a Faraday cup) than is possible on the bremsstrahlung beam.

We hope that our proposed method of the determination of the excitation functions of (γ, n) reactions in the region of relatively high energies will eliminate such large errors.

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217

DETERMINATION OF THE MOMENTUM AND EXCITATION ENERGY ACQUIRED BY A HEAVY NUCLEUS IN THE INTERACTION WITH A FAST NUCLEON

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ACCORDING to the model proposed by Serber,[1] particles with energy ~ 100 Mev and higher interact with the individual nucleons of the nucleus. As a result of the cascade of nucleon-nucleon collisions, the nucleus that remains after the emission of a few fast nucleons acquires a momentum and an excitation energy which, on the average, amount to a fraction of the momentum and the energy of the incident particle. Steiner and Jungerman[2] measured the component of the momentum of the nucleus along the direction of incidence of the proton for the interaction of uranium nuclei with protons of energy 190 and 340 Mev. The value found is $\sim 1/3$ of the momentum of the incident proton. The calculations of Porile and Sugarman[3] lead to the conclusion that, in the interaction of bismuth with protons of energy 468 Mev, the nucleus acquires a perpendicular momentum component which is of the same order of magnitude as the parallel component.

We determined experimentally the mean value of the parallel as well as the perpendicular component of the momentum of the nucleus for the interaction of 660-Mev protons with uranium nuclei. The photo-emulsion technique was used. We have assumed, in first approximation, that the angular distribution of the fission fragments is isotropic in the system of the fissioning nucleus. The parallel component of the nuclear momentum $P_{\parallel} = Mv_{\parallel}$ was determined from the expression $N_f/N_b = (1 + \eta_{\parallel})/(1 - \eta_{\parallel})$, where N_f, N_b are the numbers of fragments in the forward and backward hemispheres, respectively, $\eta_{\parallel} = v_{\parallel}/V$ is the ratio of the mean transfer velocity of the nucleus to the mean velocity of the fission fragments, and M is the mass of the nucleus after the emission of the cascade nucleons. Corrections were made for the failure of the apparatus to register fissions with an angle of inclination of $\leq 15°$ to the vertical. The perpendicular component of the momentum of the nucleus was determined from the angle between the tracks of the fragments which make an angle of $\leq 5°$ with the plane of the plate. The plate was exposed to a proton beam perpendicular to its surface:

$$P_{\perp} = Mv_{\perp}, \ \eta_{\perp} = \frac{v_{\perp}}{V} = \frac{\pi}{2} \tan \frac{\gamma_{\perp}}{2} \approx \frac{\pi\gamma_{\perp}}{4},$$

where $\gamma_{\perp}$ is the mean value of the complement to the angle between the fragments. Both equalities presuppose $M_h = M_l$. The effect of the scattering of the fission fragments from the nuclei of the emulsion is much smaller than the effect we are looking for. It was assumed

	$P_{\parallel}$ (Mev/c)	$P_{\perp}$ (Mev/c)	$P_{\perp}/P_{\parallel}$
Experiment	340	430	1.26
Computation	280	380	1.35

that nucleon evaporation occurs until fission sets in, and that the former is isotropic. In the discussion we exclude fissions accompanied by the emission of particles with $Z \geq 2$, since the momentum of these particles is larger than or equal to the momentum we want to measure, and thus "smears out" the picture. The values found are: $\eta_{\parallel} = 0.039 \pm 0.010$ and $\eta_{\perp} = 0.049 \pm 0.007$. In the table we list the values of the components of the momentum of the nucleus and their ratio, calculated from the experimental values for $\eta_{\parallel}$ and $\eta_{\perp}$, where we assume $V = 0.04c$. We also list the corresponding values computed from the data of Ivanova and P'ianov[4] on the angular and energy distributions of the cascade nucleons. These data were obtained in the calculation of the cascade for uranium at the proton energy of 660 Mev with the Monte Carlo method. In the calculation the creation of mesons was neglected.

The table shows qualitative agreement between the computed and experimental values. It should be kept in mind that the experimental values refer only to fission experiments.

From the experimental value for the parallel component of the momentum of the nucleus we can determine the excitation energy of the nucleus under the assumption, as in references 5 and 6, that the momenta of the cascade nucleons are transferred by way of one fast cascade particle in the direction of the incident proton beam. With our data, this gives $\overline{E}_f = 240$ Mev for uranium with $\overline{E}_p = 660$ Mev. This surpasses the value ~ 160 Mev of reference 6. Under the assumption that two fast cascade nucleons are emitted in the direction of the proton beam and perpendicular to it the measured values for the parallel and perpendicular components of the nucleus momentum yield for the excitation energy the value $\overline{E}_f =$ 145 Mev. It is seen that the presence of the perpendicular momentum component leads to a significantly lower value for E_f. It is obvious, however, that the second variant represents an extreme approximation just as the first variant does. It must also be pointed out that the perpendicular component of the momentum of the nucleus should be considered in the investigation of the angular distributions. The irregularity in the angular distribution of the fission fragments of bismuth in the 60 to 90° region in the laboratory system, found by Wolke and Gutman,[7] may possibly be explained by this fact, as these authors also noted.

In conclusion the author expresses his gratitude to Prof. N. A. Perfilov for a number of critical remarks, and to N. S. Ivanova and I. I. P'ianov for making available the computational data on the angular and energy distributions of the cascade nucleons of uranium.

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218

ON THE MULTIPLE INTERACTION IN QUANTUM FIELD THEORY

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THE problem of constructing the nucleon potential with the inclusion of multiple interactions by summing over the corresponding terms in the perturbation expansion was considered in reference 1 in the framework of pair mesodynamics.

In the present paper, an expression for the effective potential for the multiple interaction of two particles is found in closed form. The discussion is based on the usual methods of Feynman and Dyson under the assumption $||E| - m| \ll m$. In the expansion for the energy of the free particle (e.g., the electron)

$$|E_n| = m + p_n^2/2m + \ldots \tag{1}$$

(here, as in the following, $\hbar = c = 1$) we can therefore restrict ourselves to the first term $|E_n| \approx m$. It is easily seen[1] that in this case the Green's function for the electron has the form

$$\begin{aligned} S^F(2,1) &\approx \frac{1+\beta}{2}\delta(r_1 - r_2)\, e^{-im(t_2-t_1)}, \quad t_2 > t_1 \\ S^F(2,1) &\approx \frac{1-\beta}{2}\delta(r_1 - r_2)\, e^{im(t_2-t_1)}, \quad t_2 < t_1. \end{aligned} \tag{2}$$

We note that the approximation (2) does not imply a transition to a theory with fixed sources $(m \to \infty)$, since the Green's function S^F would then depend only on the time.

Using (2) and carrying out all calculations in the coordinate representation, we obtain for the case of a process of order $2n$, where the inter-