Contribution of α-^{12}C resonance in $^{16}O(^{12}C, 2^{12}C)^4He$ reaction at 118.8 MeV.

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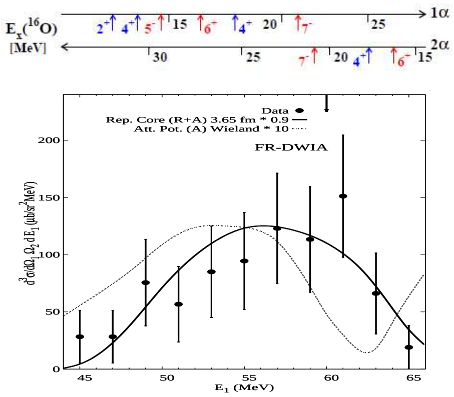

FIG. 1: Energy sharing spectrum for the 118.8 MeV $^{16}O(^{12}C, 2^{12}C)^4He$ compared with the calculations (normalized to the peak). FR-DWIA results (Solid Line) using 3.65 fm repulsive core (R+A) ^{12}C-^{12}C potential and (Dashed Lines) all through attractive (A) ^{12}C-^{12}C potential. The position of ^{16}O known members of the rotational bands with the $^{12}C+\alpha$ structure are shown.

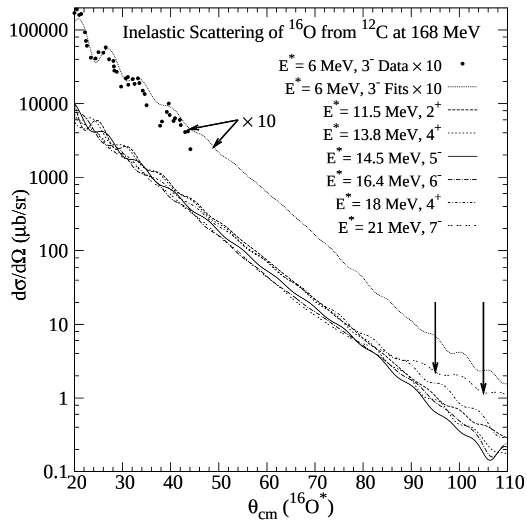

FIG. 2: 168 MeV ^{16}O inelastic scattering on ^{12}C for various ^{16}O excited states using Bassel *et al.* [2] formalism.

Besides the direct knockout the sequential α-decay of ^{16}O may also contribute to the reaction $^{16}O(^{12}C, 2^{12}C)^4He$ at 118.8 MeV [1]. In the energy range of the E_1- spectrum of this predominantly knockout reaction (Fig.1) there exist some α- decaying $^{16}O^*$ resonance (between 11.5 and 21 MeV excitation of ^{16}O) contributions as they have the same kinematics as the direct knockout. As large resonance contribution may also be misinterpreted as enhancement in the direct knockout. It is desirable to properly evaluate the contributions from these sequential decays. For the kinematics of our 118.8 MeV $^{16}O(^{12}C, 2^{12}C)^4H$ reaction the two ^{12}C's were detected at 41^o and 45^o in the laboratory frame which also correspond to the formation and sequential decay of the inelastically scattered excited $^{16}O^*$ into ^{12}C and ^4He. The $\theta_{c.m.}$ ($^{16}O^*$) for one of the ^{12}C's going at 41^o or 45^o correspond to 95^o to 105^o in the center of mass (c.m.) frame.

One can estimate the sequential decay contributions by first evaluating them from the inelastic scattering theory. We use the DWBA theory of Bassel *et al* [2] to get the inelastic scattering cross sections of $^{12}C(^{16}O, ^{16}O^*)^{12}C$ at $E_{^{16}O}$ at 168 MeV, which is equivalent to $E_{^{12}C}$=124 MeV close to our 118.8 MeV $^{16}O(^{12}C, 2^{12}C)^4H$ reaction. Here the transition amplitude is written as usual as,

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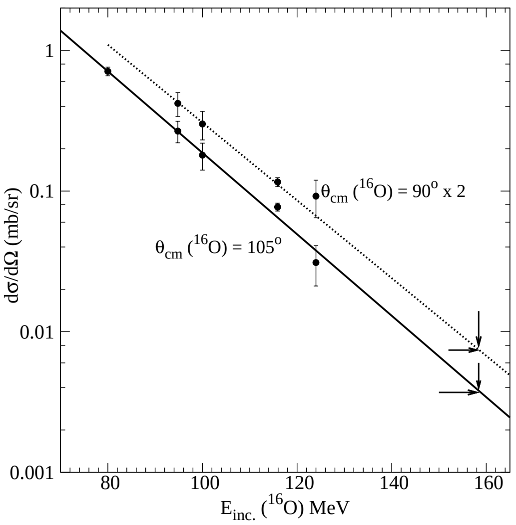

FIG. 3: Experimental inelastic scattering differential cross sections plotted for $\Theta_{cm} = 95^o$ and 105^o at various incident ^{16}O energies on ^{12}C for two ^{16}O excited states(3^- at 6.13 and 2^+ at 6.92 MeV combined), Szilner *et al.* [4]

$$T_{fi} = \int d\vec{r}\chi_f^{(-)*}(\vec{k}_f, r)\langle\Phi_f|V|\Phi_i\rangle\chi_i^{(+)}(\vec{k}_i, \vec{r})$$

with the differential cross section given by,

$$\frac{d\sigma}{d\Omega} = (\frac{\mu}{2\pi\hbar^2})^2(k_f/k_i)\sum_{av}|T_{fi}|^2 \qquad (1)$$

$\langle\Phi_f|V|\Phi\rangle$ being the interaction causing the transition taking place between the internal states of the colliding pairs, playing the role of an effective interaction for scattering for one elastic scattering to another.

In the collective model of the nucleus in the first order it has been shown to be $\langle|V_{eff}|\rangle$.

$$\langle J_f||V_e||J_i\rangle = A_\ell F_\ell(r) \qquad (2)$$

Using Woods-Saxon potential we get [3],

$$A_\ell = i^\ell(2\ell+1)^{-1/2}(\beta_\ell R_0 U_0/a) \qquad (3)$$

and $F_\ell = \dfrac{d}{dx}(e^x+1)^{-1}$

The Woods-Saxon parameters are obtained by fitting the elastic scattering data and then $(\beta_\ell R_0)$ values are obtained from the fitting of the inelastic scattering data for various ^{16}O excited α-decaying states. The differential cross section (shown in Fig. 2) between 95^o and 105^o are seen to be in the range of 1-2 $\mu b/sr$.

A check on these estimates has been made by extrapolating the $^{12}C(^{16}O,^{16}O^*)^{12}C$ angular distribution data from $E_{^{16}O}$= 80 MeV to 124 MeV by Szilner *et al* [4]. This inelastic scattering is having contributions from two resonances. Their work however, does not have data between 95^o and 105^o. Corresponding to $E_{^{12}C}$ =118.8 MeV of our $^{16}O(^{12}C,2^{12}C)^4He$ reaction the corresponding $E_{^{16}O}$ is 158.4 MeV and the extrapolated inelastic $(d\sigma/d\Omega)$ at 95^o and 105^o are seen (Fig.3) to be 3.64 and 3.72 $\mu b/sr$ respectively (the values for the two resonances combined). Individual resonance would thus contribute $\leq$ 1.85 $\mu b/sr$ a value close to our theoretical estimate. The Jacobian for $d\Omega_1 \cdot d\Omega_2$ from center of mass frame to the lab frame leads to the resonance contribution to our 118.8 MeV $^{16}O(^{12}C,2^{12}C)^4He$ reaction to $\leq$ 18.5 $\mu b/sr^2 MeV$, about 15% of the peak value cross section observed in our experiment.

References

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