CLASSICAL CALCULATION OF THE CROSS SECTION FOR DEEP INELASTIC COLLISIONS OF DEFORMED NUCLEI AND APPLICATION TO $^{238}U+^{238}U$*

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For the calculation of the cross section for the deep inelastic collision between deformed nuclei, we assume that the time evolution of the collective coordinates (first moments) can be described with classical equations of motion including friction forces. The model describes the relative motion with the relative coordinate, the rotation of the nuclei with Euler angles, defining the orientation of the principal axes of the nuclei, and the intrinsic vibrations of the nuclear shapes with the β- and γ-coordinates (see Fig.1).

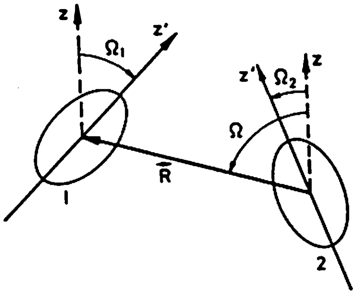

Fig.1
The collective coordinates defining the orientation of the nuclear principal axes.

The nuclear and Coulomb parts of the interaction potential are calculated with a double folding model, developed for ellipsoidal deformed nuclei[1]. The potential includes also an intrinsic energy for the β- and γ-oscillations of the separated nuclei. The stiffness and mass parameters for the vibrations and rotation of the nuclei have been taken from the rotation-vibration model.

The frictional forces are calculated within the model of Tsang[2], modified for the collision of deformed nuclei. The friction forces and their moments are obtained as double folding integrals over the nuclear densities $\rho_1(\vec{r}_1)$ and $\rho_2(\vec{r}_2)$ multiplied by the relative velocity $\vec{v}_{rel}(\vec{r}_1,\vec{r}_2)$ between the volume elements $d\tau_1$ and $d\tau_2$, e.g.

$$\vec{F}_{12} = -k\int \rho_1(\vec{r}_1)\rho_2(\vec{r}_2)\vec{v}_{rel}(\vec{r}_1,\vec{r}_2)\exp(-|\vec{r}_1-\vec{r}_2+\vec{R}|^2/r_0^2)\,d\tau_1 d\tau_2 \qquad (1)$$

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With the model we study the deep inelastic collision of ^{238}U on ^{238}U at an energy E_{lab}=7.42 MeV/amu. For this energy there are experimental reaction data of Freiesleben et al.[3] available. For comparison we calculate the classical double differential cross section for a final total kinetic energy (TKE) E and scattering angle θ with the formula

$$\frac{d^2\sigma}{dEd\theta}(E,\theta) = 2\pi\int \dot{P}(E,\theta,b)bdb, \qquad (2)$$

where the distribution function $\dot{P}$ is obtained by averaging over the initial orientations of the nuclei for a fixed impact parameter b.

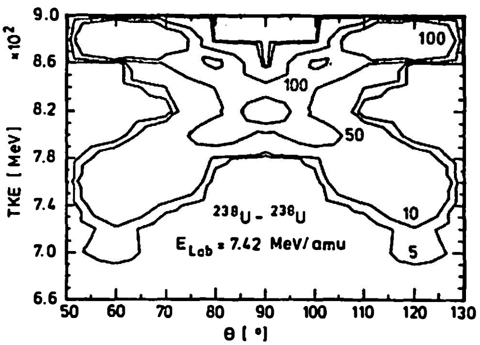

Fig.2
Double differential cross section of $^{238}U+^{238}U$ inelastic scattering at E_{lab}=7.42 MeV/amu. For the details see text.

Figure 2 shows the contour plot of the double differential cross section for a fixed orientation of the target nucleus with its intrinsic symmetry axis directed towards the beam axis. The cross section will be reduced, if one averages over all orientations of the target nucleus.

In conclusion, the distribution of the TKE versus scattering angle in the considered $^{238}U+^{238}U$ collision can be explained as due to the rotation and deformation degrees of freedom described by classical equations of motion with deformation dependent conservative and dissipative forces.

1. M. Münchow, D. Hahn and W. Scheid, Nucl.Phys. A388 (1982)381
2. C. Tsang, Physica Scripta 10A (1974) 90
3. H. Freiesleben et al., Z.Physik A292 (1979) 171