[9] D. M. Kuehn and D. J. Monson, Appl. Phys. Lett. 16, 48 (1970).
[10] A. P. Dronov, E. M. Kudryavtsev, N. N. Sobolev, and A. S. D'yakov, ZhETF Pis. Red. 11, 516 (1970) [JETP Lett. 11, 353 (1970)].
[11] V. K. Konyukhov, I. V. Matrosov, A. M. Prokhorov, D. T. Shalunov, and N. N. Shirokov, ibid. 12, 461 (1970) [12, 321 (1970)].
[12] G. V. Gembarzhevskii, N. A. Generalov, G. I. Kozlov, and D. I. Roitenburg, Zh. Eksp. Teor. Fiz. 62, 844 (1972) [Sov. Phys.-JETP 35, 447 (1972)].
[13] R. McLeary, IEEE J. QE 8, 716 (1972).

DETERMINATION OF TOTAL ηN INTERACTION CROSS SECTION IN η-MESON PHOTOPRODUCTION FROM COMPLEX NUCLEI

G. N. Dudkin, V. N. Eponeshnikov, Yu. F. Krechetov, and V. A. Tryasuchev
Nuclear Physics, Electronics, and Automation Institute at the Tomsk Polytechnic Institute
Submitted 16 July 1973
ZhETF Pis. Red. 18, No. 4, 263 - 266 (20 August 1973)

The incoherent process $\gamma + A_i \to \eta + A_f$ from C, Cu, Ag, and Pb was investigated at a maximum bremsstrahlung beam energy $E_{\gamma max} = 900$ MeV and at a c.m.s. η-meson emission angle $\theta^*_\eta = 90°$. The η mesons were detected by registering the two γ quanta from the $\eta \to 2\gamma$ decay. The total ηN-interaction cross section was determined by using the dependence of the η-meson yield from the nuclei on the mass number A and by using the optical model; it was found to be $\sigma^{tot}_{\eta N} = (66 \pm ^{29}_{20})$ mb.

We investigated the incoherent process

$$\gamma + A_i \to \eta + A_f, \quad (1)$$

where A_i and A_f are the initial and final nucleus, respectively. The measurements were made on the nuclei C, Cu, Ag, and Pb at a maximum bremstrahlung γ-quantum beam energy $E_{\gamma max} = 900$ MeV and at an η-meson emission angle $\theta^*_\eta = 90°$ in the c.m.s. Under such kinematic conditions the contribution of the coherent η-meson production to the measured process (1) is negligibly small because of the large momentum transferred to the nucleus.

The η mesons were detected by their decay into two γ quanta with two total-absorption Cerenkov spectrometers [1]. The recoil nucleons were not detected. To separate process (1) with the subsequent $\eta \to 2\gamma$ decay from the background reaction, we used measurement procedure "outside the kinematics" [2]. The Monte Carlo method was used to calculate the registration efficiency and the angular and energy resolutions of the apparatus. Figure 1 shows the energy spectrum of the η mesons in comparison with the spectrum calculated by the Monte Carlo method.

In the quasifree approximation, the differential cross section for photoproduction of an η meson from a nucleus with mass number A can be expressed in the form [3]

$$d\sigma(A)/d\Omega_\eta = A(d\sigma/d\Omega_\eta)[1 - G(p)]\, f_A(\sigma^{tot}_{\eta N}). \quad (2)$$

Here $d\sigma/d\Omega_\eta$ is the differential cross section for photoproduction from a free nucleon, averaged over the momentum distribution of the nucleons in the nucleus, G(p) is the inelastic nuclear form factor, and $f_A(\sigma^{tot}_{\eta N})$ is a factor that takes into account the interaction between the η meson and the nucleons of the nucleus. According to the optical model, we can write for a uniform density distribution of the nucleons in the nucleus

$$f_A(\sigma^{tot}_{\eta N}) = (1/V)\int e^{-\ell(x)\rho\sigma^{tot}_{\eta N}k}\, d^3x, \quad (3)$$

where $\ell(x)$ is the length of the classical trajectory, V is the nuclear volume, $\sigma^{tot}_{\eta N}$ is

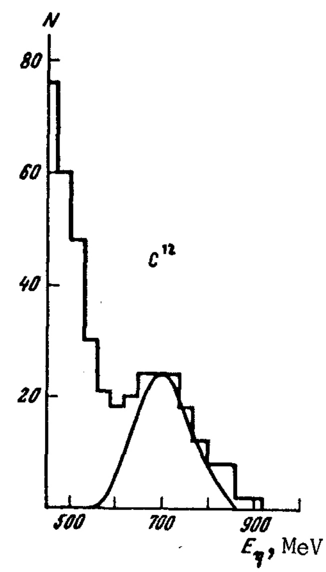

Fig. 1. Histogram - experimental spectrum obtained with C^{12}. Solid curve - η-meson energy distribution calculated by the Monte Carlo method with allowance for the energy resolution of the spectrometers.

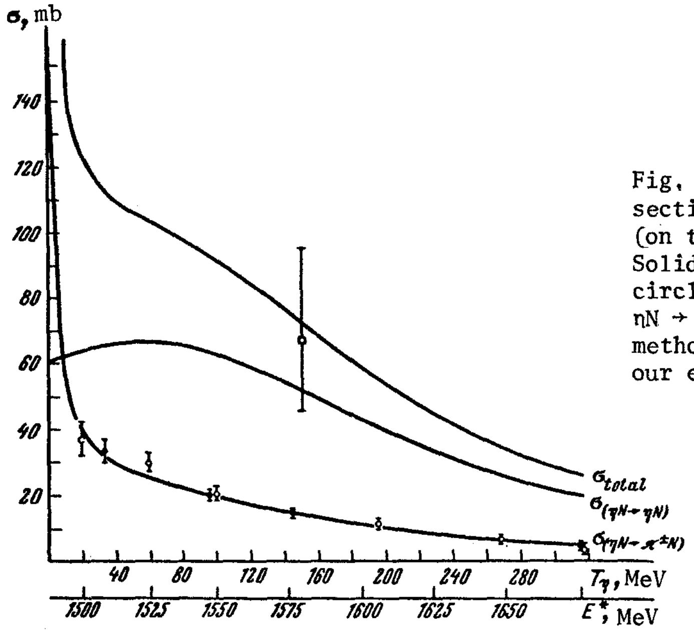

Fig. 3. Dependence of ηN interaction cross sections on the η-meson kinetic energy T_η (on the total energy of the ηN system). Solid curves - theoretical calculations; circles - cross sections of the reaction $\eta N \to \pi N$, obtained by the detailed balancing method from the inverse reaction; square - our experimental value of $\sigma_{\eta N}^{tot}$

the total ηN interaction cross section, ρ is the nucleon density, and k is a coefficient connected with allowance for the Pauli principle.

In the reduction of the experimental data we used a normalization to carbon. $G(p) \approx 0$ under our kinematic conditions. The unknown parameter $\sigma_{\eta N}^{tot}$ was obtained by least-squares fitting of the function $f_A(\sigma_{\eta N}^{tot})/f_{C^{12}}(\sigma_{\eta N}^{tot})$ to the experimental values of $N(A)/N(C^{12})$, where $N(A)$ and $N(C^{12})$ are respectively the yields of the arbitrary nucleus and the C^{12} nucleus, referred to the equivalent quantum.

We obtained $\sigma_{\eta N}^{tot} = (66 \pm ^{29}_{20})$ mb at $\chi^2 = 0.04$.

A value $\sigma_{\eta N}^{tot} \geq 65$ mb was obtained in Frascati under kinematic conditions close to ours.

We have assumed that at a given η-meson energy the main contribution to the ηN interaction cross section is made by the processes

$$\eta N \to \eta N, \qquad \eta N \to \pi N. \tag{4}$$

The cross sections of these processes were calculated under the assumption that the $S_{11}(1535)$ resonance plays the predominant role. In addition to the $S_{11}(1535)$ isobar, the nucleon pole was included in the amplitudes of these processes. The width Γ of the $S_{11}(1535)$ resonance and the value of $g_{\eta NN}$ were determined by a least-squares fit of the calculated $\eta N \to \pi^- p$ cross section to ten values of the total $\eta N \to \pi^- p$ cross section obtained in accordance with the detailed-balancing principle from the measured $\pi^- p \to \eta N$ cross sections [5, 6]. The values $\Gamma = 209$ MeV and $g_{\eta NN} = 0.04$ obtained in this manner were used to calculate the $\eta N \to \eta N$ cross section and $\sigma_{\eta N}^{tot}$, where

$$\sigma_{\eta N}^{tot} = \sigma(\eta N \to \eta N) + \sigma(\eta N \to \pi^{\pm} N) + \sigma(\eta N \to \pi^0 N).$$

As seen from Fig. 2, the measured cross section can be attributed to the processes (4) assuming that the resonance $S_{11}(1535)$ plays the predominant role.

In conclusion, the authors consider it their pleasant duty to thank S. M. Bersenev for help in the reduction of the experimental data and Yu. N. Adishchev and I. Z. Reznitskii for help with the measurements.

[1] G. N. Dudkin et al., Prib. Tekh. Eksp. No. 2, 64 (1973)
[2] C. Bacci et al., Phys. Rev. Lett. 20, 571 (1968).
[3] C. A. Engelbrecht, Phys. Rev. B133, 989 (1964).
[4] C. Bacci et al., Nuovo Cimento Lett. Ser 1, 1, 391 (1969)
[5] W. B. Richards et al., Phys. Rev. Lett. 16, 1221 (1966)
[6] F. Bublos et al., ibid. 13, 486 (1964).