Energy-loss distributions of fission fragments

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(Submitted December 29, 1975)
Pis'ma Zh. Eksp. Teor. Fiz. **23**, No. 5, 295–298 (5 March 1976)

The *f*-*f* coincidence method was used to investigate the change in the form of the energy-loss distributions of Cf^{252} fission fragments in air, down to fragment energies ~ 0.8 MeV. A theoretical model is considered for the estimate of the mean-squared deviations of the fragment energy-loss distributions.

PACS numbers: 29.70.Gn

The available experimental data on the form of the energy distribution of decelerated fission fragments were up to recently qualitative in character[1,2] and the results of the measurements of the straggling of the spontaneous-fission fragments of Cf^{252}, slowed down to ~15 MeV in various absorbers, were published only recently.[3]

We have investigated the change of the form of the energy distribution of the spontaneous Cf^{252} fission fragments slowed down in air to energies ~0.8 MeV. To suppress the α background at low energies, we used the method of f—f coincidences, which made it possible to obtain fission fragments energy-loss distributions undistorted by the α emission of Cf^{252}. To register the fragments we used semiconductor surface-barrier silicon detectors satisfying Schmitt's parameters.[4]

The experimentally obtained fission-fragment distributions were approximated by a sum of two Gaussion curves. The mean-square deviations of the energy distributions, obtained as a result of such an approximation, differed insignificantly from the corresponding values obtained directly from the amplitude distributions.

The mean-squared deviations of the Gaussian curves approximating the amplitude distributions were reconverted into energy units with the aid of a linear calibration[5] in the energy region above 25 MeV, and with the aid of a quadratic calibration[6] at energies below 25 MeV. The mean values and mean-

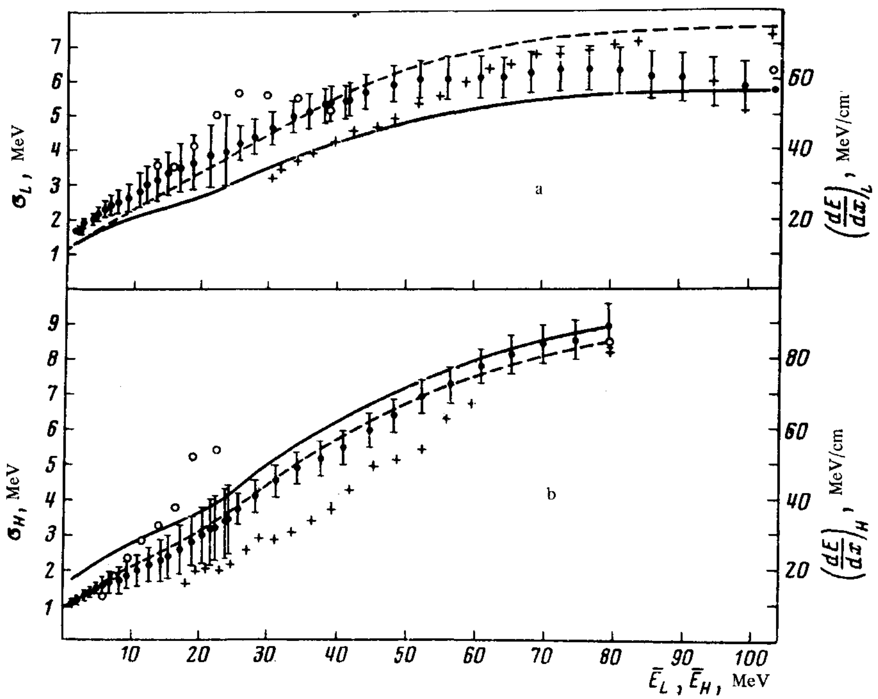

FIG. Mean-squared deviation of the energy distributions of spontaneous-fission fragments of Cf^{252} slowed down in air: a—group of light fragments, b—group of heavy fragments; ●—present work, the measurement errors are represented by the appropriate bars, ○—from[2], +—.[3] The data of[2,3] were recalculated in terms of the half-width of the distribution at the height $1/\epsilon$.

squared deviations of the mass distributions of the fragments of the spontaneous fission of Cf^{252}, used in the calibration equations, were taken from[5]. The calculations have shown that the results obtained with the aid of the calibration equation of Kaufman *et al.*[7] differ little from the results obtained with the aid of the calibration equations of[5,6].

Our experimental mean-squared deviations σ_L and σ_H of the energy distributions of the light and heavy groups of the decelerated fragments, respectively, of the spontaneous fission of Cf^{252} are shown in the figure as functions of the average energies of these distributions, together with the experimental data of[2,3]. The dashed lines of the same figure show the values of the total stopping powers of the air for the average light and the average heavy fragment of the fission fragments of Cf^{252}, obtained by us in[8]. As seen from the figure, the behavior of the experimental values of the mean-squared deviations of the energy distributions is analogous to the behavior of the stopping powers, a fact noted earlier only for α particles.[9] In[9], using α particles as an example, it is also shown that the approach proposed by Fschalar[10] for finding the mean squared deviations of the energy distributions of slowed-down light ions results in satisfactory agreement with the experimental data. An attempt can be made, however, to estimate the value of σ also in the case of fission fragments, by assuming that each peak of the energy distribution represents the energy distribution of ions with one fixed mass, equal to the average mass of the chosen group of fragments. Using further the results of[9,10] and also recognizing that the contribution of the inelastic collisions to the fluctuation of the energy losses in the case of heavy ions of the fission-fragment type is negligibly small, it is possible to obtain for σ the following expression:

$$k_E\sigma(\bar{E}) = \sigma(\bar{\epsilon}) = [\sigma^2(\bar{\epsilon}_0)\, s_1^{-2}(\bar{\epsilon}_0) + \int_{\bar{\epsilon}}^{\bar{\epsilon}_0} s_2(\epsilon) s_1^{-3}(\epsilon)\, d\epsilon]^{1/2} s_1(\bar{\epsilon}), \tag{1}$$

where, following[11,12], $s_1(\epsilon) = d\epsilon/d\rho$, $s_2(\epsilon) = (1/\epsilon^2)\int_0^{\epsilon} x^2 f(x)\,dx$, $f(x)$ is the screening force function, k_E is the coefficient for the conversion from the values of the energy $\bar{E}$ to the dimensionless Lindhard parameter $\bar{\epsilon}$, and $\bar{\epsilon}_0$ the energy of the fragments that have not been slowed down, in dimensionless units. The results of the calculation of σ_L and σ_H with the aid of expression (1) and the values of the total stopping abilities from[8] are shown in the figure by solid lines. As seen from this figure, the expression (1) can be used to estimate σ of the slowed-down fission fragments, even though it does not take into account the distributions of the fragments with respect to the masses, and to the nuclear charge, the dependence of the kinetic energy of the fragments on their masses, and also the fluctuations of the ion charge of the fragments during the course of their deceleration.

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