DISTRIBUTION OF THE FRAGMENT SPIN IN HEAVY-ION COLLISIONS

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Abstract: The angular-momentum distributions of both fragments in deeply inelastic collisions are calculated in a nonequilibrium statistical model. The distribution functions are obtained analytically on the basis of a transport equation. Fragment angular-momentum distributions are computed as functions of energy loss and compared to data.

We present a nonequilibrium-statistical approach to calculate the intrinsic angular momenta $\vec{I}_K (K = 1,2)$ of both fragments generated in a deeply inelastic heavy-ion collision. The correlation of the corresponding distributions is properly included in the treatment. The distribution function $P(\vec{I}_1,\vec{I}_2;t)$ obeys a transport equation of the Fokker-Planck type

$$\frac{\partial P}{\partial t} = -\sum_{i,k} \frac{\partial}{\partial I_i^{(k)}} \left(v_i^{(k)} P \right) + \sum_{i,j,k} \frac{\partial^2}{\partial I_i^{(k)} \partial I_j^{(k)}} \left(D_{ij}^{(k)} P \right). \qquad (1)$$

The simplifications of the angular momentum diffusion tenor D that are necessary to allow for an analytical solution via moment expansion as well as other details of the model are described in [1,2].
We derive coupled differential equations for the mean values $\langle \vec{I}_K \rangle$, variances $\sigma_K^2 = \langle I_K^2 \rangle - \langle \vec{I}_K \rangle^2$ and covariance $\sigma_{12}^2 = \langle \vec{I}_1 \vec{I}_2 \rangle - \langle \vec{I}_1 \rangle \langle \vec{I}_2 \rangle$. Under the model assumptions of [1,2], they define Gaussian solutions. The analytical solution of the differential equations are obtained via Laplace transformation. The correlations in the angular-momentum distributions of the two fragments as imposed by angular-momentum conservation enter the model through the centrifugal part of the driving potential

$$U_\ell = \frac{I_1^2}{2\mathcal{J}_1} + \frac{I_2^2}{2\mathcal{J}_2} + \frac{(\vec{\ell}-\vec{I}_1-\vec{I}_2)^2}{2\mathcal{J}_{rel}} \qquad (2)$$

and thus, through the drift coefficients v_K.

The analytical results for mean values, variances and covariances of the fragment spins are derived in [2] together with the distribution functions $P(\vec{I}_1,\vec{I}_2;t)$ and $P(|\vec{I}_1|, |\vec{I}_2|;t)$. In conjunction with a phenomenological model for the treatment of the relative motion we calculate these distributions for various reactions as a function of the total kinetic energy loss. Results for 8.5 MeV/u $^{208}Pb + ^{238}U$ are shown in Fig. 1, a comparison with data from γ-multiplicity experiments [3] on ^{86}Kr + ^{154}Sm concerning the sum of the absolute values of the fragment spin is shown in Fig.2. Experiments to test the complete distribution function are not yet available.

Refernces:

1) J.Q. Li, X.T. Tang and G. Wolschin, Phys. Lett. 10B (1981) 107

2) J.Q. Li and G. Wolschin, preprint MPI-HD (1981) submitted to Z. Physik A

3) P.R. Christensen et al., preprint (1981)

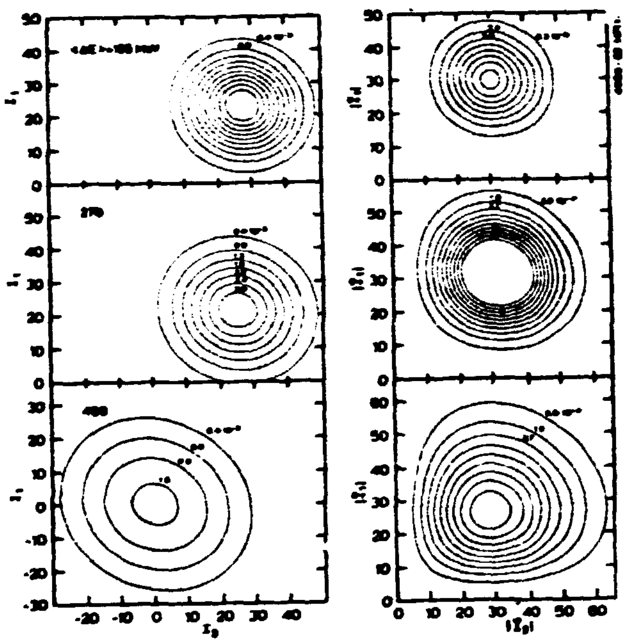

Fig. 1: Calculated distribution functions $P(I_1, I_2; \langle\Delta E\rangle)$ and $P(|\vec{I}_1|, |\vec{I}_2|; \langle\Delta E\rangle)$ for 8.5 MeV/u ^{208}Pb + ^{238}U.

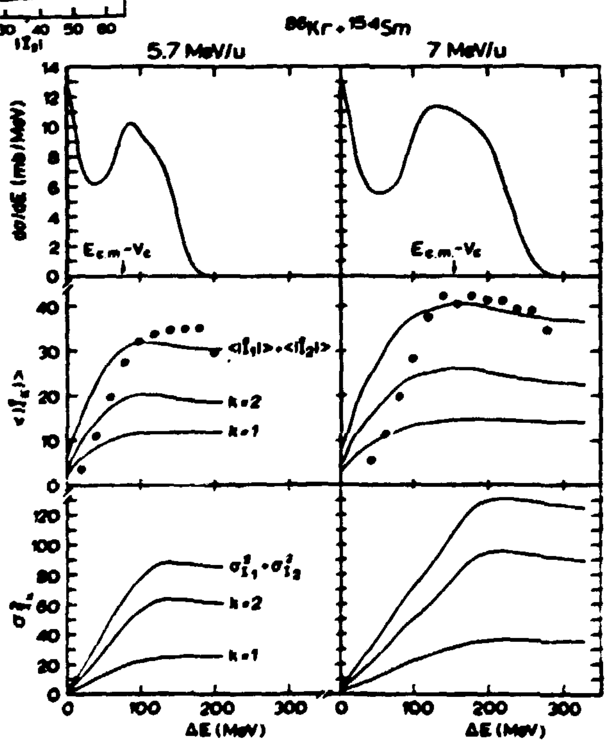

Fig. 2: Calculated energy spectra, mean values and variances of $P(|\vec{I}_1|, |\vec{I}_2|; \Delta E)$ for ^{86}Kr + ^{154}Sm. Data are from Ref.[3].