STRUCTURE IN γ-RAY YIELDS FROM THE $^{12}C + ^{12}C$, $^{12}C + ^{16}O$, $^{16}O + ^{16}O$ AND $^{12}C + ^{14}N$ REACTIONS ABOVE THE COULOMB BARRIER

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We have employed γ-ray techniques in order to study the fusion cross sections of the $^{12}C + ^{12}C$, $^{12}C + ^{16}O$, $^{16}O + ^{16}O$ and $^{12}C + ^{14}N$ reactions. For the first two of these systems, oscillations in the total fusion cross section have been reported by Sperr et al.[1] using heavy fragment detection techniques. We have been able to show that structure in the fusion cross section is associated with channels in which at least one α particle is emitted in the fusion-evaporation process. This is illustrated in the first three figures in the case of the $^{12}C + ^{16}O$ reaction. In fig. 1 the yield of the 1.63 MeV transition of ^{20}Ne is shown as a function of bombarding energy from 17 to 28 MeV c.m. energy. For this range of energies the ^{20}Ne transition, subsequent to the emission of two α-particles, is the most intense transition seen in the γ-ray spectra. Structure is observed in the excitation function which is roughly correlated with the oscillations previously observed in the total fusion cross section, though in the finer details the present results appear more complex. Other channels, especially those in which only nucleons are emitted, are much weaker. However in fig. 2 the yield of 417 keV transition of ^{26}Al, formed following the evaporation of a neutron and a proton, is shown and in contrast to the previous figure no structure is observed in the excitation function. The results for the $^{12}C + ^{16}O$ reaction are summarized

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in fig. 3 where the excitation functions for the emission of light particles α, p and n, as deduced from the intensities of ground state transitions observed in the γ-ray spectra, are shown.

We have applied the same γ-ray method to the $^{16}O + ^{16}O$ reaction, a system which is difficult to study by heavy fragment detection techniques. The total fusion cross section, obtained by summing the intensities of all the ground state transitions, is shown in fig. 4 for energies ranging from 12.5 to 30.5 MeV c.m. A periodic structure with a periodicity ≃ 3.5 MeV is clearly visible, and these oscillations are reproduced by an optical model calculation (a constant cross section has been subtracted to facilitate comparison with the experimental points) using parameters which fit the elastic scattering data[2] . As for the previous reactions, structure is observed in those channels formed by the evaporation of at least one α particle.

We have also studied one system, $^{12}C + ^{14}N$, where it has been reported that there is no structure in the total fusion cross-section. The sum of the cross-sections for the formation of 5 residual nuclei where there are one or more α particles in the evaporation chain, is shown in fig. 5. Broad structure is observed in the individual channels but is less evident in the summed curve. Calculations are in progress to determine whether this broad structure can be explained by the details of the Yrast band of the residual nucleus.

REFERENCES

1. P. Sperr et al., Phys. Rev. Lett. 36 (1976) 405 and 37 (1976) 321.

2. A. Gobbi et al., Phys. Rev. C7 (1973) 30.

FIGURE CAPTIONS

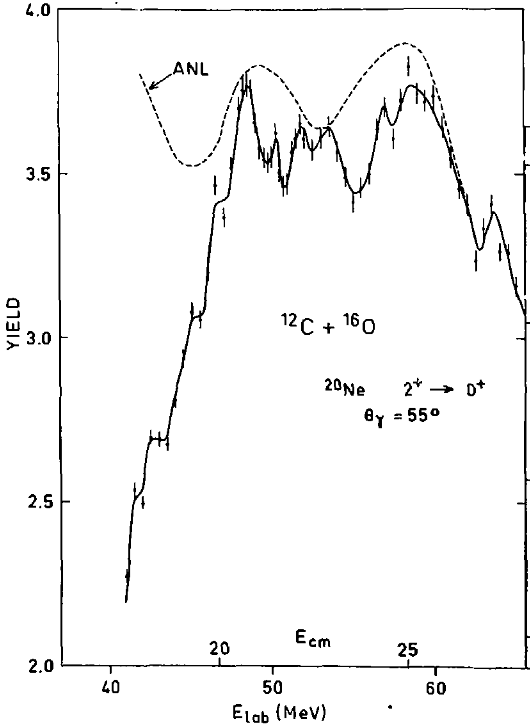
Fig. 1 Yield of the 1.63 MeV transition of ^{20}Ne from the ^{16}O (^{12}C,2α) ^{20}Ne reaction. Oscillations observed in the total fusion cross section are shown for comparison.

Fig. 2 Yield of the 417 keV transition of ^{26}Al from the ^{16}O (^{12}C,pn) ^{26}Al reaction.

Fig. 3 Yield of light fragments from the $^{12}C + ^{16}O$ fusion reaction as deduced from the γ-ray spectra.

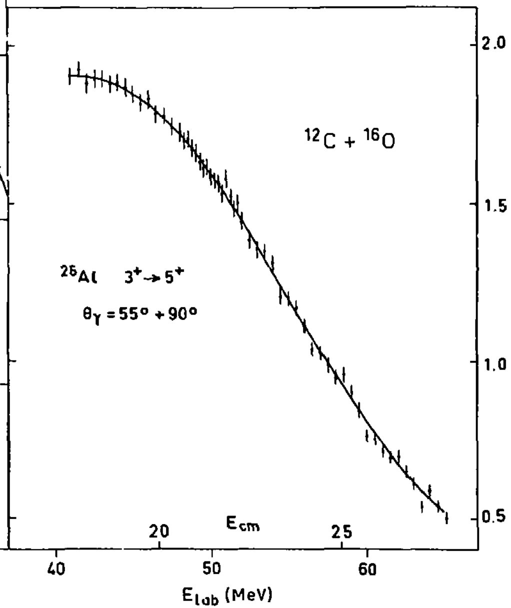
Fig. 4 Total fusion cross section for the $^{16}O + ^{16}O$ reaction obtained by summing γ-ray intensities. Full line is an optical model calculation.

Fig. 5 Fusion cross section for 5 residual nuclei following the $^{12}C + ^{14}N$ reaction.



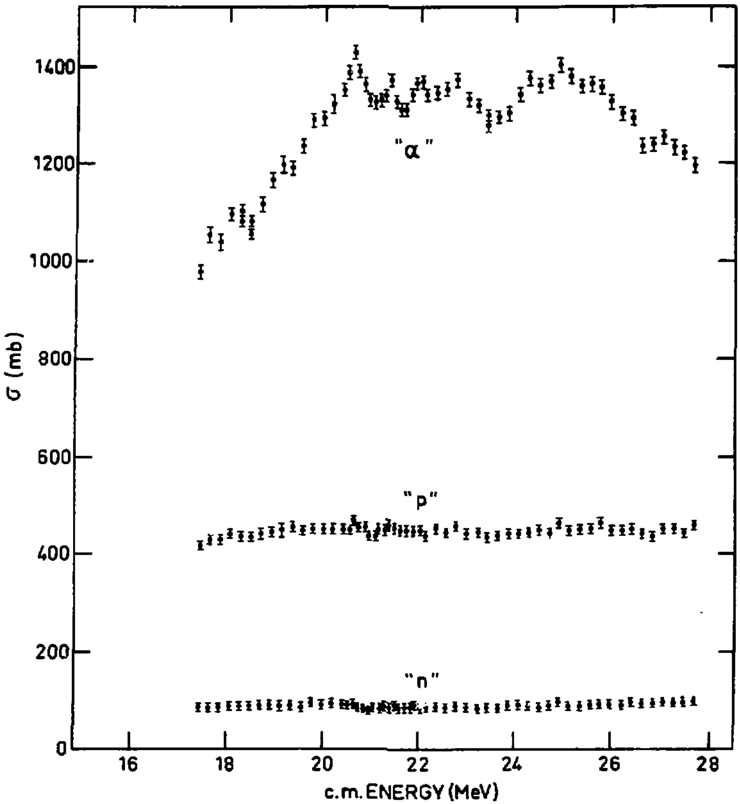
YIELD
4.0
3.5
3.0
2.5
2.0
ANL
$^{12}C + ^{16}O$
^{20}Ne $2^+ \rightarrow 0^+$
$\theta_\gamma = 55°$
E_{cm}
20
25
40
50
60
E_{lab} (MeV)

Fig. 1



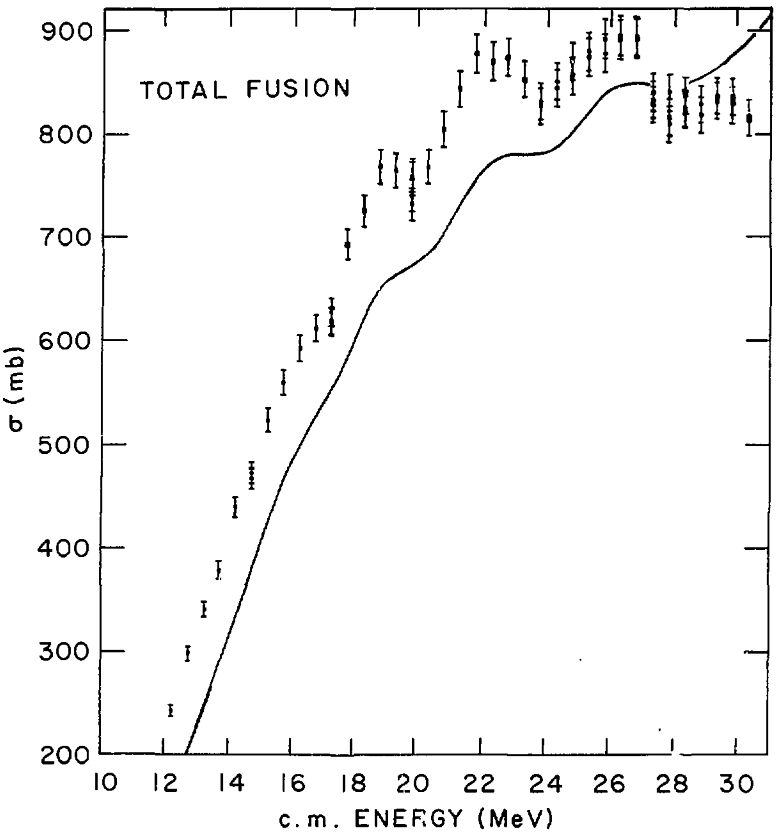
2.0
1.5
1.0
0.5
$^{12}C + ^{16}O$
^{26}Al $3^+ \rightarrow 5^+$
$\theta_\gamma = 55° + 90°$
E_{cm}
20
25
40
50
60
E_{lab} (MeV)

Fig. 2



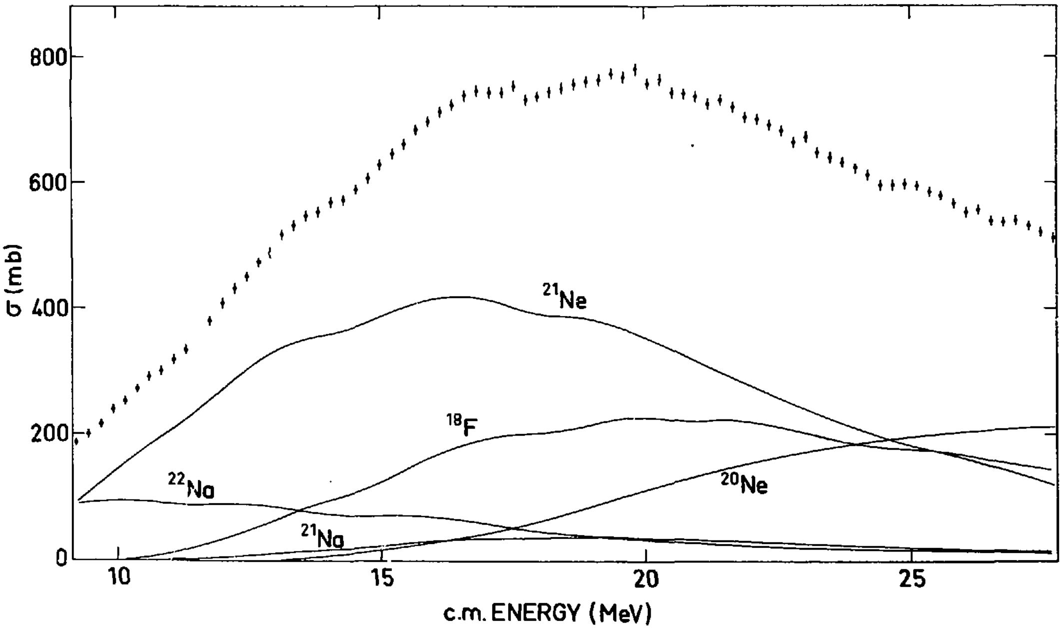
1400
1200
1000
800
600
400
200
0
σ (mb)
"α"
"p"
"n"
16
18
20
22
24
26
28
c.m. ENERGY (MeV)

Fig. 3



TOTAL FUSION
900
800
700
600
500
400
300
200
σ (mb)
10
12
14
16
18
20
22
24
26
28
30
c.m. ENERGY (MeV)

Fig. 4



800
600
400
200
0
σ (mb)
21Ne
18F
22Na
21Na
20Ne
10
15
20
25
c.m. ENERGY (MeV)

Fig. 5