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Some of the results presented in this report are in part preliminary and should not be quoted without the approval of the authors.

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The interaction of $^{12}\text{C}$ and $^{16}\text{O}$ with $^{103}\text{Rh}$

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Continuing the study of the interaction of $^{12}\text{C}$ and $^{16}\text{O}$ with $^{103}\text{Rh}$, we have measured by the activation technique the excitation of a large number of reactions induced by $\approx 290$ to $400$ MeV $^{16}\text{O}$ ions on $^{103}\text{Rh}$, and residue recoil range distribution in the same reaction at $\approx 300$ MeV and 400 MeV. The double differential spectra of the $\alpha$-particles emitted in the interaction of 400 MeV $^{12}\text{C}$ with $^{103}\text{Rh}$ have also been measured. The analysis of these data is in progress.

Most of the activation data concerning the interaction of $^{12}\text{C}$ with $^{103}\text{Rh}$, previously measured, have been analysed during the course of this year. The excitation functions for production of 53 residues over an energy range of more than 350 MeV, and the angular and the recoil distributions of several of these residues at, respectively, 230 and 320 MeV, which taken together represent the largest set of data ever measured in the case of a single heavy ion reaction, can be reproduced by assuming only a few dominant contributions to the interaction of $^{12}\text{C}$ with $^{103}\text{Rh}$ such as complete fusion, incomplete fusion of $\alpha$-type fragments and single-nucleon transfer processes, as already suggested [1–4]. However, we have measured the cross-sections of reactions leading to a much larger number of final reaction channels and extending over a much larger range of incident energies than done in previous work and thus we have been able to refine and improve the theory, including effects previously not considered such as the pre-equilibrium decay of excited nuclei and the re-emission of $\alpha$-particles after the incomplete fusion processes.
Fig. 2 shows some representative excitation functions. $^{111}$In$^9$ and $^{110}$Sn can be formed only in complete fusion. The full lines are the theoretical predictions considering the pre-equilibrium emission of particles during the nucleon-nucleon interaction cascade through which the two ions' kinetic energy transforms into random thermal energy. The dashed lines, which decrease too steeply, are the predictions neglecting such emissions. The other indium isotopes and $^{104}$Cd may be produced in complete fusion and incomplete fusion of $^8$Be fragments and the Ag isotopes in complete fusion and incomplete fusion of both $^9$Be and $\alpha$-particles. Without the re-emission of the $\alpha$-particles, the excitation functions for production of these residues are overestimated (dashed lines), while including $\alpha$-particle re-emission reproduces the tails more accurately (full lines).

The angular and the recoil range distributions give important information on the incomplete fusion and the $\alpha$-particle re-emission. These data, a few examples of which are shown in Fig. 3, suggest that after both $^9$Be and the $\alpha$-incomplete fusion the $\alpha$-particles may be re-emitted with most of their energy, as expected for very peripheral processes. A much more detailed discussion of these results may be found elsewhere [5–8].
References
8. E Gadioli et al., Invited talk to 7th International Conference on Nuclear Reaction Mechanisms, Varenna, 1997 (to be published).

Fig. 3
Comparison of a few experimental (full-line histograms) and theoretical (dashed-line histograms) angular and recoil range distributions. The angular distributions were measured at 290 MeV with annular catchers and the three upper diagrams show:

\[ \frac{d\sigma}{d\Omega} = \frac{2\pi}{\Delta\Omega} \int_{\Delta\theta} \frac{d\sigma}{d\Omega} \sin\theta \, d\theta \]  

(mb/degree) versus the observation angle \( \theta \) (degrees). The three bottom diagrams show recoil range distributions measured at 20 MeV and show:  

\[ d\sigma(df) \]  

(mb/\( \mu g/cm^2 \)) versus the range \( R \) (\( \mu g/cm^2 \)). The integrals of the theoretical distributions are normalised to the integrals of the experimental distributions.