Cluster Structure of $^{24}Mg_{g.s.}$ from $^{24}Mg(^{16}O, 2^{16}O)^{8}Be$ Knockout Reaction

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The ground state cluster structure of the so called α-conjugate nuclei such as ^{24}Mg is a subject of much interest because of the observation of heavy ion ^{12}C-^{12}C resonances observed at high excitation energies. According to Ikeda picture[1] the energetics decide the cluster structure of the low lying excited state of such nuclei. However close to 14 MeV excitation energy of ^{24}Mg the presence of $^{12}C+^{12}C$ as well as $^{16}O+^{8}Be$ cluster structure is indicated. This heavy cluster idea has been stretched down to the ground state of ^{24}Mg also. While Baldock and Buck[2] indicated that the low lying spectrum of ^{24}Mg can be understood in terms of a simple $^{12}C+^{12}C$ dinuclear cluster model. Pilt and Whitley[3] claimed that $^{16}O+^{8}Be$ dinuclear cluster model works nicely as well.

Almost same separation energies of 13.92 MeV ($^{12}C+^{12}C$) and 14.05 ($^{16}O+^{8}Be$) and same number of radial nodes (N=6) in the relative motion bound wave function leads to surface exponential decay constants, γ around 3.09 and 2.93 respectively, differing only marginally. These indicate that the surface structure of $^{24}Mg_{(g.s)}$ nucleus will be mainly decided by the intrinsic amount (or parentage) of $^{12}C+^{12}C$ or $^{16}O+^{8}Be$ clustering.

In order to obtain the percentage of $^{16}O+^{8}Be$ in $^{24}Mg_{(g.s.)}$ a heavy cluster quasi free knockout reaction, $^{24}Mg(^{16}O,2^{16}O)$ ^{8}Be experiment was performed in a symmetric coplanar geometry at two incident beam energies of 127 and 119 MeV. For these incident energies the angles were chosen to have zero

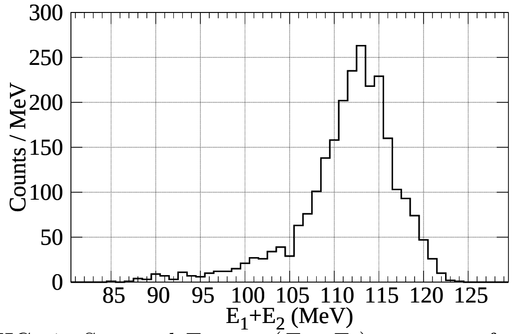

FIG. 1: Summed Energy (E_1+E_2) spectrum for the 127 MeV $^{14}Mg(^{16}O, 2^{16}O)^{8}Be$ reation.

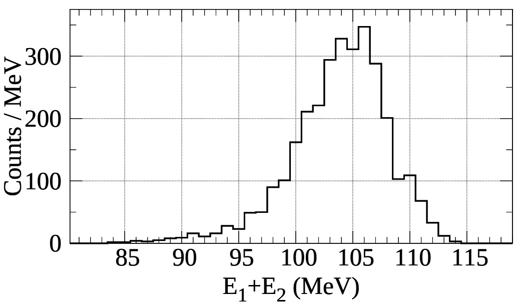

FIG. 2: Summed Energy (E_1+E_2) spectrum for the 119 MeV $^{24}Mg(^{16}O, 2^{16}O)^{8}Be$ reation.

recoil momentum observation possible with θ_1=θ_2=41.3^o and 40.95^o respectively. The energies were chosen such that for 127 MeV incident energy, corresponding to the zero recoil momentum of ^{8}Be, the two detected ^{16}O's at equal energies of 56.5 MeV individually form resonances with ^{8}Be of ^{24}Mg excited to $\sim$ 33 MeV 12^{+} resonance simultaneously. On the other hand corresponding to 119 MeV (for the zero recoil momentum position both the arms correspond to the resonance minimum of the excitation function of ^{24}Mg below the 12^{+} state at 31.5 MeV. For these two energies the summed energy spectra are shown in

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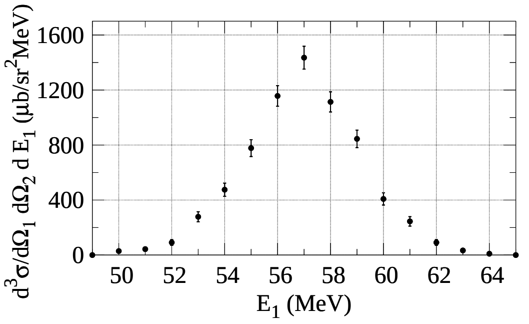

FIG. 3: Energy sharing spectrum for the 113 MeV broad peak in the (E_1+E_2) spectrum of 127 MeV $^{24}Mg(^{16}O, 2^{16}O)^8Be$ reaction.

Figs. 1 and 2. The peaks at 113 MeV and 105 MeV indicate contributions coming from the ground state of ^{24}Mg. The corresponding energy sharing spectra are shown in Figs. 3 and 4. For the 127 MeV case the peak cross section was observed close to the zero recoil momentum position at E_1=57 MeV (q_R=8.08 MeV/c) with a value of 1435±83 $\mu\, b/sr^2MeV$, quite appreciable infact. Off the resonance (119 MeV data) energy sharing spectrum showing peak at $\sim$ 53 MeV corresponding to the zero recoil momentum position having a cross sections of 1651 ± 84 μb$/sr^2MeV$. No two peaks are seen here in comparison to the $^{24}Mg(^{12}C,2^{12}C)^{12}C$ reaction at 104 MeV. The 104 MeV $^{24}Mg(^{12}C,2^{12}C)^{12}C$ reaction gave a cross section value of 29 ± 21 μb$/sr^2MeV$. Even though they may be dissimilar reactions it is quite instructive that the corresponding free scattering cross section values (for the final state energy of the two observed particles) at θ_{cm}=90^o are 3 × 10^{-2} $\mu b/sr$ and 4 × $10^{-1}\mu b/sr$ for ^{16}O+^{16}O and ^{12}C+^{12}C respectively. Under the crude assumptions of PWIA the knockout cross sections are proportional to the corresponding elastic cross sections, but the trend is seen to be reversed here. It is indicative however that the ^{12}C+^{12}C clustering in $^{24}Mg_{(g.s.)}$ is small.

While in the case of $^{24}Mg(^{12}C,2^{12}C)^{12}C$ reaction the on and off shell behaviors indicated that when the two resonances overlap in a three body system the resonance contribution vanishes and only the non-resonant direct knockout contribution shows up. Here in the present $^{24}Mg(^{16}O,2^{16}O)^8Be$ reaction we find that there is large cross section even in the case of overlapping resonances. In this case it has to be pure knockout cross section devoid of resonance contributions. This we can compare directly with the FR-DWIA predictions.

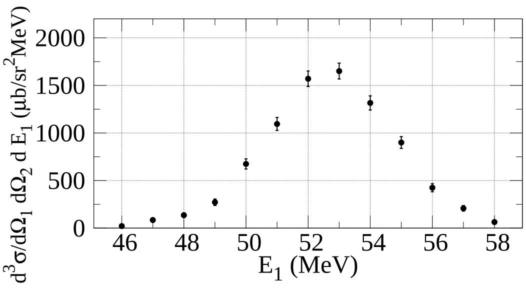

FIG. 4: Energy sharing spectrum for the 105 MeV broad peak in the (E_1+E_2) spectrum of 119 MeV $^{24}Mg(^{16}O, 2^{16}O)^8Be$ reaction.

The FR-DWIA calculations for repulsive core with longer range (R+A) ^{16}O+^{16}O potential lead to a cross section value at peak 56.5 MeV to be $\sim$ 2000 $\mu b/sr^2MeV$. A value comparable to the observed cross section of 1425±83 MeV leading to a spectroscopic factor of 0.72. An all through attractive (A) ^{16}O+^{16}O potential gives value of FR-DWIA at 56.6 MeV of $\sim$ 0.9 $\mu b/sr^2MeV$ a value of abot order of magnitude to small.

References

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