ANGULAR ANISOTROPY OF FISSION OF NUCLEI LIGHTER THAN GOLD BY 40-MeV α PARTICLES

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A study of the angular anisotropy of fission induced by charged particles [1 - 3] has yielded unique information concerning the shape of fissioning nuclei near the saddle point, and led to a reduction of the fundamental parameter of the liquid-drop model $(Z^2/A)_{crit}$ from 50 to 43 - 47 [4]. The analysis of the experimental data on the angular anisotropy of fission is based on the statistical theory [5], which establishes the connection between the form of the fragment angular distribution W(θ) and the so-called effective moment of inertia $J_{eff} = (J_{\parallel}^{-1} - J_{\perp}^{-1})^{-1}$:

$$\frac{W(\theta)}{W(90^\circ)} = \sin^{-3}\theta \frac{\phi(p\sin^2\theta)}{\phi(p)}; \quad \phi(x) = \int_0^x t^{1/2} e^{-t} I_0(t)\,dt, \quad t = \left(\frac{l\sin\theta}{2K_0}\right)^2; \tag{1}$$

$$p = \frac{\overline{l^2}}{2K_0^2} = \frac{\hbar\overline{l^2}}{2J_{eff}T}, \tag{2}$$

where $J_{\parallel}$ and $J_{\perp}$ are the moments of inertia relative to the fission axis and the perpendicular direction, respectively, l is the angular momentum, and T is the temperature of the nucleus at the saddle point.

Figure 1 shows the dependence of the reciprocal of the effective moment of inertia J_{sph}/J_{eff}, expressed in units of the moment of the equivalent sphere, on Z^2/A of the fissioning nucleus at $(Z^2/A)_{crit} = 45$. The curve was obtained by Strutinskii [4] within the framework of the liquid-drop model, with allowance for the diffuse edge of the nucleus. The light symbols are the experimental data [1 - 3] and confirm the steep drop of J_{eff}^{-1} above the maximum of the curve, which follows from this theory, and also show that $(Z^2/A)_{crit}$ is apparently even somewhat lower than 45. The points for the lowest Z^2/A, which were obtained in investigations of the angular anisotropy of the (α, f) reaction

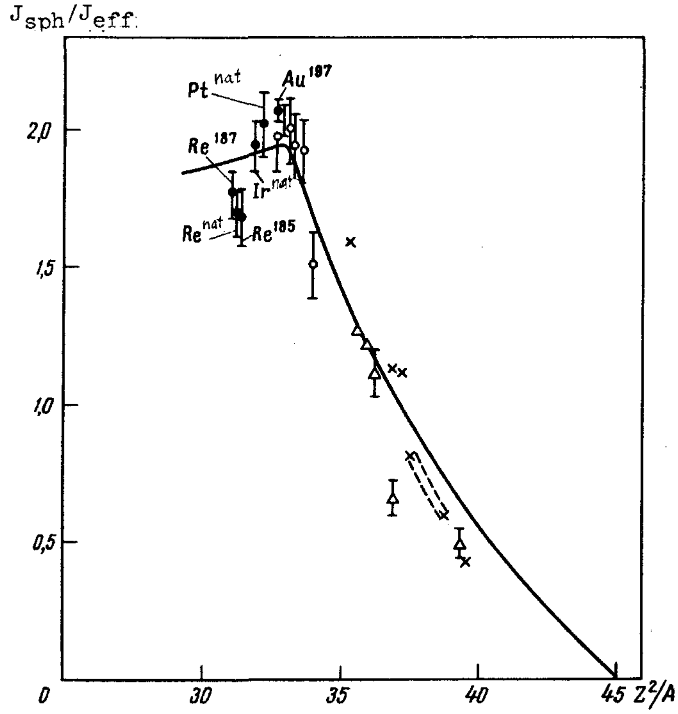

Fig. 1. Plot of J_{sph}/J_{eff} vs. Z^2/A of the fissioning nucleus (see the text). Solid curve - calculation for liquid-drop model [4], experimental data: O - [1,2], × - [2] (the dashed lines show a region of close values for 11 nuclei between Pu^{242} and Cf Cf^{248}), Δ - [3], ● - present work.

on Au, Tl, Pb, and Bi target nuclei [1, 2] do not make it possible, unfortunately, to determine the position of maximum of $J_{eff}^{-1}(Z^2/A)$. Observation of this maximum is very important both from the point of view of a more complete idea of the agreement between the liquid-drop calculation and experiment and in connection with the determination of $(Z^2/A)_{crit}$. The position of the maximum of J_{eff}^{-1}, which is by way of a rather sharp kink, gives no less an accurate estimate of $(Z^2/A)_{crit}$ than extrapolation of J_{eff}^{-1} to zero. The latter is in general problematic in view of new ideas concerning a barrier with two maxima [6], which make the position of the saddle point not fully defined in the case of heavy nuclei.

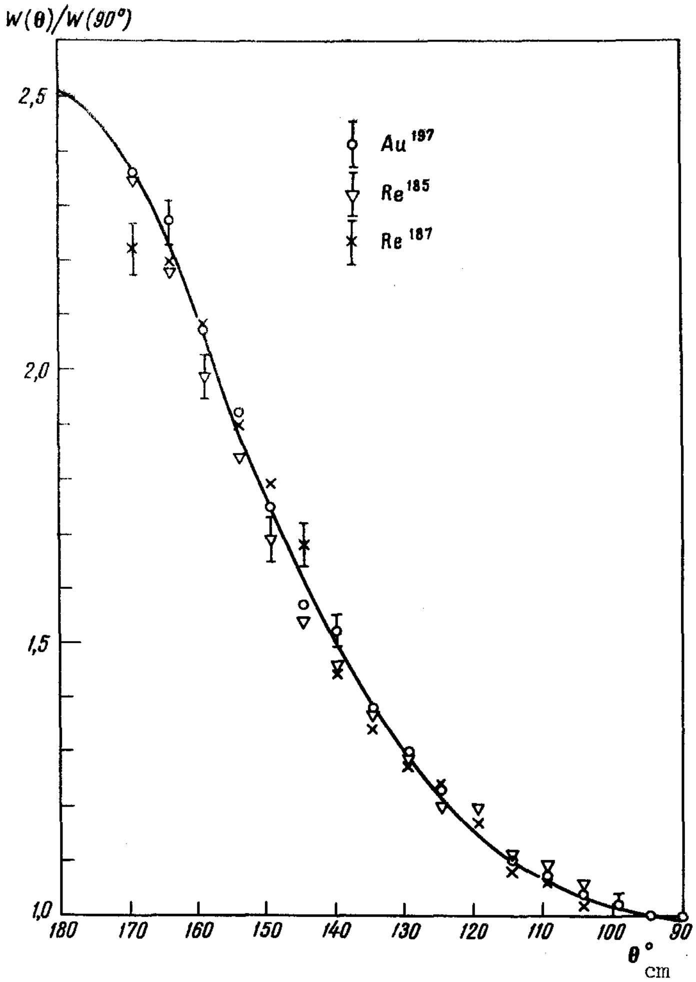

Fig. 2. Angular distribution W(θ) of the fragments of fission of Re^{185}, Re^{187}, and Au^{197} by α particles. The solid curve represents the data for $Au^{197}(\alpha, f)$ in accordance with (1)

In the present study we investigated the angular distributions of the fragments produced by fissioning separated Re^{185} and Re^{187} isotopes, isotopically pure Au^{197} nuclei, and a natural mixture of Re, Ir, and Pt isotopes by 40-MeV α particles.

The experiment was performed with the extracted beam of the 1.5-m cyclotron of the Institute of Nuclear Physics of the Kazakh Academy of Sciences. A "track" procedure was used to register the fission acts. The detectors were cylindrical bent glasses [7] placed in the rear hemisphere relative to the α-particle beam. The targets, which were placed at an angle 45° to the beam axis, were layers 1 - 2 mg/cm^2 thick on a copper substrate about 20 mg/cm^2 thick, and also thick samples in the form of foils approximately 50 - 100 μ thick. In the former case the registration efficiency was practically independent of the angle, and the latter it varied cosinusoidally [7]. It was verified that results obtained with both types of target are in satisfactory agreement. The maximum scatter of θ, due to the detector dimensions and the beam width, did not exceed 3.5°

The results of measurements of W(θ) in the c.m.s., for the fission of Re^{185}, Re^{187}, and Au^{197}, are shown in Fig. 2. A comparison of the experimental values of W(θ) with relation (1), shown in Fig. 2 with Au^{197} as an example, makes it possible to determine the parameter p. The values of J_{eff}^{-1} determined from (2) are shown by the dark circles in Fig. 1. The calculations were based on the systematics of the fission thresholds [8], the α-particle binding energies from [9], and the relation for the level-density parameter a = A/8, which was also used to calculate other values of J_{eff}^{-1} shown in Fig. 1. The errors shown in Fig. 1 for J_{eff}^{-1} include only those incurred in the determination of p. The deviations of the points for Re from the calculated values may be due to a deviation of the parameter a from the employed smooth dependence [6].

The data obtained in the present investigation on the effective moment of inertia also confirm the presence of a maximum in accordance with the consequences of the liquid-drop model [4]. Its position agrees with a value $(Z^2/A)_{crit} = 45 \pm 1$.

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PASSIVE Q-SWITCHING IN SOLID-STATE LASERS, BASED ON STIMULATED MANDEL'SHTAM-BRILLOUIN SCATTERING OF LIGHT

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The generation of single pulses of coherent laser emission with an instantaneous power exceeding 1 MW, based on Q-switching, presupposes the maximum speed of transition (< 20 nsec) from the initial high-loss conditions in the system to low-loss conditions at the instant of time for which the pump ensures maximum gain in the active element.

The phenomenon of stimulated Mandel'shtam-Brillouin scattering (SMBS) is characterized by a number of parameters which permit its use for passive Q-switching of a laser resonator:

1. The electrostriction pressure waves - acoustic phonons - which are produced and amplified effectively by the field of the light waves, satisfy the condition $\bar{q} = \bar{k}_{exc} - \bar{k}_{sc}$, where $\bar{q}$, $\bar{k}_{exc}$, and $\bar{k}_{sc}$ are respectively the wave vectors of the phonon and of the exciting and scattered photons [1].

2. SMBS is a process having a sharp threshold dependence.

3. The magnitude of the Stokes shift for the components of the scattered light is determined by the velocity of the hypersound in the medium, and amounts to approximately 0.2 cm^{-1} for most liquid media in the optical band [1], i.e., the corresponding component lies within the limits of the amplification-line half-width of solid-state lasers even in the case of multiple scattering.