TOTAL CROSS SECTION FOR THE INTERACTION BETWEEN NEUTRONS AND PROTONS AT 5.5 GeV

M. N. KHACHATURYAN and V. S. PANTUEV

Joint Institute for Nuclear Research

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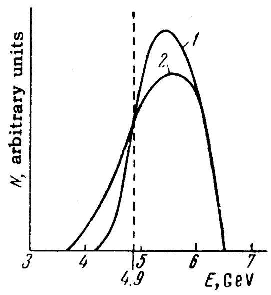
The total neutron-proton interaction cross section is measured at an effective energy of 5.5 ± 0.7 GeV and is found to be $\sigma_t = 41.2 \pm 1.7$ mb. The measurements were carried out by a difference method (CH_2—C) under good geometry conditions ($\theta/2 = 0.228°$).

WE measured the total cross section for the interaction of neutrons of effective energy 5.5 GeV with protons, using apparatus previously described [1-3]. The measurements were carried out under conditions of good geometry ($\theta/2 = 0.228°$), governed by the distance between the target and the neutron-detector converter.

Targets of polyethylene and carbon 48.53 and 41.56 g/cm^2 thick, respectively, were used. The energy spectrum of the neutrons registered by the detector was limited on the high-energy side by the maximum energy of the protons in the accelerator (E_p = 6.5 GeV), while the lower limit was set by the operating thresholds of the discriminators. The discriminator thresholds were chosen by calibrating the Cerenkov spectrometer with an electron beam. The energy of the calibration electrons was 0.5, 1.0, 2.0, and 3.0 GeV [4]. The energy thresholds above 3 GeV were determined by linear extrapolation of the resultant data to the high-energy region. Gatti et al [5] have shown that the region of linearity of a lead glass total absorption Cerenkov spectrometer with dimensions and geometry close to ours, extends to 14 GeV. The low-energy threshold chosen in the indicated manner for the Cerenkov counter was $E_{thr} \approx 4.9$ GeV. To determine the lower energy limit of the spectrum of the neutrons registered by the detector, E_{min}, it is necessary to take into account the energy resolution of the spectrometer in the energy region under consideration and to determine the spectrum of the neutrons from the accelerator for E_p = 6.5 GeV (E_p —proton energy).

The energy resolution of the spectrometer Δ_0 for electrons with energy 1.0 GeV is $\Delta_0 = \pm 15\%$. The counter resolution for energies exceeding 1.0 GeV was determined with the aid of the empirical formula $\Delta(E) \approx \Delta_0/\sqrt{E}$, where $\Delta(E)$ is the energy resolution for the energy E. The neutron



spectrum generated by protons with energy 6.2 GeV was measured by Holmquist [6] with a hydrogen-filled diffusion chamber. To determine the effective neutron energy we used this spectrum, multiplied by suitable factor to account for the difference in the proton energies. Calculation shows (see curve 1 of the figure) that the lower energy limit of the spectrum of the registered neutrons $E_{min} \approx 4.2$ GeV. The effective neutron energy was found by numerical integration of the curve to be E_{ef} = 5.5 GeV with a half-width ± 0.7 GeV. The end-point energies are $5.5^{+0.1}_{-0.3}$ GeV. In order to ascertain the extent to which the effective energy and the lower limit of the energy spectrum E_{min} depend on the resolution of the Cerenkov counter, we also calculated the effective neutron spectrum for the case when $\Delta = \pm 15\% = \text{const}$ for neutrons with energy above 1.0 GeV (curve 2). It is seen from the figure that the effective value of the energy is practically independent of the spectrometer resolution, and the lower limit of the effective spectrum changes by 0.25 GeV (13%).

The experimental data were obtained by alternately exposing targets of polyethylene and carbon to approximately 10—15 accelerator operating cycles. This method yielded approximately 1000 points, which were then analyzed with an electronic computer. Provision was made in the program for selecting the experimental points in accordance with a definite criterion. The use of the first criterion has led to rejection of all the points more than four standard deviations away from the mean. Following the determination of the new mean value, the criterion of Rossini and Deming[7] was applied, on the basis of which all the points more than two standard deviations away from the mean were discarded as incompatible. During the analysis processing, the mean values were also obtained without using the criteria indicated above. The effective cross sections obtained by the two methods coincide within the limits of experimental error. The experimentally obtained value of the total cross section for the interaction between neutrons with effective energy 5.5 GeV and protons is $\sigma_t = 41.2 \pm 1.7$ mb, which does not agree with the data obtained in Berkeley[8] for 5.0-GeV neutrons ($\sigma_t = 33.6 \pm 1.6$).

From the analysis of the data on total cross sections of np interactions, obtained in [1,9] and in the present research, it follows apparently that the total neutron-proton interaction cross section is practically constant and differs from the cross section of proton-proton interaction over a wide range of energies, from 1.4 to 8.3 GeV. This is possibly connected with the fact that the np system, unlike the pp system, is a mixture of two equally possible states with isospins T = 0 and T = 1.

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286