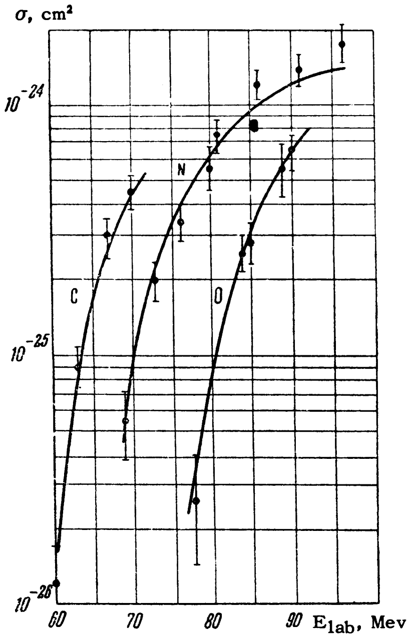
The comparison of the cross sections (6) with the experimental data of Druin and Polikanov[4] on the fission cross sections of bismuth bombarded by the ions of carbon, nitrogen, and oxygen, which practically coincide with the corresponding cross sections for the formation of a compound nucleus, leads to good agreement (see the figure) for the following choices of the parameter R:

$$C^{12},\ R = 1.17\cdot 10^{-12}\ \text{cm};$$
$$N^{14},\ R = 1.24\cdot 10^{-12}\ \text{cm};$$
$$O^{16},\ R = 1.27\cdot 10^{-12}\ \text{cm}.$$



Thomas[5] and Piliya[6] also considered the cross section for compound nucleus formation caused by heavy ions. Thomas calculated the cross sections numerically for several ions and target nuclei, using formula (3) with a definite choice of the nuclear potential parameters R and U, which makes it difficult to use his results in the case of arbitrary nuclei (see also footnote‡). The results of Piliya are quite different from those quoted above, since he made use of an incorrect asymptotic expansion.

In conclusion I express my gratitude to G. N. Flerov for his interest in this work and also to G. N. Vyalov and S. M. Polikanov for fruitful remarks.

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*The whole discussion is in the center-of-mass system of the colliding nuclei.

†Condition (1) differs from $|d\lambda\!\!\!^{-}(R)/dR| \ll 1$ by a coefficient ~ 1 which was introduced to be used in connection with condition (4).

‡The condition of complete absorption at the nuclear boundary in the quantum mechanical description (only incoming waves in the region $r < R$) is different from the analogous condition in the classical model. The use of the quantum description for all angular momenta would lead to a smaller cross section which does not go over into the classical result for $\hbar \to 0$ ($\rho \to \infty$).

**In the same way we can obtain expressions for the average moment of inertia of the nucleus.

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*PHOTOPRODUCTION OF POSITIVE PIONS IN HYDROGEN NEAR THRESHOLD**

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EXPERIMENTS on photoproduction of pions from nucleons near threshold play an essential role in testing the meson theory based on dispersion relations. In particular, there is great interest in the behavior of the square of the matrix element for the photoproduction of positive pions near threshold, since according to the theory the direct interaction of the photon with the meson current leads to an increase in the square of the matrix element as the photon energy decreases. Besides this, a comparison of the π^+ photoproduction cross section for hydrogen near threshold with the π^- photoproduction cross section for neutrons[1,2] allows us to match the experimental data with the predictions of meson theory about the quantity σ^-/σ^+ near threshold. Our work is devoted to clarifying these questions.

The differential cross section for positive pion photoproduction was measured for the proton energy intervals 152.9 — 158.3 and 158.3 — 161 Mev. It was convenient to measure the energy in a given region by the CH_2—C subtraction method. The Coulomb fields present in the nucleus strongly decrease the possibility of the formation of low-energy positive pions from carbon.† In addition, such a method gives the possibility of using thin targets, which allow the detection of low-energy mesons and free us from the necessity of introducing corrections for energy loss and the scattering of mesons in the target.

The mesons formed in the polyethylene and carbon targets (by the action of a gamma ray beam from the synchrotron of the Joint Institute for Nuclear Research with a maximum energy of 263 Mev) were detected by photographic plates. The plates were subjected to a double scanning. In this, the effectiveness of discovering mesons was 90%, on an average. Those π-μ decays found in the emulsions were chosen whose muon tracks ended in the emulsion.

The experimental geometry was such that mesons with energies from 0.5 to 6 Mev at angles of 60° and 120° to the proton beam in the laboratory system were detected in the plates.

To find the cross sections in the center-of-mass system, all the events were broken down by energy and angular intervals. The cross section was taken as the weighted average of all the values obtained.

The values of the cross sections $d\sigma^+/d\Omega$ for 120° and the square of the matrix element $(d\sigma^+/d\Omega)\,\pi/w$ are given below, where w is the ordinary kinematic factor

$$w = \eta\omega / (1 + \omega / M)(1 + \nu / M);$$

η, ω, and ν are respectively the momentum, total meson energy, and photon energy in the center-of-mass system, and M is the proton mass. Here we give the values of the square of the matrix element, calculated according to the formula

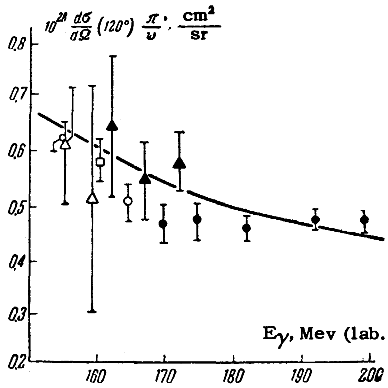
$$\frac{d\sigma^+}{d\Omega}\frac{\pi}{w} = \frac{2e^2f^2}{\mu^2\nu\omega}\left[1 - \frac{\eta^2}{2\nu^2}\frac{\sin^2\theta}{(1-\eta\cos\theta)^2} - \frac{g_n + g_p}{M}\left(1 - \frac{\eta^2}{2}\right)\right].$$

The coupling constant f^2 is taken as 0.08.

Photon energy E_γ, Mev (lab.)		155.6	159.6
$10^{30}\frac{d\sigma^+}{d\Omega}$, $\frac{cm^2}{sr}$ (c.m.)		3.4±0.6	4.2±1.7
$10^{28}\frac{d\sigma^+}{d\Omega}\frac{\pi}{w}$, $\frac{cm^2}{sr}$ (c.m.)	experiment	0.6±0.1	0.5±0.2
	theory	0.621	0.577

It should be noted that the value of the π^+ photoproduction cross section for hydrogen at E_γ = 160 Mev given in the recently published work of Barbaro et al.[3] agrees well with our data.

The figure‡ comparing the theoretical dependence of the square of the matrix element on the photon energy with experimental data from various authors, shows that the increase in the squared matrix element actually takes place up to threshold, and confirms the correctness of taking into account the direct interaction of the photon with the meson beam in the extrapolation to threshold.



The dependence of the square of the matrix element of pion photoproduction on the energy of the photons. The curve was calculated from dispersion theory. △ – data from our work, □ – data from reference 3, ● – from reference 4, ○ – from reference 5, ▲ – data of Adamovich, Larionova, and Kharlamov (private communication).

The value of the ratio σ^-/σ^+, calculated on the basis of our data and of data on the photoproduction of pions in the same energy interval[1,2] is $\sigma^-/\sigma^+ = 1.3 \pm 0.3$, which agrees well with the predictions of meson theory.

The authors express thanks to Academician V. I. Veksler for directing the work and to M. I. Adamovich for his interest in the work and his participation in examining the results.

*The results in the present letter were given in the summary report of Bernardini at the Kiev conference on high energy physics, July, 1959.

†It is interesting to note that the cross section for positive pion photoproduction from one proton of carbon is ~ 0.1 of the cross section for hydrogen.

‡The figure is taken from the report of Bernardini at the conference on high energy physics at Kiev, 1959.

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