introduce a correction for Na^{24} produced from silicon in the "forward-backward" experiments. In making the comparison with the control experiments, all the variable factors were taken into account: a) proton stream, b) chemical yields, c) weight of the beryllium sheets, d) time of irradiation and time between the end of the irradiation and the beginning of the counting, e) isotopic composition. After the introducing of these corrections, it was found that in the rear beryllium sheet (with respect to the direction of the proton beam) the entire activity was due to the admixture of silicon, and in the front sheet the activity produced by the reaction on silicon Si^{28} (p, 4pn) N^{24} constituted only 20% of the total Na^{24} activity. Hence the major part of all Na^{24} nuclei produced from uranium is emitted in the forward direction.

2. An investigation of the angular distribution from 0 to 180° in angular intervals of 30° was carried out for Na^{24} and Sr^{91} nuclei emitted from a gold thread 300 μ in diameter (see reference 1 for the experimental arrangement). The angular distribution obtained for S^{91} was isotropic within the limits of error. The small anisotropy in the angular distribution of fission fragments observed by other authors[2,3] was not observed in the present work.

In view of the difficulty in making a correction for the admixture of silicon in the experiments on the angular distribution, the results for Na^{24} cannot be considered conclusive; nevertheless, there was an appreciable sharp asymmetry in the forward direction. After introducing the correction for the admixture of silicon, we observed that the activity of Na^{24} due to nuclei emitted from the gold thread are distributed in the angular intervals 0 — 30°, 30 — 60° as follows: If the activity of Na^{24} in the interval 0 — 30° is taken as unity, then the Na^{24} activity in the interval 30 — 60° is 0.4. The major part of the Na^{24} activity in the angular intervals 60 — 90°, 90 — 120°, 120 — 150°, 150 — 180° is apparently due only to the admixture of silicon.

Comparison of the data obtained for the angular distribution of Na^{24} nuclei and the fission fragments Sr^{91}, Br^{76}, I^{131}, and $I^{130+133}$ indicates that the greater part of the Na^{24} nuclei are apparently not produced in the fission process, which is contrary to the previous assumptions.[4] The Na^{24} nuclei apparently cannot be produced in an evaporation process, since in this case their angular distribution should be close to isotropic.

At present, the investigation of the angular distribution is being continued. Materials not containing admixtures of heavy elements are being used as absorbing foils, which will make it possible to obtain more accurate data.

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SCATTERING AND RADIATIVE CAPTURE OF Λ PARTICLES

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IN the interaction of low energy Λ particles with even-even nuclei, the spin, noncentral, and spin-orbit forces do not come into play. This permits us to estimate the magnitude of the scattering cross section for slow Λ particles in a simple fashion, provided that we know the parameters of the central spin-independent part of the Λ-N interaction, which is weaker and has smaller range than the N-N forces.[1,2] Regarding the range of the Λ-N forces as small in comparison with the radius of the nucleus and neglecting the deformation of the core,[2] we can write the potential of the interaction of the Λ particle with the nucleus in the form

$$V(r) = \int \rho(r_1) V_{\Lambda N}(r_{12})\, dv_1 \approx \rho(r) C_{\Lambda N}(1 + R_2^2/R^2(r)),$$

$$R_2^2 = C_{\Lambda N}^{-1} \int V_{\Lambda N}(r_{12})\, r_{12}^2 dv_{12},$$

$$R^2 = \rho^{-1}(r)\left\{\frac{1}{2}\frac{d^2\rho(r)}{dr^2} + \frac{2}{3r^2}\frac{d\rho(r)}{dr}\right\},$$

$$\mathbf{r}_1 = \mathbf{r} + \mathbf{r}_{12}, \qquad C_{\Lambda N} = \int V_{\Lambda N}(r_{12})\, dv_{12}, \tag{1}$$

where $\rho(r)$ is the nucleon density in the nucleus, $V_{\Lambda N}$ is the potential of the Λ-N interaction, r is the distance of the Λ particle from the center of the nucleus, while $C_{\Lambda N}$ characterizes the strength and R_2 the range of the Λ-N interaction.

The de Broglie wavelength of Λ particles with energies of the order of a few Mev is considerably greater than the range of the potential well (1). Therefore, only S wave scattering is important, and we can use the approximation which is independent of the form of the potential between the Λ particle and the nucleus. In this approximation the phase shift δ is related to the scattering length a and the range of interaction r_0 by the well known equation[3,4]

$$k \cot \delta = -1/a + r_0 k^2/2, \tag{2}$$

where $k = \sqrt{2ME}/\hbar$, and M is the reduced mass; the cross section is

$$\sigma(k^2) = 4\pi / [k^2 + (r_0 k^2/2 - 1/a)^2]. \tag{3}$$

Since the numerical values of the parameter R_2 are not yet known exactly, we restrict ourselves in the numerical calculations to the case where the range of the Λ-N forces is zero. In this case we have for the nucleus He_2^4

$$B_\Lambda \approx 2.9\,\text{Mev}, \qquad C_{\Lambda N} \approx 180\,\text{Mev. f}^3$$

Furthermore, according to the electron scattering experiments,[6]

$$\rho(r) = \rho_0 \exp(-r^2/b^2),$$

where the parameter b, which also incorporates the proton radius, is equal to 1.14 f. The numerical solution gives in this case a = 2.57 f, r_0 = 1.04 f. The scattering cross section at zero energy is σ(0) = 0.8 b.

We should like to emphasize that it is possible, in principle, to determine the parameters $C_{\Lambda N}$ and R_2 more exactly from the experimental cross sections for the scattering of Λ particles by nuclei. Up to the present time, however, only very preliminary results on the scattering of Λ particles with energies of 75 to 150 Mev in hydrogen[7] have been published (see also reference 8).

Besides the elastic scattering, the radiative capture of Λ particles may play an important role in the region of small energies. If we restrict ourselves to Λ particles of extremely low energy, we may assume that the capture leads only from an S state of the continuous spectrum to an S state of the hypernucleus. The parities of the initial and final states are identical, so that this capture process may be accompanied by the emission of a magnetic dipole γ quantum. The cross section for capture with emission of magnetic dipole radiation with frequency ω is given by the formula[3]

$$\sigma_{\Lambda\gamma} = \frac{16\pi}{9}\left(\frac{\omega}{c}\right)^3 \frac{M}{\hbar^2 k} \sum_m |\mathfrak{M}'_{1m}|^2, \tag{4}$$

where

$$\mathfrak{M}'_{1m} = \frac{e\hbar}{2M_p c}\,\frac{M_p}{M_\Lambda}\sqrt{\frac{3}{4\pi}}\,\mu_\Lambda \sum \int (\varphi_b^* \sigma \varphi_a) \nabla\, r_{(m)}\, d\tau$$

$$r_{(0)} = z, \qquad r_{(\pm 1)} = (x \pm iy)/\sqrt{2}, \tag{5}$$

μ_Λ is the magnetic moment of the Λ particle in nuclear magnetons, and M_p and M_Λ are the mass of the proton and of the Λ particle, respectively; φ_b and φ_a are the wave functions of the final (b) and initial (a) states; $\hbar\omega = E_a - E_b$; the summation goes over the spins of the final state. Assuming zero range of the interaction between the Λ particle and the nucleus, we can write φ_a and φ_b in the form

$$\varphi_a = \chi_a \sin(kr + \delta)/kr, \qquad \varphi_b = \sqrt{2\beta/4\pi}\, e^{-\beta r}\chi_b, \tag{6}$$

where $\beta = \sqrt{2MB_\Lambda}/\hbar$, and χ_a and χ_b are the spinor functions of the initial and final states. From (4) — (6) follows

$$\sigma_{\Lambda\gamma} = \pi\alpha \left(\frac{\hbar}{M_p c}\right)^4 \left(\frac{M_p}{M}\right)^2 \mu_\Lambda^2 \,\frac{k^2+\beta^2}{k}\,\frac{(\beta a - 1)^2 \beta}{a^2 k^2 + 1}, \tag{7}$$

where $\alpha = e^2/\hbar c$. In the region of extremely small energies the ratio of $\sigma_{\Lambda\gamma}$ and the corresponding cross section for the radiative capture of neutrons by protons is

$$\frac{\sigma_{\Lambda\gamma}}{\sigma_{n\gamma}} \sim \left(\frac{M_\Lambda}{M_n - M_p}\right)^2 \cdot 10^{-2}$$

and $\sigma_{\Lambda\gamma}$ is of the order of 10^{-7} b at energies of ~ 20 Mev. Despite the fact that the capture cross section of Λ particles can reach large values in the region of very low energies, there will be practically no capture of Λ particles because of their short lifetime. (The ratio of the capture and decay probabilities for Λ particles is ~ 10^{-7} to 10^{-9}.) However, it could well be that radiative capture is to be observed for heavier nuclei.

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COMPARISON OF THE PROBABILITIES OF THE TRIPLE FISSION OF U^{233}, U^{235}, *AND* Pu^{239}

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RECENTLY there has been a considerable increase in the interest in nuclear fission accompanied by the emission of long-range α particles. A study of this phenomenon yields more information on the fission mechanism, since the emission of the α particle is connected with the initial stage of the process and characterizes the state of the nucleus during the instant of fission.

One of the most important characteristics of nuclear fission with emission of long-range particles is the probability of the given process relative to the fission into two fragments. The determination of the probability of triple fission of U^{235} induced by slow neutrons has been the subject of many investigations,[1-9] but U^{233} and Pu^{239} have not been sufficiently investigated in this respect. Thus, data on the relative probabilities of triple fission of Pu^{239} and U^{235}, determined by Farewell et al.[4] and Allen and Dewan,[6] do not agree with each other — whereas it follows from reference 4 that the probability of triple fission of Pu^{235} is half that of U^{235}, reference 6 yields a probability that is 1.14 times greater. It is therefore interesting to obtain more exact values for the relative probabilities of triple fission of U^{233}, U^{235}, and Pu^{239}, induced by slow neutrons.

We used for this purpose a setup intended for the investigation of the energy distribution of triple-fission fragments.[10] The triple fissions were identified by the coincidences of the pulses from the fragment chamber and from the α-particle chamber. The fraction of registered triple fissions depended on the solid angle of the α chamber relative to the target of the fissioning substances, on the argon pressure in the chamber, and on the degree of pulse discrimination in the α channel. Under the condition of the present experiment, a calculation of this fraction is subject to great errors, and therefore the determination of the absolute probabilities of triple fission does not seem advisable. The apparatus used can measure, with great accuracy, the ratios of probabilities of triple fission of different nuclei. The geometry of the chamber and the chosen argon pressure resulted in maximum pulses from the α particles with the most probable energies. It is known that the energy spectra of long-range α particles, emitted upon fission of the investigated nuclei, are nearly equal.[6] The measurement conditions in experiments with different nuclei remained unchanged. Consequently, the sought ratio of probabilities of triple fission of nuclei 1 and 2 is

$$\eta_1 / \eta_2 = (N_{tr} / N_d)_1 / (N_{tr} / N_d)_2,$$

where N_{tr} is the number of triple fissions and N_d is the number of double fissions registered per unit time.

The targets were irradiated with slow neutrons in the experimental reactor of the U.S.S.R. Academy of Sciences. The measurement results are listed in the table, and the background of random coincidences, which amounted to 3% of N_{tr}, was taken into account. The statistical errors are indicated.

Nucleus	N_{tr}, pulse/min	N_d, pulse/min
U^{233}	7.45±0.15	28600±140
U^{235}	8.86±0.18	41600±200
Pu^{239}	18.53±0.37	74000±400

The resultant data were used to determine the ratios of triple-fission probabilities:

$$\eta(U^{233}) / \eta(U^{235}) = 1.22 \pm 0.06,$$

$$\eta(Pu^{239}) / \eta(U^{235}) = 1.18 \pm 0.06.$$

According to the results of Allen and Dewan,[6] these values are 1.25 ± 0.22 and 1.14 ± 0.23 respectively.

Thus, the probability ratios obtained in the present work agree with those calculated from the data of Allen and Dewan. The use of the