A simultaneous R-matrix analysis of $\alpha - \alpha$) elastic scattering and capture reaction data.

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Introduction

Production of ^{8}Be by fusing two alpha particles is the first reaction of He burning stage of a star and is the first step in the synthesis of ^{12}C by triple alpha process in star. The ground state of ^{8}Be is a resonance state of two alpha with energy of 0.092 MeV. It has a lifetime 6.7×10^{-17}s. This is considered a *sufficiently* long time for a small amount of ^{8}Be to survive in the star for further reaction ^{8}Be$(\alpha,\gamma)^{12}$C to take place. Besides the 2α cluster ground state, ^{8}Be has two other resonant states which are at E_x=3.04 MeV and E_x=11.4 MeV having spin parity $J^\pi=2^+$ and 4^+ respectively forming a rotational band based on a dumbell-shaped structure for the nucleus. In 2005 and 2013 in two different experiments [2, 3] Datar *et al.* studied the radiative capture of 2α-s in the resonant 4^+ excited state and reported the 4^+ to 2^+ electromagnetic transition as a test for the cluster structure of the excited states. future for better estimation we are planning to extend our R-matrix analysis by introducing more reaction channels leading to ^8Be, which will help us to generate proper extrapolation of capture cross section at low energy region as well as it will help us to understand α cluster structure of

The present work reports a simultaneous R-matrix analysis of capture reaction $\alpha(\alpha,\gamma)^8$Be data of Ref. [3] along with the available low energy $\alpha-\alpha$ resonant elastic scattering data from Tombrello *et al.*[4] to probe the resonant parameter values.

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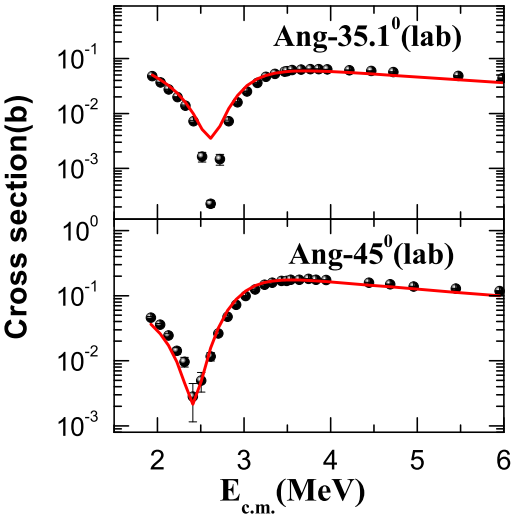

FIG. 1: R-matrix fit to the $\alpha-\alpha$ scattering data from Ref.[4].

Analysis

We have performed the R-matrix analysis using the multi-channel, multi-level code AZURE2[5]. The channel radius value of 4.2 fm has been chosen for $\alpha+\alpha$ channel. The fit of the elastic data of $\alpha-\alpha$ scattering has been shown in Fig. 1 for the two different angles. The elastic scattering data over the measured energy region actually constrain the parameters of the 2^+ resonance state. On the other hand the excitation function data of Refs [2, 3] tests the parameters of 4^+ and 2^+ states. The fit to the $4^+\rightarrow2^+$ γ-transition data from the radiative capture reaction $\alpha(\alpha,\gamma)^8$Be is shown in Fig. 2. The resultant resonant parameters

TABLE I: The resonance parameters obtained from the R matrix fits

J^π	E_x (MeV)	Γ_p (MeV)	Γ_Υ R→0.0 (eV)	Γ_Υ R→3.04 (eV)
0^+	0.00	6.17×10^{-6}		
2^+	3.04	1.57	8.3×10^{-3}	
4^+	11.4	3.5	0.71	0.61
2^+	20.0	5.0	100	0.34
4^+	20.0	5.0	5.07	47.96

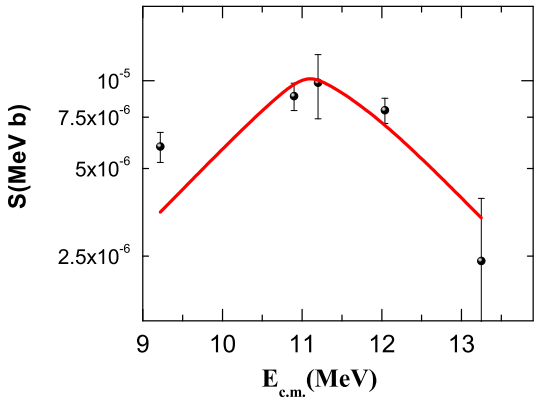

FIG. 2: Fit to the $4^+ \rightarrow 2^+$ transition cross section data from Refs.[2, 3]

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from the simultaneous fitting are tabulated in Table I. To simulate the non-resonant part in the excitation function, two high energy background poles having same spin parity as the two resonant states have been introduced with pole energy of E_x=20 MeV.

Results & Discussions

The parameters obtained from R-matrix analysis agree well with the previous calculations[6, 7]. In our simultaneous analysis, the resultant parameter set is unable to reproduce the dip in the excitation function of $\alpha - \alpha$ scattering at the angle $\theta_{lab} = 35.1^o$. A possible reason could be the unavailability of capture cross section data to the 2^+ resonance state.

Further calculation is in progress to generate proper extrapolation of capture cross section at low energy region through the phenomenological R-matrix modeling. Details of the calculation with the inclusion of more number of channels will be presented in the symposium.

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