Study of Resonance Overlap from ^{24}Mg (^{12}C, ^{12}C ^{12}C) ^{12}C Reaction at 110 MeV

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In the excitation energy spectrum of ^{24}Mg very high lying resonances have been observed in the inelastic scattering as well as resonance breakup reactions [1-2]. High energy resonances observed in the inelastic channels $^{12}C^{(2+)} + {}^{12}C^{(2+)}$ [3] and $^{12}C^{(3-)} + {}^{12}C^{(3-)}$ [4-5] have witnessed resonances up to a maximum of 22^+ at $E_x \sim 56$ (±1.5) MeV. The high lying resonance states have been interpreted in various models and one of the most successful model in the weak coupling scenario is the Band Crossing Model (BCM) [6-7]. In this the interaction between di-nuclear system ($^{12}C + {}^{12}C$ or $^{12}C^* + {}^{12}C^*$) sustain quasi bound molecular configurations where the real part of the optical potential has a series of states as rotational band [6-7]. According to Abe's Bend Crossing Model [6-7] the resonance at around $E_x \sim 56$ MeV should be a resonance composed of two Carbons in the ground state. Surprisingly however, Morsad et al. [3] observed this resonance in $^{12}C^{(2+)} + {}^{12}C^{(2+)}$ channel and Bremner et al. [4] and Chappell et al. [5] observed this resonance in $^{12}C^{(3-)} + {}^{12}C^{(3-)}$ channel and not in the $^{12}C_{gs} + {}^{12}C_{gs}$ channel.

In the present experiment performed at the BARC - TIFR Pelletron LINAC Facility, Mumbai, we looked for the resonances in the forward angles in the 110 MeV ^{24}Mg (^{12}C, 2 ^{12}C) ^{12}C reaction with ^{12}C's detected in coincidence. Silicon ΔE - E detector telescopes (with ΔE being 15 micron to 30 micron) were used to detect ^{12}C's one at 20^0, 30^0 in the upper arm and the others at -10^0, -20^0 in the lower arm of the scattering chamber. The angular resolution was $\pm 0.7^0$ and solid angles were, $\Delta\Omega_1 = \Delta\Omega_2 = 0.45$ msr. In the present contribution we present the data for only one combination of detector setup one at 20^0 and the other at -10^0. These forward angles were chosen to look for higher energy excitations such as $E_x \sim 56(\pm 1.5)$ MeV with 22^+ resonance state of ^{24}Mg. Natural Mg of 420 μg/cm^2 thickness was used for the target.

With this kinematics the recoil energy of the third ^{12}C is $E_3 \sim 6.1$ MeV and $\theta_3 \sim 160^0$. The summed energy spectrum, i.e. coincidence counts vs $E_1 + E_2$ is shown in Fig.1. The structure at $E_1 + E_2 \sim 90$ MeV corresponds to Q-value = $Q_{ggg} = -13.93$ MeV because in this case the $E_1 + E_2 + E_3 \sim 96$ MeV for the $^{12}C_{gs} + {}^{12}C_{gs} + {}^{12}C_{gs}$ channel. On the other hand the structure at $E_1 + E_2 \sim 81$ MeV corresponds to $^{12}C^{(2+)} + {}^{12}C^{(2+)} + {}^{12}C_{gs}$ channel. Events from a few percent of ^{25}Mg and ^{26}Mg present in the natural Mg target are suppressed due to their higher separation energies.

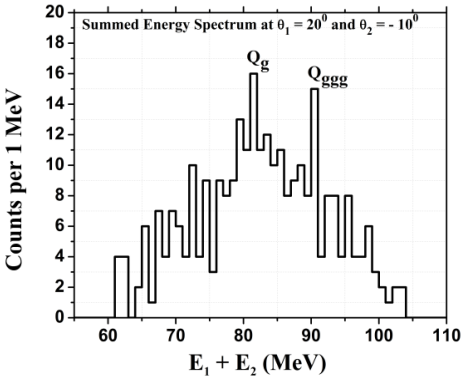

Fig.1: Summed Energy Spectrum at $\theta_1 = 20^0$ and $\theta_2 = -10^0$ for ^{24}Mg (^{12}C, 2 ^{12}C) ^{12}C Reaction.

Corresponding to the peaking structure in Fig.1 at $E_1 + E_2 \sim 90$ MeV the energy sharing spectrum has a minimum at $E_1 \sim 43$-45 MeV, as seen in Fig.2. For this minimum the relative

energy E_{13} = 42.1 MeV and E_{23} = 41.9 MeV and both these corresponding to $E_{Mg^*} \approx E_{13} - Q \approx E_{23} - Q \sim 56$ MeV. The chosen angles θ_1 and θ_2 were such that the resonances in the 1-3 and 2-3 branches overlap in this kinematics choice and correspond to the same $E_x \sim 56$ (±1.5) MeV of $^{24}Mg^*$.

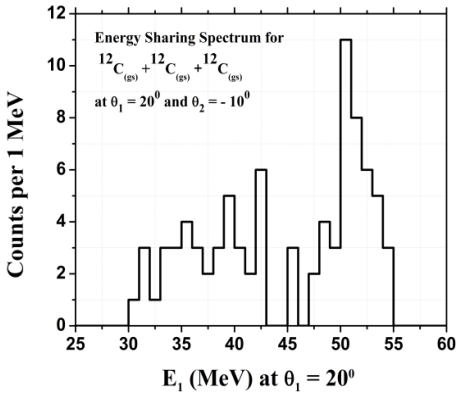

Fig.2: Energy Sharing Spectrum of E_1 for the $^{12}C_{gs}+^{12}C_{gs}+^{12}C_{gs}$ channel.

The observations in Fig.2 indicate that at $E_1 \sim 43$ MeV (correspondingly $E_2 \sim 47$ MeV) the two $^{24}Mg^*$ (22^+) resonances in 1-3 and 2-3 branches appear simultaneously and corresponding to that there is a minimum.

There is some indication in Figs.1 and 2 that the structure at $E_1 + E_2 \sim 90$ MeV (corresponding to $E_x \sim 56$ MeV) decays into $^{12}C_{gs}+^{12}C_{gs}+^{12}C_{gs}$ channel. In ref. [3-5] however it is argued that this resonance is observed in the $^{12}C^{(2+)} + ^{12}C^{(2+)}$ and $^{12}C^{(3-)} + ^{12}C^{(3-)}$ channels only. However our preliminary finding indicates that the $E_x \sim 56(\pm 1.5)$ MeV 22^+ state of ^{24}Mg can decay in to the $^{12}C_{gs}+^{12}C_{gs}$ channel also. However for the strong conclusion from the present findings somewhat better statistics is required.

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