that the number of $d\alpha$-dominant states is much less than that of $np\alpha$-dominant states in the present model space P. As seen above, $d\alpha$ breakup is favored in ^{6}Li scattering. This property is now called *$d\alpha$-dominance*, and we have found that the *$d\alpha$-dominance* is realized in a wide energy range [2]. In other words, d (*i.e.* the n-p subsystem of ^{6}Li) hardly breaks up during ^{6}Li scattering.

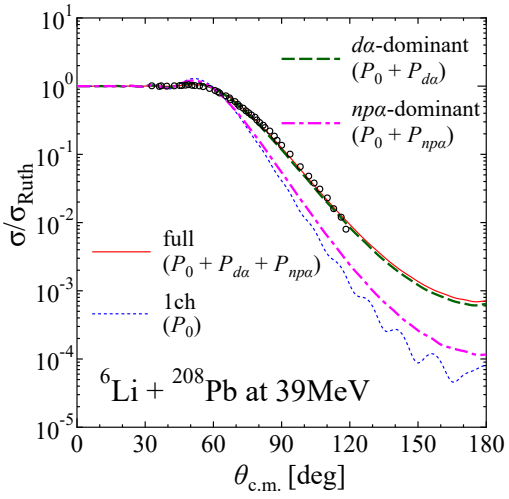

Figure 1: Elastic cross sections for ^{6}Li + ^{208}Pb scattering at 39 MeV. The solid and dotted lines correspond to the results of full and 1ch calculations, respectively. The dot-dashed line represents the calculation with the model space $P_0 + P_{np\alpha}$, whereas the dashed line shows the calculation with $P_0 + P_{d\alpha}$. The experimental data is taken from Ref. [4].

References

[1] N. Keeley *et al.*, Phys. Rev. C **68**, 054601 (2003).
[2] S. Watanabe *et al.*, Phys. Rev. C **92**, 044611 (2015).
[3] S. Watanabe *et al.*, Phys. Rev. C **86**, 031601(R) (2012).
[4] N. Keeley *et al.*, Nucl. Phys. A **571**, 326 (1994).