Analyzing power for $^{6}Li(d,\alpha)^{4}He$ reaction at incident energy of 90 keV

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$^{6}Li/^{7}Li$ abundance ratio is thought of as a key to investigate the baryon density and some authors indicated that ^{6}Li+d reactions play important roles to calculate the primordial abundance of the ^{6}Li when some inhomogeneous big bang nucleosynthesis model is assumed. Generally, cross section of the reactions between charged particles exponentially decrease when the incident energy decreases because of the Coulomb barrier. When cross-section data are not available at a given energy, one should extrapolate the data in a high energy region. In the case of ^{6}Li+d reaction, a sub-threshold resonance of ^{8}Be affects the reaction cross section [1] and the study of reaction mechanism become important for the extrapolation. Moreover, these reaction have been researched as example cases of the study of the electron screening effect for light nuclei. Some group evaluated the screening potential and discrepancy exist between there results.

In this work, we studied the reaction mechanism of $^{6}Li(d,\alpha)$ reaction and used analyzing powers to evaluate the resonant effect. Angular distribution of the analyzing powers are sensitive to the information of the resonance level of ^{8}Be.

The experiment was performed at the University of Tsukuba Tandem Accelerator Center (UTTAC) using the Lamb shift-type polarization ion source [3]. The polarization of the deuteron beam was measured by the quench-ratio method [5] about every two hours. The typical value of the beam intensity was about 100 nA, and that of the beam polarization was about 0.70. The uncertainty of the polarization was about 0.02. Figure 1 shows the placement of the detectors and the target. The beam was introduced to the lithium carbonate layer and was intercepted by the aluminum backing, which played the role of a Faraday cup. The target was a layer of lithium carbonate, Li_2CO_3, having a thickness of about 10 $\mu g/cm^2$ on an aluminum backing having a thickness of about 15 μm. A slit with a diameter of 5 mm was placed at a distance of 150 mm upstream from the target. The energy loss in the layer of lithium carbonate was about 8 keV. We placed twelve Si-SSD's around the target at every 15^o scattering angles from 0^o to 165^o. Each detector was placed at a distance of 140 mm from the target, and had a solid angle of 10 msr. On each Si-SSD placed in the range of scattering angles from 90^o to 165^o, a mylar sheet having a thickness of 9 μm was placed in order to block elastic deuterons.

$^{6}Li(d,\alpha)^{4}He$ reaction at a low incident energy, by using the invariant amplitude method (IMA) [2], the analyzing powers are represented as

$$
\begin{aligned}
iT_{11} &= 0, \\
T_{2q} &= -\frac{1}{\sqrt{5}} fP_{2q}(\cos\theta).
\end{aligned}
\tag{1}
$$

where P_{2q} is Legendre function. The angular momentum of initial channel was restricted to 0. The coefficient f is represented by using invariant amplitude F as

$$
f = \frac{|F(2020)|^2 - 2\sqrt{2}\,\mathrm{Re}\{F^*(0000)F(2020)\}}{|F(0000)|^2 + |F(2020)|^2}. \tag{2}
$$

The invariant amplitude F is described as

$$
F = F(s_i s_f K l_i) \tag{3}
$$

where s_i and s_f are initial and final channel spin, K is the rank of spin-space tensor, l_i is the orbital angular momentum of initial channel. $|F(2020)|^2$ and $|F(0000)|^2$ describes the $s = 2$ and $s = 0$ component of the cross section, where s is total spin of the reaction. By using the coefficient f, we can evaluate the fraction of the 2^+ component of the cross section as

$$
f_{2+} = \frac{|F(2020)|^2}{|F(2020)|^2 + |F(0000)|^2} \approx \left\{1 + \frac{1}{8}(1-f)^2\right\}^{-1} \tag{4}
$$

In this work we assume that the resonance is composed by 2^+ components and the non-resonant one almost does not include a lot of 2^+ ones. If it is valid, the fraction of the resonant component is approximately equal to that of 2^+ one. Experimental result was well explained by above Equations as shown Fig. 2. The dashed line represents $f_{2+} = 1$. The solid one is fitting result. The deduced value is f = 0.862 \pm 0.087. It corresponds the value f_{2+} = 0.998 \pm 0.003. If we assume that 2^+ component is dominant in the resonant component and it is not dominant in the non-resonant one, our result is inconsistent with the fraction of the resonant component extracted in Ref 1, which is about 0.5. We think they overestimated the non-resonant component.

References

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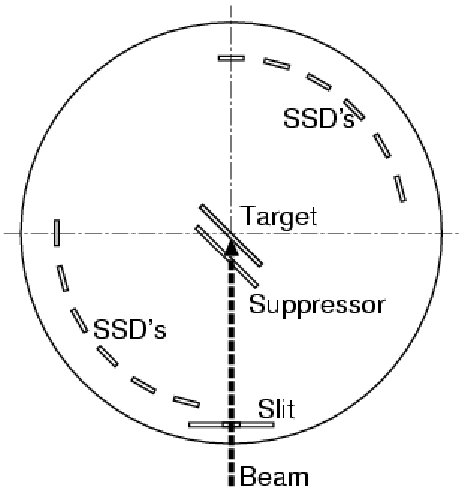

FIGURE 1. Layout of detectors and target in the scattering chamber.

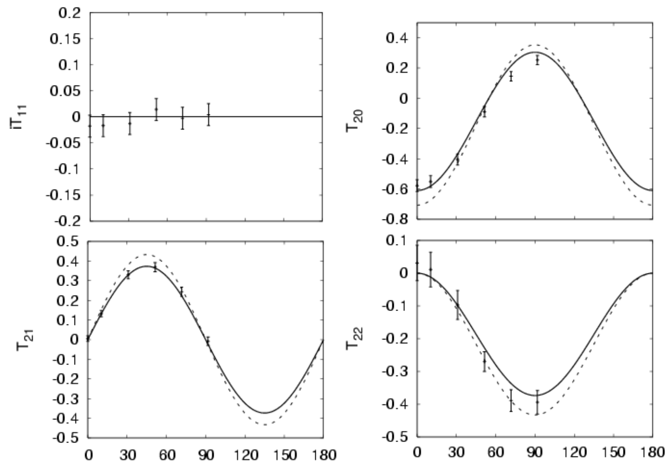

FIGURE 2. Experimental results for $^6Li(d,\alpha)^4He$. The dashed curve represents the prediction when $f = f_{2+} = 1$. The solid curve is the fitting result $f = 0.86$.