CORRELATED PAIRS OF $\alpha$ PARTICLES DUE TO PROJECTILE DISSOCIATION

J. Uckert, M. Bürgel, H. Fuchs, H. Homeyer, A. Budzanowski

To cite this version:

J. Uckert, M. Bürgel, H. Fuchs, H. Homeyer, A. Budzanowski. CORRELATED PAIRS OF $\alpha$ PARTICLES DUE TO PROJECTILE DISSOCIATION. Journal de Physique Colloques, 1986, 47 (C4), pp.C4-95-C4-97. <10.1051/jphyscol:1986411>. <jpa-00225774>

HAL Id: jpa-00225774
https://hal.archives-ouvertes.fr/jpa-00225774
Submitted on 1 Jan 1986

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
CORRELATED PAIRS OF \( \alpha \) PARTICLES DUE TO PROJECTILE DISSOCIATION

J. UCKERT, M. BÜRGERL, H. FUCHS, H. HOMEYER and A. BUDZANOWSKI*

Hahn-Meitner-Institut für Kernforschung, D-1000 Berlin 39,
F.R.G.

Abstract - Correlations have been measured between pairs of light particles (p, d, t, \( \alpha \)) emitted in collisions of 390 MeV \(^{18}\)Ne + \(^{197}\)Au. Treating the example of \( \alpha - \alpha \) correlations, the contributions of various well-established processes (complete fusion, massive transfer, sequential decay of the projectile after quasi-elastic or deep-inelastic collisions) have been calculated and found to virtually exhaust the measured coincidence cross sections. Conclusions on possible emission from hot subsystems are hampered by the overwhelming competition of the processes mentioned above.

Correlations measured between two light particles often are analyzed /1/ by attributing them entirely to emission from a thermal source which may be smaller than the compound nucleus and exists prior to equilibration within the collisions complex. Suspecting that quasi-direct dissociation of the projectile, too, yields correlated particle pairs, for instance \(^8\)Be g.s. + \( \alpha + \alpha \) as frequently as the fragment \(^8\)Be g.s., we have studied light-particle correlations of the system 390 MeV \(^{18}\)Ne + \(^{197}\)Au for which previous investigations provide us with ample information on projectile dissociation processes and their cross sections /2-7/.

For demonstration we consider the example of correlations between two \( \alpha \) particles. The experiment was carried out at the VICKSI accelerator. Light particles were detected in two solid-state detector telescopes and 10 phoswich BGO/pilote U detectors, both in narrow geometry and for large relative angles. Pairs of \( \alpha \) particles observed in close geometry at \( \theta = 16.5^\circ \) have a spectrum of relative energies dominated by the \(^8\)Be g.s. peak at \( E_{12} = 92 \) keV (see fig. 1). Angular correlations for four emission angles \( \theta_M \) of the triggering \( \alpha \) particle are shown in fig. 2.

For their interpretation the contributions of the following processes effectively had to be considered and were calculated by Monte Carlo simulations using as input angular distributions and distributions of Q-values and excitation energies from previous investigations /2,3/.

1. Complete fusion with evaporation of two \( \alpha \) particles. This yields a quasi-isotropic angular correlation for all trigger angles. Its strength is fixed by the isotropic component at large trigger angle (160\(^\circ\)), giving 650 mb cross section to be com-
Fig. 1 - Measured spectrum of relative energies between two $\alpha$ particles detected at close-lying forward angles, together with Monte-Carlo simulated contributions of processes 2 and 4 (see text).

pared to 800 mb complete fusion, 1500 mb incomplete fusion and to 2700 mb evaporated $\alpha$ particles altogether /2,4/.

2. Incomplete fusion (massive transfer) with forward emission of one fast $\alpha$ particles and capture of $^{8}$Be by the target nucleus with subsequent evaporation of one $\alpha$ particle. The correlation is quasi-isotropic if triggered at forward angle (by the first, forward emitted $\alpha$ particle) and forward-peaked if triggered by the second $\alpha$ particle (at back angles). The latter component was used to fix its strength. The result is 400 mb, in comparison to 800 mb incomplete-fusion $\alpha$ particles altogether /5/.

3. Incomplete fusion (massive transfer) with forward emission of $^{8}$Be decaying into two $\alpha$ particles. The $^{8}$Be g.s. contributes only by a narrow spike around the trigger angle not visible with the in-plane detector intervals used for the correlations shown, the first excited state has 60 mb at most.

4. The quasi-elastic reaction $^{20}$Ne + $^{197}$Au + X + $^{12}$C* with $^{12}$C* decaying via $^{8}$Be into three $\alpha$ particles (60 mb).

5. Deep-inelastic collisions with emission of two or three $\alpha$ particles from the outgoing projectile-like fragment (about 180 mb). Cross sections of primary decaying fragments relevant for processes 3 to 5 may be estimated from the primary-fragment yields determined by various coincidence measurements /3,6,7/. For instance, the yield of $^{12}$C* decaying into $\alpha + ^{8}$Be was set equal to that of $^{13}$C* found in $\alpha$-Be coincidences.

6. Forward emission of an $\alpha$ particle from $^{20}$Ne in the first reaction phase, the $^{16}$O remainder emitting a second sequential $\alpha$ particle after a deep-inelastic collision. This process still must be quantified.

Processes 3 to 6 yield correlated pairs with both partners going into forward direction, and actually come up for almost all of the measured forward-forward cross section. The relative angles extend to $80^\circ$ or more. This corresponds to rather large relative energies, and consequently the processes mentioned contribute equally at the large relative energies in the narrow-geometry distributions like that of
Fig. 2 - Possible reaction mechanisms (left) and their contribution to the experimental angular correlations (right) of α particles coincident with an α particle detected at θ_M. The histograms are the Monte Carlo simulations of the processes with two or more outgoing α particles (see text).

Fig. 1. Thus they distort precisely that portion of the spectra decisive for a possible determination of source temperature exploiting the intensity of the 6Be (2^+) resonance at E_{12} = 3.0 MeV relative to that of the g.s.. Moreover, also the source radii become uncertain, because they are extracted from the value of the correlation function at small relative energy, the absolute normalization of this function being fixed at large relative energy, where the contributions of the projectile dissociation processes considered is dominant.

REFERENCES

/2/ Ch. Egelhaaf et al., Nucl. Phys. A 405 (1983) 397 and references quoted therein