EFFECT OF LOCAL EQUILIBRATION IN DISSIPATIVE HEAVY-ION COLLISION

H.L.YADAV and W.NÖRENBERG
GSI, Darmstadt, W. Germany.

The main objective of this communication is to point out and emphasize the influence of the local equilibration process on the observable quantities in the collision of two heavy ions. No attempt has been made to provide a best fit to the experimental data. The calculations have been performed within the framework of the Fokker-Planck equation. The collective variables of the reaction are the relative position r and momentum p, the angle θ and angular momentum ℓ, the mass asymmetry α, and the deformation ε related to the neck size. The Fokker-Planck equation for the probability distribution function $f(r,p,\theta,\ell,\alpha,\varepsilon,t)$ is written as

$$\begin{aligned}\partial f/\partial t = & - p/\mu\, \partial f/\partial r + \partial U_{dyn}/\partial r\, \partial f/\partial p - \partial(v_p f)/\partial p + \partial^2(D_{pp} f)/\partial p^2 \\ & - \ell/J_{rel}\, \partial f/\partial\theta - \partial(v_\ell f)/\partial \ell + \partial^2(D_{\ell\ell} f)/\partial \ell^2 \\ & - \partial(v_\alpha f)/\partial\alpha + \partial^2(D_{\alpha\alpha} f)/\partial\alpha^2 \\ & - \partial(v_\varepsilon f)/\partial\varepsilon + \partial^2(D_{\varepsilon\varepsilon} f)/\partial\varepsilon^2\end{aligned} \tag{1}$$

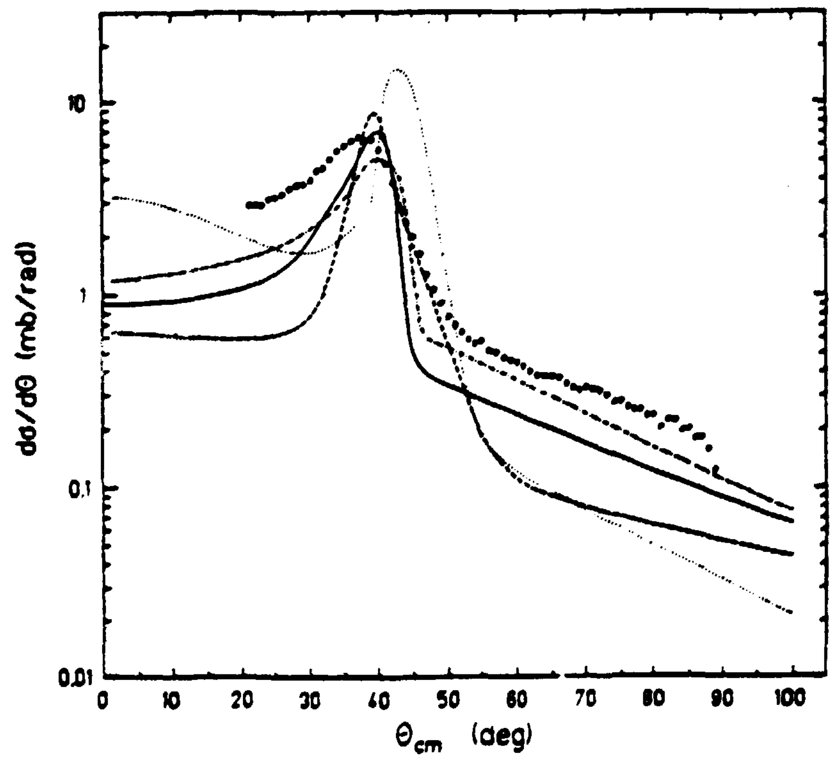
where μ and J_{rel} denote ,respectively, the reduced mass and the relative moment of inertia. The transport coefficients v_i and D_{ij} are obtained from the microscopic expressions of refs.[3,4]) with a strength factor f(r). The form factor f(r) is given by the square root of the density overlap normalized at the contact radius. The effect of local equilibration is treated[2]) through a time dependent dynamical potential

$$\begin{aligned} U_{dyn} = & U_{ad}\,[1-\chi(t)] + U_{diab}(r)\,\chi(t) = U_{ad} + (\Delta U)^{*}_{diab}\;\chi(t) \\ & \chi(t) = \exp[-(1/\tau_{loc})\int_{t_0}^{t} f(r(t'))\,dt'\,] \end{aligned} \tag{2}$$

where the decay factor $\chi(t)$ describes a smooth transition to equilibrium within the time interval τ_{loc}. The quantities r(t) and t_0 denote, respectively, the trajectory and a time well before the collision. The additional repulsive potential $(\Delta U)^{0}_{diab}$ is that of ref[2]). The adiabatic potential U_{ad} is described in terms of the three shape parameters r, α, and ε, and is adapted[5]) from the model of Möller and Nix[6]). In order to account for a consistent treatment of the diabaticity at the initial stage of the collision, the transport coefficients are multiplied by the factor $[1-\chi(t)]$. The diffusion coefficient for the mass assymetry $D_{\alpha\alpha}$, however, is not modified to allow for the fact that the diabaticity does not inhibit the exchange of particles due to the residual interaction.

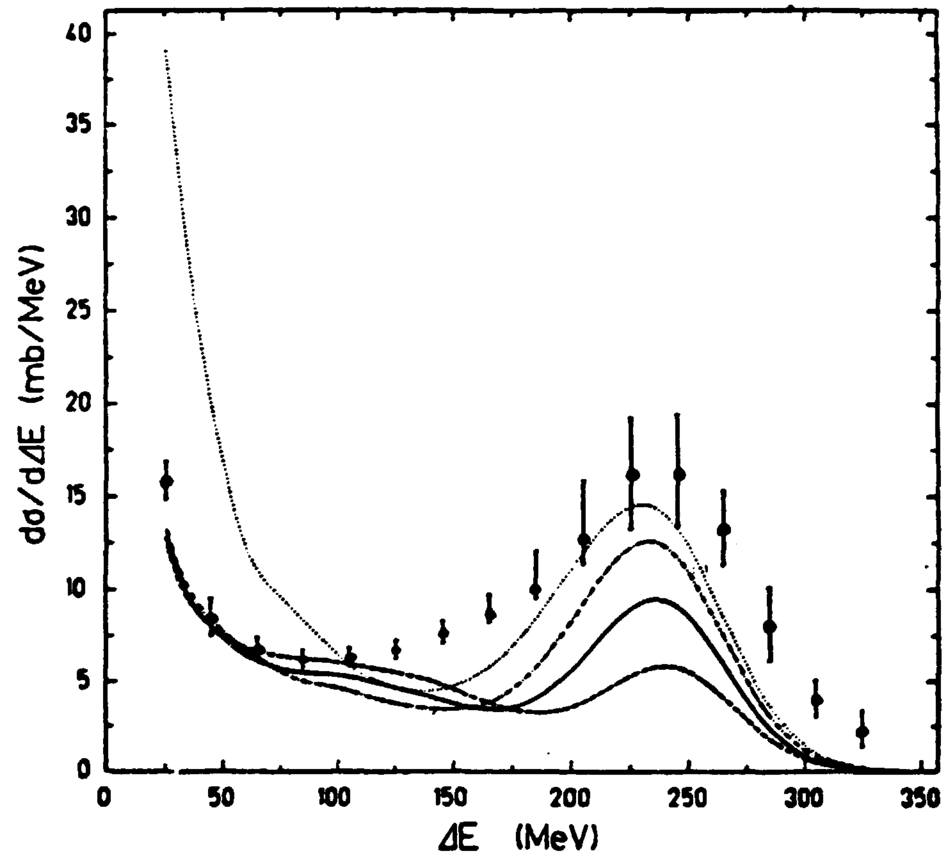
For the numerical treatment of the Fokker-Planck equation we use the moment expansion up to second order. For small impact parameters, however, it is found that the method of moment expansion breaks down. Such a difficulty in employing the moment expansion has recently been confirmed by Nix[7]). A critical limit for the validity of the moment expansion can be expressed through the variance for the distance between the surfaces of the two nuclei, $\sigma^2_{ss} < 1$ fm². After a trajectory attains $\sigma^2_{ss} > 0.3$ fm² we, therefore, perform the calculations within an approximation[8]) justified for creeping motions. This approximation, however, does not provide any information regarding the distribution in the s variable. In figs. 1 and 2 we show, as representative examples, the results for the

Fig. 1



angular and energy distributions for the reaction ^{86}Kr(8.18 MeV/u) + ^{166}Er calculated with different values of the local equilibration time ($\tau_{loc} \cdot 10^{22}$ = 0.001(....), 5(-.-.-.), 10(----), and 20(- - - -); experimental data[3,9]) are shown by thick dots). It is evident that the results show a remarkable dependence on the size of τ_{loc}. This conclusion holds good for other cross sections as well.

Fig. 2



1) W. Nörenberg, Phys. Lett. 104B (1981) 107
2) W. Nörenberg and C. Riedel, Z. Phys. A290 (1979) 335
3) A. Gobbi and W. Nörenberg, in "Heavy-Ion Collisions", ed. by R. Bock, Vol.2 (North-Holland, Amsterdam, 1980); and references therein
4) S. Ayik, G. Wolschin and W. Nörenberg, Z. Phys. A286 (1978) 271
5) H. L. Yadav, C. Riedel and W. Nörenberg, in preparation
6) P. Möller and J. R. Nix, Nucl. Phys. A281 (1977) 354
7) J. R. Nix, private communication
8) D. Agassi, C. M. Ko and H. A. Weidenmüller, Phys. Rev. C18 (1978) 223
9) A. Gobbi, private communication