The $^{16}O(C, 2C)^4He$ Reaction and the Nature of the Short Range C-C Interaction.

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The α-cluster knockout reaction using α-beams yielded very large α-spectroscopic factors[1], orders of magnitude larger than the corresponding (p, pα) reactions[2]. At some what higher α energy however this anomaly disappeared[3, 4]. The explanation came forward from the finite range (FR) DWIA analysis where the α-α repulsion below 170 MeV was ascribed to the enhancement of the (α, 2α) cross sections[5]. It was thus established that the (α, 2α) reactions are extremely sensitive to the shorter range component of the α-α interaction. We therefore concluded that in heavy cluster knockout in the $^{16}O(^{12}C, 2^{12}C)^4He$ reaction, the cross section will be enhanced much more in comparison to the α-cluster knockout cross section in $^{16}O(\alpha, 2\alpha)^{12}C$ reaction (due to these finite range effects) if the ^{12}C-^{12}C interaction is also repulsive at short distances. However, if the ^{12}C-^{12}C interaction contains stronger attraction at short distances, as has been advocated by Wieland et al[6], then there will be no enhancement. In order to decide between these two contradicting scenarios the $^{16}O(^{12}C, 2^{12}C)^4He$ reaction experiment was performed at 118.8 MeV at the Pelletron-LINAC facility (PLF). The Experimental details and preliminary result were presented last year[7]. The final results of this experiment are presented in Fig.1 and 2. In the summed energy spectrum of Fig.1 one can easily see the separate ground state of the struck ^{12}C as well as the excited state of either of the two ^{12}C's in the final state. Fig.2 clearly shows the typical ℓ=0 knockout peak at 60 MeV energy sharing spectra. The peak cross section is seen to be $151(\mu b/sr^2MeV)$ which is about 15 times larger than the peak cross section in the 140 MeV $^{16}O(\alpha, 2\alpha)^{12}C_{g.s}$ reaction.

We have performed the conventional Zero Range (ZR) DWIA calculations of this reaction. The beauty of the $^{16}O(\alpha, 2\alpha)^4He$ and $^{16}O(^{12}C, 2^{12}C)^4He$ reaction is that the optical distortions in both these reactions arise from the α-^{12}C optical potentials. Therefore the optical distortion effects in these two reactions are similar. The optical distortions, however differ mainly in the (B/A)-prescription for the entrance channel, which in any way is not a very reliable prescription[2]. In the more reliable folding model prescription[1, 8] optical distortion do not differ much for the two reactions. Therefore the main difference between the (C, 2C) and (α, 2α) arise due to the C-C and α-α knockout vertex. As the enhancement in the $^{16}O(\alpha, 2\alpha)^{12}C$ reaction

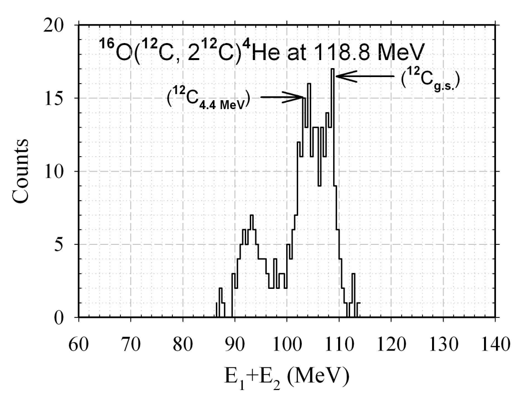

FIG. 1: Summed energy spectrum for the 118.8 MeV $^{16}O(C, 2C)^4He$.

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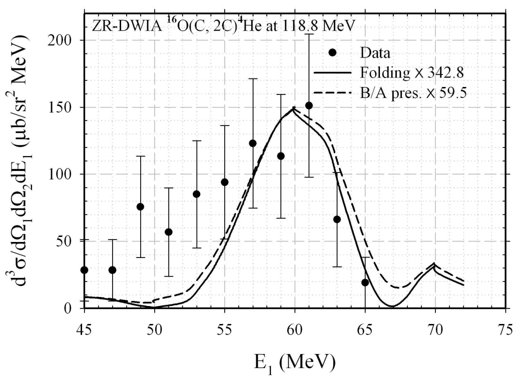

FIG. 2: Energy sharing spectrum of the (C, 2C) reaction corresponding to the knockout of the $^{12}C_{g.s.}$ from ^{16}O.

cross section compared to the ZR-DWIA as seen to arise because of the short range α-α repulsion the similar enhancement should not be seen in the ^{12}C-^{12}C interaction having strong attraction at short distances as advocated by Wieland et al. The conventional ZR-DWIA calculations using entrance channel optical potential from the folding model and the B/A prescription are compared with the $^{16}O(^{12}C, 2^{12}C)^4He$ data at 118.8 MeV. The calculated curve are normalized to the data peak value. The normalization constants are found to be 342.8 and 59.5 for the folding and B/A prescriptions respectively. In comparison to these values the theoretical value is 0.23[9]. The More reliable folding model prescription therefore indicates a 1450 times enhancement in the $^{16}O(^{12}C, 2^{12}C)^4He$ case much larger than even the (α, 2α) case[8] (50 times). This clearly indicates, much against Wieland et al, that there is a hard core in the C-C interaction at least around E_{CM}=55 MeV. This leaves much to be looked for as to what energy the short range C-C repulsion changes to attraction for the complete fusion of the two ^{12}C's. Fresh (C, 2C) experiments will have to be performed at different but higher energies to identify the position at which the two ^{12}C's will be overlapping just as it was identified from the FR-DWIA analyses of the $(\alpha, 2\alpha)$ reactions that a transition will occur in these reactions at around 168 MeV for the two α's to fuse. The full finite range, FR-DWIA calculations for the $^{16}O(^{12}C, 2^{12}C)^4He$ reaction using ^{12}C-^{12}C interaction which are either purely attractive or which have a repulsive core will be presented separately.

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