# Breakup Induced Transfer effects in the $^{12}C(^{7}Li,t)^{16}O^{*}$ reactions at 20 MeV

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## Introduction

The $^{12}C(^{6/7}Li,d/t)$ reaction at various incident energies [1-3] have been used to determine the alpha spectroscopic factors ($S_{\alpha}$) of the $^{16}O$ states. The spectroscopic factors provide information about the alpha cluster structure of these states and can be used to evaluate thereduce alpha widths. Thermonuclear reactions in the star mostly occur at energies much below the Coulomb barrier and the cross-sections are very small. The $^{12}C(\alpha,\gamma)$ reaction at 300 keV that determines the formation of $^{16}O$ in helium burning stars has a very low cross-section ($10^{-10}$ barn) and its direct determination experimentally is almost impossible with the presently available techniques [4]. The R matrix theory is used to extrapolate the $^{12}C(\alpha,\gamma)$ cross-section measured at higher energies to the desired energy at 300 keV. The extrapolation process involves reduced alpha widths that are treated as fitting parameters besides the R matrix pole energies. In case of bound states instead of the spectroscopic factors the Asymptotic Normalization Constant (ANC) is evaluated if only the reaction is peripheral. This is advantageous as ANC's in peripheral reactions are independent of the binding potential forming the state. However, it is difficult in general to determine ANC for any reaction. This is because peripherality is best ensured at sub-Coulomb energies and at these the transfer cross-sections are low. So it is easier to extract the $S_{\alpha}$ from higher energy transfer reactions. Since $S_{\alpha}$ depends strongly on the potential parameters involved, the use of a proper reaction model to analyze the reaction data to extract $S_{\alpha}$ is absolutely necessary.

Recently the $^{12}C(^{6}Li,d)$ reaction [5] was studied in this context. The deuteron angular distributions were measured at 20 MeV as only very old data exist in the literature. Our measurements showed some difference from the earlier one particularly for the population of the $^{16}O$ ground state. The breakup effect on transfer reaction was investigated in the framework of the Continuum Discretized Coupled Reaction Channel (CDCC-CRC) theory. Interestingly, the most prominent breakup effect was found for the ground state where our experimental data differs from the earlier data. This was also shown to have a strong effect on the E2 S-factor for decay to the ground state using a potential model for the capture reaction.

In this work we present the measurement and analysis of the $^{12}C(^{7}Li,t)$ reaction at 20 MeV. The prime motivation is to make a comparative study with respect to $^{12}C(^{6}Li,d)$ reaction that showed a strong breakup effect on transfer since $^{7}Li$ has a higher breakup threshold than $^{6}Li$.

## Experiment

The experiment was carried out using the $^{7}Li^{3+}$ beam from the IUAC, 15UD Pelletron facility, New Delhi. The triton angular distribution measurements were carried out using the General Purpose Scattering Chamber (GPSC) facility. Silicon telescopes were utilized for particle identification. Some details of the experiment are available in a previous report.

## Results and Discussion of Analysis

The CDCC-CRC calculations for four bound states of $^{16}O$ were carried out in the framework of the coupled channel program FRESCO v2.9 [6]. In order to examine the breakup effects the ($\alpha$+t) continuum of $^{7}Li$ was constructed above its threshold. In this continuum 2 resonance states were considered at Ex=4.63 MeV ($7/2^{-}$) and 6.68 MeV ($5/2^{-}$). In all previous calculations the DWBA formalism was used and the breakup effects were not considered. The α+t potential used were simply suited to reproduce the separation energy of the $^{7}$Li ground state. It is therefore necessary to find a potential that generates the two resonances of $^{7}$Li mentioned before. A Woods-Saxon potential was used for this purpose and the results of the phase-shift analysis are shown in fig.1(a) and (b). The widths of the resonances obtained from this analysis are 0.09 MeV and 1.57 MeV for the 4.63 and 6.68 MeV states respectively.

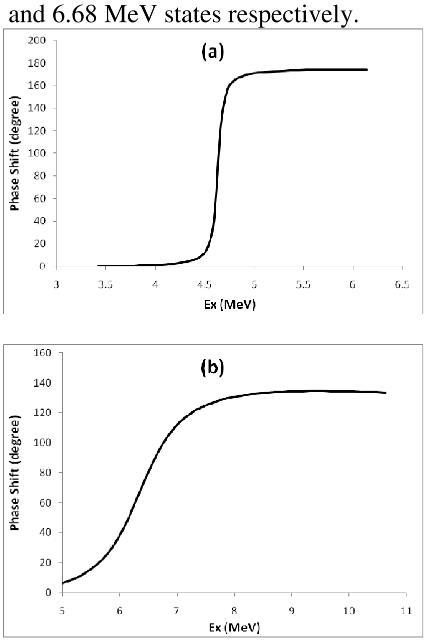


**Fig. 1** Phase shift analysis for **(a)** 4.63 MeV and **(b)** 6.68 MeV

The results of the CDCC-CRC angular distribution calculations (red lines) are shown in fig.2(a) and (b) for the population of the 6.92 MeV ($2^{+}$) and the 7.12 MeV states of $^{16}$O. The corresponding FRDWBA calculations are shown by green lines. The calculations were carried out under similar potentials. The only difference that is to be taken care off is that in CDCC calculation the entrance channel potential is obtained by folding an α+$^{12}$C and t+$^{12}$C potential. The global α+$^{12}$C and t+12C were obtained from Refs [7] and [8] respectively.

Results of the calculations show a clear indication of breakup effects in the transfer process. Similar observation was for the ground state [9]. The extraction of $S_{\alpha}$ should therefore consider this effect.

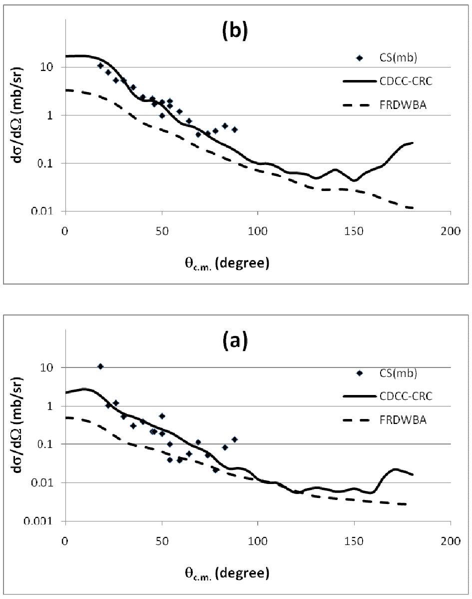


**Fig. 2** Comparison of the measured angular distributions (symbols) for the population of the **(a)** 6.92 MeV state of $^{16}$O and **(b)** 7.12 MeV state with the CDCC-CRC (solid lines) and FRDWBA calculations (dashed lines).

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