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ANGULAR MOMENTUM DEPENDENCE OF THE FRAGMENT KINETIC ENERGIES IN DEEPLY INELASTIC COLLISIONS

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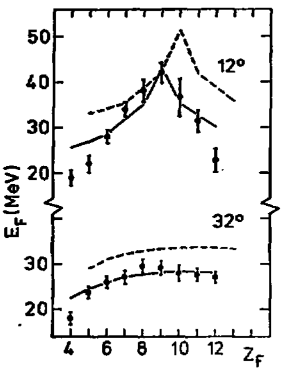
In a deeply inelastic reaction the colliding nuclei are assumed to form a dinuclear system whose final configuration is a pair of sticking rotating fragments [1-6]. Taking into account the frictional force, the kinetic energy (KE) of the rotating system at scission is given

$$E_F = V_{Coul}(d) + V_{nucl}(d) + f^2 \frac{L_i (L_i + 1) \hbar^2}{2\mu d^2} , \qquad (1)$$

where μ is the reduced mass in the exit channel, d the effective scission radius, and the dominant exit channel angular momentum is related to the entrance channel angular momentum L_i through the ratio $f = L_f/I$. In previous works on lighter heavy-ion systems [1-4] the rotational energy has been deduced from the measured fragment KE by assuming a fixed l chosen to be the wave just greater than those going to fusion [1,4] or the one midway between fusion and grazing [2,3]. Equally consistent methods of analyzing the KE have however led to quite different values for the scission radius [4]. Eq (1) can in effect be satisfied either by a solution with d much larger than the nuclear radii so that the nuclear potential is practically negligible, or a solution with d comparable to the nuclear radii where the attractive nuclear potential compensates for the increase of the Coulomb and rotational parts.

The angular behaviour of the experimental fragment KE obtained in the present work for the deeply inelastic collisions of 151 MeV ^{20}Ne with ^{27}Al, ^{40}Ca and ^{59}Co is consistent with a contribution from two physical components: a partially damped component around the grazing angle with a clear dependence on the mass transfer, and a fully relaxed component with a saturated KE, at angles much larger than the grazing. The present approach, described previously [6], assumes that L_i depends on the initial impact parameter and then on the degree of overlap between the interacting nuclei in the initial stage of the reaction [5]. The partially damped component is associated with the solution of Eq. (1) with large d (i.e. small nuclear overlap) and L_i dependent on the mass transfer. The fully damped component is associated with the solution with small d, comparable to the critical and nuclear radii, and with L_i just larger than the fusion critical angular momentum (i.e. large nuclear overlap).



The total fragment kinetic energies for $^{20}Ne + ^{27}Al$ are plotted vs. the detected fragment charge for 12° and 32° lab., the grazing angle deduced from the elastic scattering angular distribution being about 9° lab. The system at scission was described by two uniform spheres of radii R_3, R_4 joined by a neck. The distance between the mass centers of the two fragments is then given by

$$d = R_3 + R_4 + \delta \qquad (2)$$

where R_i is taken to be $R_i = 1.2\, A_i^{1/3}$ fm and the neck length δ is used as a free parameter in the KE calculations using Eq (1). The dashed curves were calculated for the primary fragments before evaporation. The solid curves take into account a kinematical correction assuming an evaporation of $\Delta Z = 1$, $\Delta A = 2$ by each primary fragment in the exit channel. The calculations were made with $\delta = 3.7$ fm for 12° and $\delta = -0.1$ fm for 32°. For 12° it was assumed that $L_i = \alpha L_{cr} + (1 - \alpha)\, L_{gr}$ where α accounts for the degree of nuclear overlap and depends explicitly on the nucleon transfer 5,6). The critical angular momentum L_{cr} was deduced from the complete fusion cross section and the grazing L_{gr} from the grazing angle. The nuclear potential was taken to be the proximity potential 7) whose radius was modified in order to fit the fusion data at lower energies 6). For 32°, L_i was kept fixed to $L_i = L_{cr}+1$. Similar results were also obtained for the $^{20}Ne + ^{40}Ca$ system 6) and $^{20}Ne + ^{59}Co$.

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