MASS TRANSFER AND INERTIA EFFECTS IN HEAVY ION COLLISIONS

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1. Introduction.

Mass tranfer between interacting ions has been extensively studied in the overdamped regime. Simple models were recently used in order to investigate inertia effects [1-3]). We analyze these effects in the framework of a semi realistic phenomenological model which we apply to the study of physical observables in the reaction between medium-weight nuclei. The results are compared to those obtained some time ago in the overdamped regime [4]).

2. The model.

The mass transfer is described by the mass asymmetry variable $y = (A_2-A_1)/(A_1+A_2)$ (A_1, A_2 = number of nucleons in the ions). The mass distribution function $P(y,p_y;t)$ is derived through a Langevin equation and reads :

$$\frac{\partial P}{\partial t} = -\frac{\partial}{\partial y}\left[\frac{P_y}{\mu}P\right] + \frac{\partial}{\partial p_y}\left[\left(\frac{\partial V}{\partial y} + \frac{\gamma P_y}{\mu}\right)P\right] + \frac{\partial^2}{\partial {p_y}^2}\left[D_p P\right] \quad (2.1)$$

where $P_y = \mu\dot{y}$, the mass parameter of the generalized inertia force, V a conservative potential [4]), γ a friction coefficient and D_p a diffusion coefficient. These transport coefficients are derived through Einstein relations. They depend explicitly on y and the excitation energy of the interacting system. The mass parameter is supposed to be constant. Its evaluation by means of different approaches (hydrodynamical, cranking model...)

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yields values lying between 5.10^4 and $1.5.10^5$ MeV x $bsec^2$ (1 bsec=10^{-23}sec).

In practice, P is approximated by a Gaussian distribution defined by its first moments $\langle y(t)\rangle$, $\langle p_y(t)\rangle$, the variances $\sigma_y^2(t)$, $\sigma_{p_y}^2(t)$ and the covariance $\sigma_{yp_y}(t)$, the equations of motion of which are derived from (2.1). These equations are coupled to the classical equations of motion of the collective variables r, ℓ, ℓ_1, ℓ_2 (resp. the relative distance and angular momentum, the angular momenta of the ions) [4].

3. Applications to S on Ge.

The reaction ^{32}S on ^{74}Ge at E_{lab}=170 MeV was studied in the case μ=0 [4]. It was shown that the system drifts towards symmetric fragmentation for ℓ in the vicinity of ℓ_{orb}, the upper limit of classical orbiting. Fig. 1 shows the evolution of $\langle y(t)\rangle$ as a function of time. The regime is clearly quasi-oscillatory. For the somewhat small value $\mu=10^4$, the system can cross $\langle y\rangle$=0 corresponding to symmetric fragmentation. For $\mu=7.10^4$ this

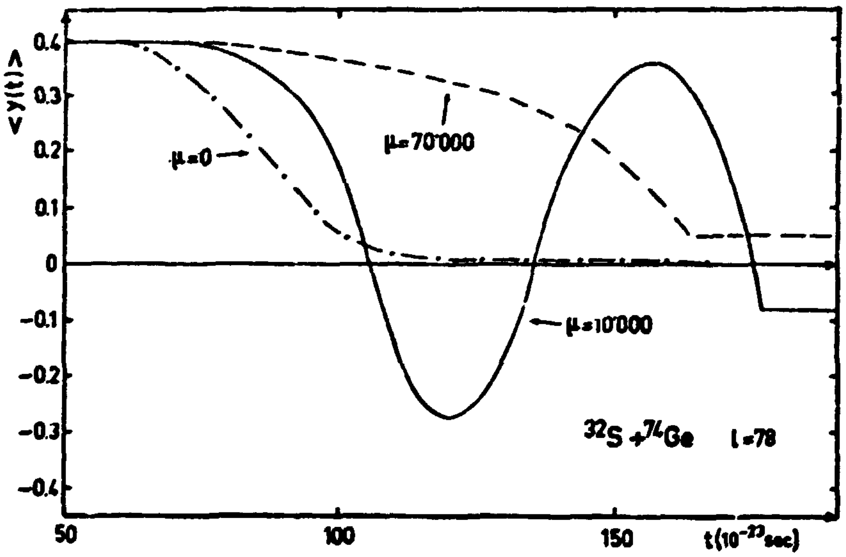

Fig. 1

happens only for ℓ values quite close to ℓ_{orb}, hence if the interaction time is long enough. In the case μ=0 the mass transfer is much quicker. The variances σ_y^2 and $\sigma_{p_y}^2$ as well as the thermal excitation energy E_ℓ^* for fixed ℓ exhibit an overall increase with time with some oscillations present over a certain range of time. The oscillations are more pronounced for $\mu=10^4$ than for $\mu=7.10^4$.

The classical deflection function as a function of ℓ shows the interesting feature that the increase of μ leads to a reduction of the orbiting window. Fig. 2 represents the differential cross section [4] cor-

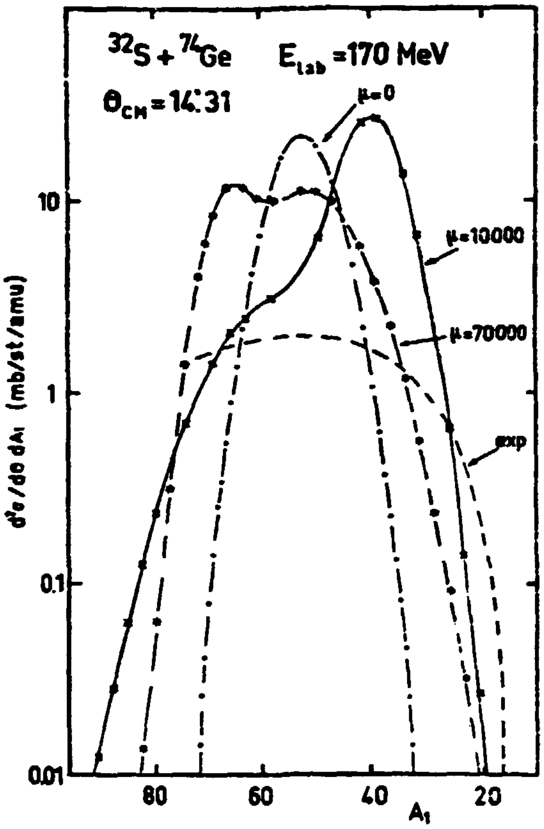

Fig. 2

responding to $\mu=0$ [4]), 10^4 and 7.10^4 and fixed θ_{CM}. It widens with increasing μ and gets closer to the experiment [5]) showing some tendency towards asymmetry with respect to $A_1=A/2=53$.

4. Discussion and conclusion

The analysis shows that inertia effects can sensibly affect the centroid and the widths of mass distributions. For realistic values of the mass ($\approx 7.10^4$ MeV bsec^2) the comparison with the experiment indicates an improvement over the case $\mu=0$. The appearance of a possible asymmetry in the cross sections with respect to $A_1=A/2$ is a striking feature which is absent in the overdamped regime. It seems however difficult up to now to confront this feature with the experiment[5]).

Several points remain to be improved and investigated. The mass μ should depend on the relative distance, the mass asymmetry, the temperature, to quote the most evident variables. Further, the validity of the Gaussian approximation to the distribution function should be checked by exact integration of (2.1). These points are under investigation.

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