vacancies in the inner shells. Lifting of this excitation by means of auto-ionization transitions can occur both after the separation of the atomic particles, when the "individuality" of each atom is sufficiently clearly pronounced, and at the instant of collision, when the system of colliding particles can be characterized by the properties of the quasimolecule. Processes of the former type play a major role in the formation of the structure in the energy spectrum of the electrons, whereas those of the latter type apparently have a much broader energy distribution and can make an appreciable contribution to the formation of the continuous part of the spectrum. It can be assumed that the first two lines of the characteristic losses (R_I^* and R_{II}^* [1]) are connected with auto-ionization transitions occurring when the M shell and the $L_{2,3}$ subshell of Ar are respectively excited. However, an exact identification of the lines of inelastic losses on the basis of data on the electron spectra is difficult, since experiments performed with the aid of the coincidence method are used to investigate processes that occur at a fixed value of the impact parameter, whereas the processes participating in the electron production take place at all values of the impact parameter.

A detailed investigation of the auto-ionization states of Ar and an identification of the lines of the energy spectra of the electrons will be carried out in our subsequent studies.

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ANGULAR ANISOTROPY OF FISSION OF Pu^{238} BY NEUTRONS

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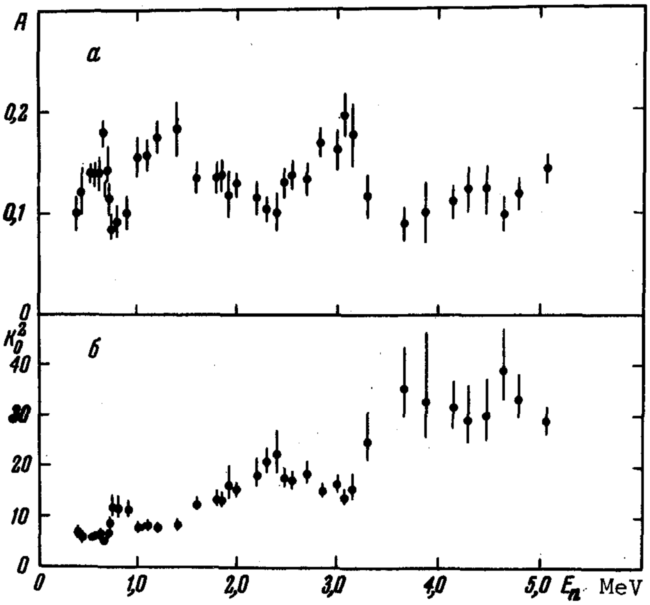
The angular anisotropy of the scattering of nuclear-fission fragments is the consequence of the inhomogeneity of the distributions of the projections K of the angular momentum I on the symmetry axis (the scission direction). The distribution f(K) is formed by the spectrum of the accessible fission channels - the quantum levels of the fissioning nucleus in the intermediate state. According to the Bohr model [1] it is expected that f(K) depends strongly on the excitation energy in the near-threshold region of the excitation, where a small number of channels participate in the fission and the variation of the cross section is determined primarily by the barrier penetrability. This region is characterized by appreciable changes in the form of the angular distribution of the fragments $W(\theta)$, the value of the coefficient of angular anisotropy $A = W(0°)/W(90°) - 1$, and other characteristics of the fission process - the so called-channel effects. They become quite clearly pronounced in the neutron fission of the "light" nuclei Th^{230}, Th^{232}, and U^{234}, but attenuate quite rapidly when the number of the nucleons in the fissioning nucleus increases: the quantity A decreases and the form of $W(\theta)$ becomes stable [2].



Dependence of the angular-anisotropy coefficient A (a) and of the parameter K_0^2 of the statistical theory (b) on the neutron energy.

The vanishing of the channel effects, a surprising fact from the point of view of traditional concept, has induced us to undertake a detailed investigation of W(θ) for heavy nuclei from uranium to americium, concerning which only fragmentary information was available at the start of the measurements (approximately 2 years ago). We report here the experimental data on the angular distribution of the fragments in neutron fission of Pu^{238}.

The measurements of W(θ) were made with the aid of a "track" procedure. We used cylindrical glass detectors. The main difficulty of the experiment was the smallness of the measured effect ($A \sim 0.1$). A statistical accuracy ∿ 1 - 2% was assured for each of the ten angle intervals into which the measured distribution of the number of fragment tracks was broken up. The results of the measurements, agree from the very threshold ∿ 0.5 MeV, within the limits of these errors in the entire investigated neutron energy range with the simple relation

$$W(\theta)/W(90^\circ) = 1 + A\cos^2\theta, \quad (1)$$

which follows from the statistical theory of the angular anisotropy of fission [3]. The criterion of the agreement between experimental data and the hypothesis (1), P_{χ^2}, exceeds 0.05 throughout. The dependence of the coefficient of angular anisotropy A on the neutron energy E_n, the values of which were obtained by least squares, is shown in Fig. a. There is satisfactory agreement, in general outline, with the only published data on Pu^{238}(n, f) [4], measured in the range $E_n < 1.5$ MeV. The results of our measurements of W(θ), however, do not confirm the existence of a maximum at $\theta \approx 30°$ when $1.0 < E_n < 1.5$ MeV, as observed in [4].

The agreement between the experimental data on W(θ) and the statistical distribution was noted also in the (n, f) reaction on U^{238}, Am^{241}, and Pu^{240}, and apparently occurs also in fission of other heavy nuclei [5]. It shows that the fission of the heavy nuclei near threshold, and even in the sub-barrier region (U^{239} [5]) occurs as if the reaction were to have sufficiently large number of fission channels. This situation is not compatible with the notions concerning the barrier in the liquid-drop model, but can be given a rather natural qualitative interpretation by taking into account, following Strutinskii [6], the shell effects that lead to the occurrence of two maxima in the potential energy of the deformation, and assuming that the second maximum is lower than the first. In this case the threshold observed in the cross section is determined by the height of the first (larger) barrier, and f(K) is determined by the energy E* of excitation at the second barrier. At an appropriate difference between barriers, the value of E* near the observed threshold may turn out to be sufficient to realize the statistical distribution f(K) (see [5, 6] for details).

The scanty data available so far has produced the impression that in addition to the decrease of A in the case of heavy nuclei, the rate of change of this quantity also decreases with increasing energy. The data obtained in the present study show that this is not the case. Figure b shows a plot of the parameter K_0^2 against E_n, calculated from the data on A in accordance with the quasiclassical formula

$$A = \frac{(2{,}10\sqrt{E_n} + 1)^2}{8K_0^2}.$$

It has essentially an irregular "steplike" character, similar to that observed in the fission of even-even nuclei in the (d, pf) reaction [7]. Preliminary results of our measurements for the reactions U^{238}(n, f) and Np^{237}(n, f) also confirm this regularity. It apparently offers evidence that the density of the internal excitations of the nuclei at low energies increases nonmonotonically and that this effect is inherent in nuclei with different parity of the number of nucleons. To explain the irregular variation K_0^2 at low excitations, Strutinskii's [8] notions concerning a discrete variation of the number of excited quasiparticles are highly promising. For more definite opinions concerning the nature of this phenomenon, further research is necessary.

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