NUCLEON INTERACTION CROSS SECTIONS AT 9 Bev ENERGY

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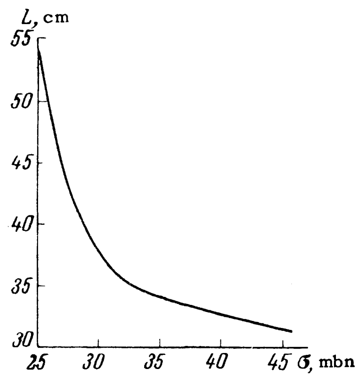
BOGACHEV et al.[1] obtained a value $\sigma \sim 40$ mbn for the total effective cross section of the NN interaction at E = 9 Bev. However, a more exact value of σ can be obtained by using the experimental value of the mean range of the proton in photoemulsion.

We consider first the mean range of a proton in an Ilford G-5* emulsion at E = 5.7 Bev.[2] The theoretical value of this range, calculated on the basis of the optical model, is in good agreement with the mean experimental value L = 37.6 cm, if the density distribution of the nucleons in the nucleus is taken from experiments on the scattering of fast electrons by nuclei,[3] and if a value $\overline{\sigma} \approx 32$ mbn is taken for the cross section of interaction between the incident nucleon and the nucleon in the nucleus, a value also in good agreement with the experimental value $\sigma = 31.3 \pm 1.5$ mbn at E = 6.15 Bev.[4] Detailed calculations made by us, on the basis of the optical model, for other cases,[5] also show that in the energy region E $\gtrsim$ 1 Bev good agreement can be obtained with experiment if the density of the distribution of the nucleons in the nuclei is obtained from experiments on the scattering of fast electrons by these nuclei. With accuracy to several percent, we have here $\overline{\sigma} = \sigma$, where σ is the interaction cross section of free nucleons.[6] Similar conclusions were reached by Elton and Bazhenov.[7]

It is natural to assume that these conclusion remain in force also at E = 9 Bev. The diagram shows the calculated values of the mean range $L(\sigma)$ of a proton in a NIKFI-R photoemulsion at $\overline{\sigma} = \sigma$ with E = 9 Bev.[1] Calculations show that this curve differs only by a few percent from the analogous curve for $L(\overline{\sigma})$, calculated for σ = 30 mbn.

The theoretical value of the range equals the experimental value L = 37.1 ± 1.0 cm (reference 1) if $\overline{\sigma} = \sigma = 30^{+1}_{-0.5}$ mbn. For a rougher value, L = 34.7 ± 1.5 cm (reference 8), we obtain from the figure a value $\overline{\sigma} = \sigma = 33^{+5}_{-3}$ mbn for the proton-nucleon cross sections. The values obtained for σ are close to the total cross



section for proton-proton interaction at E = 6.5 Bev.[4]

The calculated cross sections σ_{in} for the elements C, N, O, Br, and Ag at E = 9 Bev are respectively equal to 240, 260, 290, 900, and 1070 mbn (see references 1, 6, and 9 concerning the cross sections σ_{in} and σ_{el} for hydrogen).

Thus, the results obtained, together with the results of reference 9, show that the optical model can be successfully used to describe the interaction of elementary particle in the energy region E > 1 Bev.

We note that at E $\gtrsim$ 1 Bev the cross sections for the interaction between a nucleon and the nuclei become sensitive to the diffuseness of the nuclear boundary. In this case the principal contribution is made by interactions with impact parameters on the order of the nuclear radius. This uncovers new possibilities for an experimental investigation of the diffuseness of the nucleus.

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*The calculations were based on the following photoemulsion composition (number of atoms $N \times 10^{-22}$ per cubic cm). N_H = 3.37, 2.93; N_C = 1.36, 1.39; N_N = 0.29, 0.37; N_O = 1.02, 1.06; N_{Br} = 1.02, 1.02, and N_{Ag} = 1.02, 1.02 for the Ilford G-5 and NIKFI-R emulsions, respectively.

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BETA INTERACTION AND NUCLEON FORMFACTOR

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ONE of the characteristic features of β-interaction is the rapid increase with energy of processes induced by it. However the existence of strong interactions leads to the acquisition of a formfactor by nucleons which may substantially change the energy dependence of β processes. The study of β transitions at high energies, for example the transformation of an electron into a neutrino

$$e + p \rightarrow n + \nu, \tag{1}$$

can be used for the measurement of this formfactor.

At the present time one may, apparently, consider as established[1,2] the fact that β interaction consists of the vector and axial-vector interactions. The general expression for the matrix element for the process (1) should have the following form:[3,4]

$$M = \frac{g}{\sqrt{2}} (\bar{u}_\nu \gamma_\mu (1+\gamma_5) u_e) \times \left\{\bar{u}_n \left[a\gamma_\mu + i\frac{b}{M}\hat{q}\gamma_\mu + \gamma_5\left(c\gamma_\mu + \frac{id}{M}q_\mu\right)\right] u_p\right\}. \tag{2}$$

Here u_ν, u_e, u_n, u_p are the neutrino, electron, neutron, and proton amplitudes respectively; q is the electron-neutrino momentum difference; a, b, c and d are real functions of q^2 determining the vector (a, b) and axial vector (c, d) vertex functions of the nucleon. If the Gell-Mann and Feynmann hypothesis[1] is correct, then the vector β-interaction vertex function is identically the same as the electro-magnetic vertex function. Therefore the functions $a(q^2)$ and $b(q^2)$ may be determined from electron scattering experiments.[5]

The differential cross section for process (1) is

$$d\sigma = \frac{g^2}{(4\pi)^2} do \frac{1}{\varepsilon^2 + M^2}\left\{(a^2+c^2)\left(4f^4 - 2f^2q^2 + \frac{q^4}{2}\right) - (a^2-c^2)M^2q^2 + (ac+2bc)(q^4 - 4f^2q^2) + b^2\left(q^4 + \frac{4q^2f^4}{M^2} - \frac{2f^2q^4}{M^2}\right) + 2abq^4\right\},$$

$$q^2 = \varepsilon^2(1-\cos\vartheta), \quad f^2 = \varepsilon^2\left(1+\sqrt{1+M^2/\varepsilon^2}\right),$$

where M is the nucleon mass, ϵ and θ are the energy and scattering angles in the barycentric systems. We have assumed that the electron energy is high compared to the electron rest mass. In that case the last term in (2), containing the function $d(q^2)$, does not contribute to the cross section.

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