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Comprehensive study of the reactions induced by ^{12}C on ^{103}Rh up to 33 MeV/nucleon

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Abstract

Fifty-three excitation functions for the production of radioactive residues in the interaction of ^{12}C with ^{103}Rh have been measured from the Coulomb barrier up to 400 MeV by means of the activation technique. These excitation functions have been analyzed considering complete fusion, incomplete fusion of ^{8}Be and α-particle fragments and, above about 200 MeV, the transfer of either one proton or one neutron from ^{12}C to ^{103}Rh. The emission of pre-equilibrium particles during the thermalization of the excited composite nuclei formed in all these processes and, in the case of ^{8}Be and α incomplete fusion, also the re-emission of α-particles after a mean-field interaction or a few interactions with the target nucleons have been taken into account.

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1. Introduction

A considerable number of experiments employing the activation technique to measure the yield of radioactive residues produced in the interaction of two heavy ions has been performed in the past thirty years. Some representative papers for ^{12}C-induced reactions are given by Refs. [1–22]. The activation technique yields *comprehensive* information, allowing the measurement of cross-sections of a large number of reactions. The analysis of these data is expected to be quite sensitive to the reaction mechanisms assumed.

Some of these experiments [7,9,12,14,15,19] used thick-target-thick-catcher configuration which yielded cross-sections averaged over several tens of MeV, measured only at a few incident energies separated by large energy intervals, and thus did not provide any detailed information on the energy evolution of the reaction mechanisms. However, the measured cross-sections and the accompanying measurements of the

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forward/backward average recoil ranges showed that, in agreement with other observations [23–25], the fraction of the energy and the linear momentum transferred from the projectile to the target decreases quite significantly with increasing energy. Other experiments [1–6,8,10,11,13,16–18,20–22], at low incident energies, provided useful information on the complete fusion of ^{12}C, and also indicated the presence of incomplete fusion of α-type fragments of ^{12}C.

Most of these papers did not attempt to give a theoretical description of the experimental results. A few considered the decay of the equilibrated compound nucleus formed in the complete fusion reactions [10,13,17], and a few also evaluated the emission of pre-equilibrium particles [16,20,22]. Only two [16,20] analyzed the incomplete fusion reactions.

However these papers showed the potential of such comprehensive measurements for the study of the reaction mechanisms. In order to exploit these possibilities fully in the case of the interaction of ^{12}C with ^{103}Rh, we have analyzed a large number of excitation functions, extending over an energy range of some hundreds of MeV and show in this letter that a detailed and consistent description of the reaction mechanisms and their energy evolution is possible.

2. Experimental data

The excitation functions for production of 53 radioactive residues, ranging from ^{113}Sb to ^{75}Se, in the interaction of ^{12}C with ^{103}Rh have been measured from 45 to 400 MeV. The data have been collected over a period of about 2 years in a series of experiments made, at incident energies below about 100 MeV, at the Laboratorio Nazionale del Sud in Catania (Italy) and, between 100 and 400 MeV, at the National Accelerator Centre at Faure (South Africa). The details of the experiments will be discussed elsewhere [26]. Here we limit ourselves to mention that the rhodium foils were from Goodfellow Metals Ltd., U.K., and their thickness was specified to within an uncertainty of about 20%. Considering the various sources of errors, including the uncertainty in target thickness, in the beam fluence measurement, the Ge(Hp) detector efficiency, the counting efficiency due to electronics dead time and the statistical errors in evaluating the γ-line intensity and the background subtraction, the uncertainty in the cross-sections reported later is estimated to be less than 30 % ($\approx$ 25 % random and 5% systematic).

Fig. 1 provides an example of the data collected and demonstrates the accurate matching of data obtained in different irradiations. This figure shows representative excitation functions of residues with mass number varying from 113 to 90. The majority of these residues were produced cumulatively, that is both directly in the interaction of ^{12}C with ^{103}Rh and via β^+ decay of their precursors, but six of them (^{113}Sb, ^{110}In^m, ^{108}In^m, ^{96}Tc^g, ^{94}Tc^g and ^{93}Mo^m) were produced independently. Table 1 gives the relevant contributions to the cumulative production cross-sections.

3. Theory

All the measured excitation functions have been analyzed using a unique theoretical description and the same set of input parameters.

Our theoretical analysis was based on the results of a large number of previous investigations which suggested the various contributions discussed below. Activation [5,6,8,16,18,20,21] and $\alpha-\gamma$ coincidence experiments [27] showed that, in the interaction of ^{12}C with nuclei, the dominant contributions to the reaction cross-section are complete fusion and incomplete fusion of a ^{8}Be fragment and an α-particle. This is also substantiated by the large number of α-particles emitted in ^{12}C-induced reactions, known since the early sixties [28]. However, the direct measurement of break-up fragments in peripheral collisions of ^{12}C with ^{197}Au [29] also suggests that, at the highest incident energies of our experiment, break-up of ^{12}C into a ^{11}B and a proton, followed by the interaction of the proton with the target nucleus (or, in other words *one proton transfer* from the projectile to the target), may be sizeable. The yield of the break-up fragments, as a function of the break-up Q-value [29] also suggests that the transfer of one neutron may be of some importance. On the basis of these results we assumed as dominant contributions to the total reaction cross-sections: complete fusion of ^{12}C, incomplete fusion of either a ^{8}Be or an α-fragment and, at the higher energies, the transfer of either a proton or a neutron from ^{12}C to ^{103}Rh. The corresponding cross-sections, as a function of incident energy, are shown in Fig. 2, and

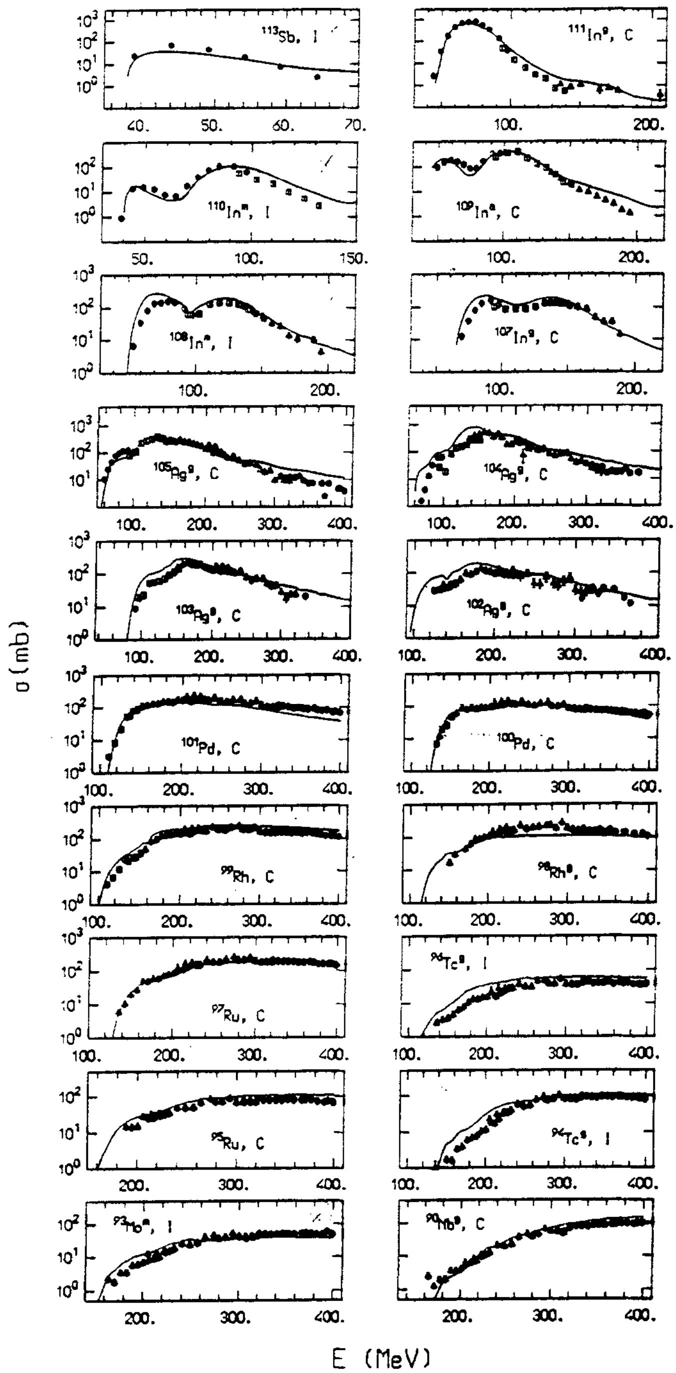

Fig. 1. Typical excitation functions for the production of heavy residues in the interaction of ^{12}C with ^{103}Rh. The theoretical predictions are given by the full lines.

Table 1
Contributions to the cumulative production cross-sections of the residues shown in Fig. 1.

Residue	Contribution to cumulative residue production
^{113}Sb	independent
$^{111}In^g$	$^{111}In^g+1.002\,^{111}In^m+1.009(^{111}Sn+^{111}Sb)$
$^{110}In^m$	independent
$^{109}In^a$	$^{109}In^a+1.005(^{109}In^b+^{109}In^c)+1.079\,^{109}Sn+1.080\,^{109}Sb$
$^{108}In^m$	independent
$^{107}In^g$	$^{107}In^g+1.027\,^{107}In^m+1.11\,(^{107}Sn+^{107}Sb)$
$^{105}Ag^g$	$^{105}Ag^g+0.981\,^{105}Ag^m+0.982(^{105}Cd+^{105}In^g+^{105}In^m+^{105}Sn+^{105}Sb)$
$^{104}Ag^g$	$^{104}Ag^g+0.639\,^{104}Ag^m+3.860\,^{104}Cd+3.956\,^{104}In+2.042(^{104}Sn+^{104}Sb)$
$^{103}Ag^g$	$^{103}Ag^g+1.001\,^{103}Ag^m+1.134\,^{103}Cd+1.153\,^{103}In+1.155(^{103}Sn+^{103}Sb)$
$^{102}Ag^g$	$^{102}Ag^g+1.211\,^{102}Ag^m+2.111\,^{102}Cd+2.176(^{102}In+^{102}Sn+^{102}Sb)$
^{101}Pd	$^{101}Pd+1.022(^{101}Ag^g+^{101}Ag^m)+1.925(^{101}Cd+^{101}In+^{101}Sn+^{101}Sb)$
^{100}Pd	$^{100}Pd+^{100}Ag^m+^{100}Ag^g+1.001(^{100}Cd+^{100}In+^{100}Sn+^{100}Sb)$
^{99}Rh	$^{99}Rh^m+^{99}Rh^g+1.054\,^{99}Pd+1.062\,^{99}Ag^g+1.063\,^{99}Ag^m+1.064(^{99}Cd+^{99}In\,^{99}Sn+^{99}Sb)$
$^{98}Rh^g$	$^{98}Rh^g-0.967\,^{98}Pd-1.062\,^{98}Ag-1.064(^{98}Cd-^{98}In-^{98}Sn-^{98}Sb)$
^{97}Ru	$^{97}Ru+1.007\,^{97}Rh^g+1.012\,^{97}Rh^m+1.008(^{97}Pd+^{97}Ag+^{97}Cd+^{97}In+^{97}Sn+^{97}Sb)$
$^{96}Tc^g$	$^{96}Tc^g+0.988\,^{96}Tc^m$
^{95}Ru	$^{95}Ru+1.054\,^{95}Rh^g+1.069\,^{95}Rh^m+1.049(^{95}Pd+^{95}Ag+^{95}Cd+^{95}In+^{95}Sn+^{95}Sb)$
$^{94}Tc^g$	independent
$^{93}Mo^m$	independent
$^{90}Nb^g$	$^{90}Nb^g+^{90}Nb^m+1.602\,^{90}Mo+1.603\,^{90}Tc^g+1.539(^{90}Tc^m+^{90}Ru+^{90}Rh+^{90}Pd+^{90}Ag+^{90}Cd+^{90}In+^{90}Sn+^{90}Sb)$

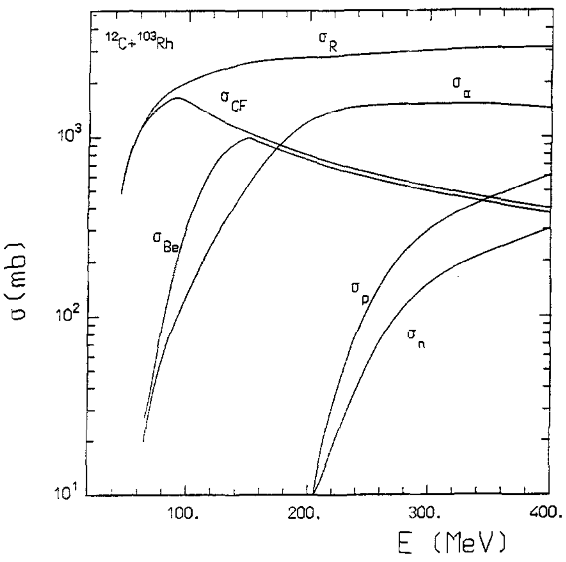

Fig. 2. Contributions to the reaction cross-section σ_R. σ_{CF} is the complete fusion cross-section, while σ_{Be}, σ_α, σ_p and σ_n are the cross-sections for, respectively, the incomplete fusion of a ^8Be and an α-particle fragment and for the transfer of a proton and a neutron from the projectile to the target.

were calculated as discussed below.

The guiding theoretical concepts in our analysis have been:

(a) An entrance-channel critical angular momentum exists for fusion [30–35]. The balance of the nuclear, Coulomb and centrifugal forces determines whether the colliding ions fuse or not. They can fuse only up to a maximum total attractive potential V_T (that is, only if V_T shows a pocket). Using the expression given by Krappe [36] for the Coulomb potential of diffuse and partly overlapping charge distributions and the Saxon-Woods nuclear potential suggested by Glendenning for the rather similar interaction of ^{16}O with silver [37], we estimated a value $L_{crit}^{fus} \approx 50\hbar$ for the critical angular momentum in the fusion of ^{12}C with ^{103}Rh.

Even at the lowest incident ^{12}C energies, emission of pre-equilibrium particles during the thermalization of the composite nucleus must be considered. The number and the spectra of the emitted pre-equilibrium particles have been estimated by the Boltzmann Master Equation theory as described in [22,38].

(b) As discussed by K.Siwek-Wilczyńska et al., [27,39], the critical angular momentum concept can be extended to the case of incomplete fusion. We retained the essential ideas of their work, but with a minor change as regards relating the critical angular momentum for fusion of a fragment of ^{12}C to the corresponding angular momentum of ^{12}C itself. The critical angular momentum for fusion of a ^{8}Be fragment is estimated to be about $L_{\rm cr}^{\rm Be} \approx 40\hbar$, and that for fusion of one α-particle $L_{\rm cr}^{\alpha} \approx 30\hbar$. K. Siwek-Wilczyńska et al. [27,39] suggested evaluating the corresponding angular momenta of ^{12}C considering only the difference of the masses of ^{12}C and the fusing fragments, and therefore multiplying the above mentioned values by 3/2 and 3 respectively. We propose, however, that one must also take into account the displacement of the centre of mass of ^{12}C with respect to that of the fragment. Assuming that, at the moment of the incomplete fusion, the ^{12}C is made up of a ^{8}Be and an α-particle touching at the half-density radii, the corresponding ^{12}C angular momenta were estimated to be $70\hbar$ and $116\hbar$, respectively.

One must also take into account the experimental evidence [5,6,8,20,21,40,41] that incomplete fusion of a ^{8}Be and an α particle may also occur below the threshold energies predicted by the above model, which in this case were ≈ 87 and 130 MeV, respectively. This is done in more realistic theoretical approaches, as for instance the *sum rule model* of Wilczyński et al. [40,41], by removing the sharp cut-off approximation on the angular momenta. In the calculation we discuss here, the values of the incomplete fusion cross-sections below the threshold energies given above were estimated by fitting the excitation functions for production of In and Ag isotopes, respectively. With this procedure the calculated cross-sections for incomplete fusion of ^{8}Be and one α particle, which are given in Fig. 2, become sizeable already at about 80 MeV. Above about 150 MeV both cross-sections are those predicted by the critical angular momentum model [27,39]. The excitation energy distribution of ^{111}In formed after ^{8}Be incomplete fusion was estimated according to the Serber approximation [20,42,43],

(c) The analysis of α-particle induced reactions [44] shows that energetic α particles absorbed by a nucleus may be re-emitted after a mean-field interaction or a few collisions with the target nucleons, with a large fraction of their initial energy. Over a large range of incident energies the energy distribution of these α-particles depends only weakly on the emission energy. In reactions induced by α-particles on nuclei with mass around 100, the probability of α-particle re-emission departs from zero at an α-particle incident energy of about 20-30 MeV and saturates to a value of about 0.3 at incident energies above about 70 MeV [44]. These results suggest also considering the possibility of re-emission of one or both the α particles of ^{8}Be, with a flat spectrum. The same holds true in the case of the absorption of a single α-particle. We thus introduced in our calculations an energy-dependent probability for α-particle re-emission which departs from zero at the energy at which incomplete fusion starts to be sizeable (about 80 MeV, which corresponds to an average energy of about 27 MeV for the α's within ^{12}C) and saturates at ^{12}C-energies exceeding about 200 MeV. The probability of α-re-emission may, in the case of incomplete fusion, be considerably greater than that found in α-induced reactions, since incomplete fusion is a peripheral process, occurring in a reduced density region of the target nucleus. The values we used for the re-emission probability in the case of ^{8}Be and α-particle incomplete fusion saturate to a value of 0.35 and 0.6, respectively, and were obtained by fitting, in the tail region, the excitation functions for the production of In and Ag isotopes to which formation these incomplete fusion processes greatly contribute. When the α-particles are not re-emitted, we considered (also in the case of incomplete fusion) the possibility of the emission of pre-equilibrium particles during the thermalization of the composite nucleus. In the case of α-particle re-emission, the remaining excited nucleus was assumed to be equilibrated.

(d) The total cross-sections for transfer of a proton or a neutron between 300 and 400 MeV were estimated by subtracting from the reaction cross-section, evaluated as suggested by Wilcke et al.,[45] the cross-sections up to the critical angular momentum of $116\hbar$ discussed in (b). Using the empirical dependence of the break-up probability on the break-up Q-value [29], we assumed the cross-section for transfer of a proton to be double that for transfer of a neutron. The values found at 300 MeV for these cross-sections were smoothly extrapolated back to zero at about 200 MeV. This is a quite arbitrary assumption, but does not appreciably affect the calculated cross-sections, due to the rather low values of the nucleon transfer cross-sections below 300 MeV.

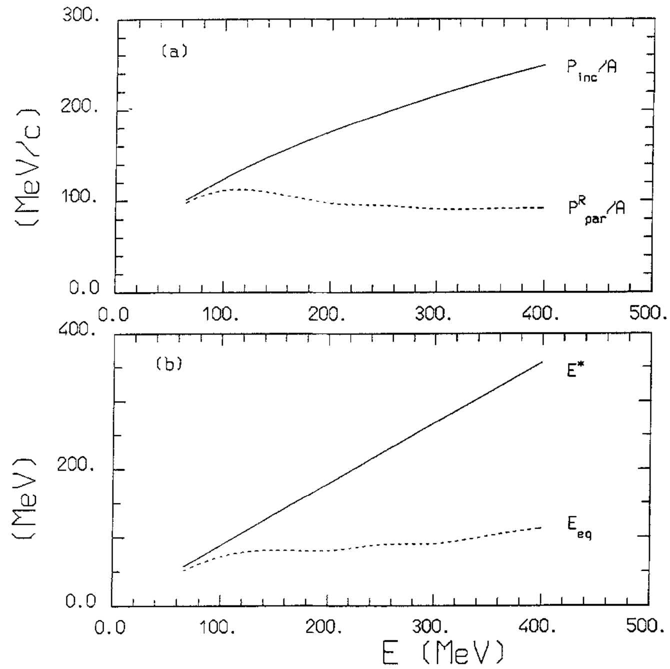

Fig. 3. (a) Predicted average forward linear momentum per projectile nucleon of the residues, P^R_{par}/A (dashed line), and projectile linear momentum per nucleon, P_{inc}/A (full line) as a function of the projectile energy; (b) Excitation energy of the thermalized nuclei, E_{eq} (dashed line), and excitation energy corresponding to a full conversion of the projectile kinetic energy, E^* (full line), as a function of the projectile energy.

It is important to note that, as discussed above, most of the input parameters, were given a priori, as were the further parameters entering the calculation, such as the ejectile binding energies [46,47], the residual nucleus pairing energies [48], the emitted particle inverse cross-sections [49,50] and the level density parameter, for which we used a value $a = A/8$ MeV^{-1}. A previous analysis [51] suggested for the yrast state energies values about 70 % of those estimated, for nuclei in this mass region, by the charged rotating liquid droplet model [52]. The thermalization of the nucleus was simulated with a Monte Carlo calculation, using the probabilities for emission of pre-equilibrium particles, in small time intervals along the thermalization cascade as well as their spectra, calculated by solving a set of coupled Boltzmann Master equations [53].

Results of these calculations are given by the solid lines in Fig. 1, which show a reasonably accurate reproduction of the data in all the cases. The agreement obtained is typical of that found in the case of all the measured excitation functions. It is very encouraging that the accuracy for reproducing the independent formation cross-sections of ^{113}Sb, ^{110}In^m, ^{108}In^m, ^{96}Tc^g, ^{94}Tc^g and ^{93}Mo^m is comparable to that for reproducing the cumulative cross-sections. This suggests that the accuracy of the calculation does not result from summing the calculated values for independent production over a large number of isobars.

4. Predicted linear momentum transfer and average energy of the equilibrated nuclei after thermalization

In Fig. 3a, the calculated average forward component of the residue's linear momentum per projectile nucleon, P^R_{par}/A, given by the dashed line, is compared to the projectile's linear momentum per nucleon, P_{inc}/A, given by the full line. In Fig. 3b, the calculated average excitation energy of the thermalized nuclei, E_{eq}, given by the dashed line, is compared to the excitation energy corresponding to a full conversion of the projectile kinetic energy into excitation energy,

E^*, given by the full line. Assuming, as is usually done, that particle evaporation does not change the average forward momentum of a decaying thermalized nucleus, $P^R_{\rm par}/A$ is also representative of the value of the average forward linear momentum of the thermalized nuclei. At the highest energy, only about 35% of the linear momentum and 31% of the excitation energy are predicted to be transferred to equilibrated nuclei. The remaining momentum and energy are mainly carried away by fast fragments of the projectile and by fast pre-equilibrium particles in the course of the thermalization. This seems to indicate that it becomes increasingly difficult to create hot nuclei. This simple and apparently important conclusion must however be taken with caution, since the predicted momentum and energy distributions are very broad, and most of the information gets lost when measuring or predicting the average values only.

The values we report for $P^R_{\rm par}/A$ saturate to about 90 MeV/c with increasing energy, and are about 30% smaller than the values given by Chung et al. [15,19] for the interaction of ^{12}C with silver. This is not surprising, since the deduction of the average forward linear momentum from a measurement of the forward range using a thick target [15], overestimates $P^R_{\rm par}/A$ when the forward momentum distributions are very broad, as our calculations predict, due to the fact that the partial thickness of the target contributing to a given forward range increases linearly with the range. More sensible information would be gained from thin-target recoil-range distribution measurements. One must also take into account the fact that our theoretical prediction depends quite sensitively on the angular distribution of the emitted particles, while the calculation of the angle integrated cross-sections does not. Thus, our predictions of $P^R_{\rm par}/A$ may be modified slightly when we dispose of data concerning residue's recoil ranges and angular distributions. The measurement and analysis of such data is currently in progress.

5. Conclusions

In this letter we have shown that it is possible to provide an accurate description of a very large set of excitation functions of reactions occurring in the interaction of ^{12}C with ^{103}Rh up to an incident energy of 400 MeV, considering only a small number of contributing reaction mechanisms. To our knowledge, comprehensive calculations of comparable accuracy, in energy ranges as wide as ours, have not been reported in the literature previously. We are of the opinion that our results may be applicable more generally to the study of the interaction of ^{12}C with nuclei, since they are not sensitive to the structure of ^{103}Rh.

References

[1] T. Darrah Thomas et al., Phys. Rev. 126 (1962) 1805.
[2] J.M. Alexander and G.N. Simonoff, Phys. Rev. 133 (1964) 93.
[3] G.N. Simonoff and J.M. Alexander, Phys. Rev. 133 (1964) 104.
[4] R. Bimbot, M. Lefort and A. Simon, J. Phys. (Paris) 29 (1968) 563.
[5] R. Bimbot, D. Gardès and M.F. Rivet, Nucl. Phys. A 189 (1972) 193.
[6] Y. Le Beyec, M. Lefort and M. Sarda, Nucl. Phys. A 192 (1972) 405.
[7] T. Lund et al., Z. Phys. A 306 (1982) 41.
[8] D.J. Parker et al., Phys. Rev. C 30 (1984) 143.
[9] H. Kudo, K.J. Moody and G.T. Seaborg, Phys. Rev. C 30 (1984) 1561.
[10] R. Kossakowski et al., Phys. Rev. C 32 (1985) 1612.
[11] R. Kossakowski et al., Phys. Rev. C 33 (1985) 1514.
[12] S.Y. Chao et al., Phys Rev. C 36 (1987) 2349.
[13] S. Baba et al., Z. Phys. A 331 (1988) 53.
[14] S.Y. Chao, N.T. Porile and D.J. Morissey, Phys Rev. C 39 (1989) 2227.
[15] Y.H. Chung, S.Y. Chao and N.T. Porile, Nucl. Phys. A 533 (1991) 170.
[16] D.J. Parker et al., Phys. Rev. C 44 (1991) 1528.
[17] Li Wenxin et al., Phys. Rev. C 46 (1992) 1538.
[18] B.S. Tomar et al., Z. Phys. A 343 (1992) 223.
[19] J.P. Whitfield and N.T. Porile, Phys. Rev. C 47 (1993) 1636.
[20] P. Vergani et al., Phys. Rev. C 48 (1993) 1815.
[21] M. Crippa et al., Z. Phys. A 350 (1994) 121.
[22] M. Cavinato et al., Phys. Rev. C 52 (1995) 2577.
[23] J. Galin et al., Phys. Rev. Lett. 48 (1982) 1787.
[24] L. Kowalski et al., Phys. Rev. Lett. 51 (1983) 642.
[25] T. Batsch et al., Phys. Lett. B 189 (1987) 287.
[26] C. Birattari et al., to be published.
[27] K. Siwek-Wilczyńska et al., Nucl. Phys. A 330 (1979) 150.
[28] H.C. Britt and A.R. Quinton, Phys. Rev. 124 (1961) 877.
[29] J. Pouliot et al., Phys. Rev. C 43 (1991) 735.
[30] J. Wilczyński, Nucl. Phys. A 216 (1973) 386.
[31] J. Galin et al., Phys. Rev. C 9 (1974) 1018.
[32] R. Bass, Nucl. Phys. A 231 (1974) 45.
[33] D. Glas and U. Mosel, Phys. Rev. C 10 (1974) 2620.
[34] D. Glas and U. Mosel, Nucl. Phys. A 237 (1975) 429.
[35] J.R. Birkelund et al., Phys. Rep. 56 (1979) 107.
[36] H.J. Krappe, Ann. of Phys. 99 (1976) 142.

[37] N. Glendenning, Proceedings of the Nashville Conference on Reactions between Complex nuclei, Vol II, 1974, p. 137.
[38] C. Brusati et al., Z. Phys. A 353 (1995) 57.
[39] K. Siwek-Wilczyńska et al., Phys. Rev. Lett. 42 (1979) 1599.
[40] J. Wilczyński et al., Phys. Rev. Lett. 45 (1980) 606.
[41] J. Wilczyński et al., Nucl. Phys. A 373 (1982) 109.
[42] R. Serber, Phys. Rev. 72 (1947) 1008.
[43] N. Matsuoka et al., Nucl. Phys. A 311 (1978) 173.
[44] E. Gadioli and P.E. Hodgson, Pre-Equilibrium Nuclear Reactions (Clarendon Press, Oxford, 1992), Chapter 8, p. 417 ff.
[45] W.W. Wilcke et al., At. Data Nucl. Data Tables 25 (1980) 389.
[46] G. Audi and A.H. Wapstra, Nucl. Phys. A 565 (1993) 1.
[47] W.D. Myers and W.J. Swiatecki, Nucl. Phys. 81 (1966) 1; Ark. Fys. 36 (1967) 343.
[48] P.E. Nemirovski and Yu.V. Adamchuck, Nucl. Phys. 39 (1962) 551.
[49] I. Dostrovsky, Z. Fraenkel and G. Friedlander, Phys. Rev. 116 (1959) 683.
[50] E. Gadioli, E. Gadioli Erba and J.J. Hogan, Phys. Rev. C 16 (1977) 1404.
[51] M. Cavinato et al., Phys. Rev. C 54 (1996) XXX.
[52] A.J. Sierk, Phys. Rev. C 33 (1986) 2039.
[53] M. Cavinato et al., Phys. Lett. B 382 (1996) 1.