

$\alpha$ -Cluster Transfer in the Reaction  $^{16}_0\text{O} + ^{40}_{20}\text{Ca}$

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In this contribution, we wish to show, that the measured mass spectrum of 75 MeV  $^{16}_0\text{O} + ^{40}_{20}\text{Ca}$  reaction<sup>1)</sup>, indicating an explicit  $\alpha$ -cluster transfer is the collective  $\alpha$ -particle<sup>2)</sup>, fragmentation given by the dynamical fragmentation theory<sup>3)</sup>, as is suggested by Greiner<sup>4)</sup>.

We solve numerically the stationary Schrödinger equation in the collective mass asymmetry coordinate  $\eta_A = (A_1 - A_2)/(A_1 + A_2)$ , at a fixed relative separation R,

$$\left[ -\frac{\hbar^2}{2\sqrt{B_{\eta_A}\eta_A}} \frac{\partial}{\partial \eta_A} \frac{1}{\sqrt{B_{\eta_A}\eta_A}} \frac{\partial}{\partial \eta_A} + V(\eta_A) \right] \Psi_R^{(\nu)}(\eta_A) = E_R^{(\nu)} \Psi_R^{(\nu)}(\eta_A) \quad (1)$$

The percentage mass fragmentation yields  $Y(A_1)$ , after proper scaling, are then given by

$$Y(A_1) = |\Psi_R(\eta_A(A_1))|^2 \sqrt{B_{\eta_A}\eta_A(A_1)} \frac{200}{(A/2)} \quad (2)$$

with the temperature effects included through a Boltzmann-like function

$$|\Psi_R|^2 = \sum_{\nu=0}^{\infty} |\Psi_R^{(\nu)}|^2 \cdot \exp(-E_R^{(\nu)}/\Theta) \quad (3)$$

Here  $\Theta$  is the nuclear temperature (in MeV), related to the excitation energy  $E^* = (A/9)\Theta^2 - \Theta$ .

In order to calculate the fragmentation potential  $V(\eta_A)$ , following a recent work of Gupta et. al<sup>5)</sup>, we consider the particle transfer to occur at the touching configuration of the nuclei ( $R=R_1+R_2$ ;  $R_i=r_0 A_i^{1/3}$ ,  $r_0=1.15$  fm) and in steps of  $\Delta\eta_A=2/A$ . The potential  $V(\eta_A)$  is then defined as

$$V(\eta_A) = -B_1(A_1, Z_1) - B_2(A_2, Z_2) + \frac{Z_1 Z_2 e^2}{R} + 4\pi\gamma b \frac{R_1 R_2}{R_1 + R_2} \Phi(0) + \frac{\hbar^2 \ell(\ell+1)}{2\mathcal{I}_S} \quad (4)$$

where  $B_i(A_i, Z_i)$  are the experimental binding energies,  $b=1$  fm,  $\gamma=0.9517 [1-1.7826(N-Z)^2/A^2]$  MeV fm<sup>-2</sup> and the universal function of proximity  $\Phi(0)=-1.7817$ . The angular momentum  $\ell$ , in terms of the incident centre-of-mass energy  $E_{cm}$ , is

$$\ell = R \sqrt{2\mu E_{cm}} / \hbar$$

with  $\mu = A_1 A_2 M / (A_1 + A_2) = AM(1-\eta_A^2)/4$ , as the reduced mass. M is the nucleon mass. The moment of inertia  $\mathcal{I}_S$ , in the limit of

complete sticking, is given by

$$J_S = \mu R^2 + \frac{2}{5} A_1 M R_1^2 + \frac{2}{5} A_2 M R_2^2 \quad (6)$$

For the mass parameter  $B \eta_A \eta_A$ , we assume a constant value

$$B \eta_A \eta_A = 1.2 \times 10^4 M \text{ fm}^2 \quad (7)$$

which means the neglect of dynamical effects due to masses.

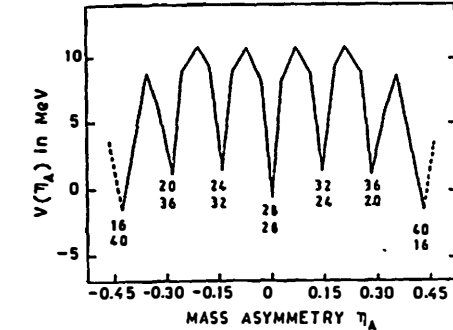
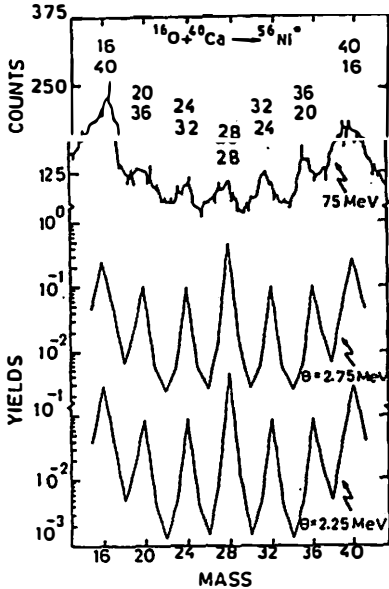


Fig.1 Fragmentation potential of  $^{56}\text{Ni}$ .

Fig.2 Calculated mass fragmentation yields compared with experimental data of Ref.1.

Fig.1 gives the calculated potential  $V(\eta_A)$  for the composite system  $^{56}\text{Ni}$ . We notice that the  $\alpha$ -cluster structure is already revealed. The minima in this potential lie only and exactly at the  $\alpha$ -particle transfer of nucleons.

The calculated mass yields at two  $\Theta$ -values and the experimental data are shown in Fig.2. It is interesting to see that, in agreement with experiments, the calculated mass yields are peaked only at the  $\alpha$ -particle mass fragmentation. In the absence of the dynamical effects of the mass parameter, we do not expect any detailed comparison of our calculations with the experiments. But the gross structure is already obtained, thereby showing that the  $\alpha$ -cluster transfer in this reaction is the collective  $\alpha$ -particle fragmentation.

#### References:

1. R.R. Betts, Proc. Resonances in Heavy Ion Reactions, Bad-Honnef (West Germany), 1981, p.185.
2. See e.g. R.K. Gupta, D.R. Saroha and N. Malhotra, J. de Physique Colloque, September 1984.
3. W. Greiner, same as Ref. 1, p.415.
4. R.K.Gupta, M. Münchow, A. Săndulescu and W. Scheid, J.Phys.G:Nucl. Phys. 10(1984)209.