DETERMINATION OF THE PION-NUCLEON INTERACTION CONSTANT FROM THE DIFFERENTIAL CROSS-SECTIONS OF ELASTIC *pp*-SCATTERING

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We have used the p-p scattering cross sections at 147, 330 and 380 Mev to determine the π-N interaction constant f^2. The results obtained from E_p equal to 137 and 380 Mev do not disagree with a value $f^2 = 0.08$. The cross sections for an energy of 330 Mev can not be made to agree satisfactorily with the value $f^2 = 0.08$.

An analysis of the experimental data on neutron-proton scattering[1] has shown that, within the limits of experimental error, the differential cross section $\sigma_{np}(\vartheta)$ is apparently not in disagreement with a value of the renormalized pion-nucleon interaction constant $f^2 = 0.08$ in a wide energy range from 90 to 630 Mev. As a similar study of the data on proton-proton scattering may give interesting results, we studied $\sigma_{pp}(\vartheta)$ at energies of 147[2], 330[3], and 380[4] Mev by the same method as the one used in [1].

The Coulomb effects were taken into account by a method proposed by Stapp and co-workers.[5] To do this the $\bar{R}$ matrix is written in the form

$$\bar{R} = \bar{S} - 1 = \bar{S} - \bar{S}_c + \bar{S}_c - 1 = \bar{\alpha} + \bar{R}_c,$$

where $\bar{\alpha}$ is the matrix the elements of which can be expressed in terms of the total phase shifts δ_1 and the phase shifts due purely to Coulomb scattering, Φ_1, and $\bar{R}_c$ is the R-matrix of the Coulomb scattering alone. The values of the δ_1 are taken from [5] and [6].

The corrections to the Coulomb expression which we have obtained were evaluated from the differential cross sections. The errors introduced here were determined from the errors in the phase shifts, assuming these to be independent. This leads, apparently, to an increase in the error of determining the Coulomb effects as one can show that there exists the relation $\bar{\Delta}^2/\bar{\Delta}_c^2 = \bar{k}$ between the weighted mean squares of the error sources $\bar{\Delta}_c^2$ and $\bar{\Delta}^2$ found with and without taking correlations between parameters into account; $\bar{k} = (\Sigma k_i)/m$ is the average correlation factor[1] and m the number of parameters which is varied.

The nuclear part of the p-p scattering cross section was written in the form

$$\sigma_{pp}(\vartheta) = a_1 b^2 \left[\frac{1}{(x_0 - x)^2} + \frac{1}{(x_0 + x)^2}\right] + a_2\left[\frac{1}{x_0 - x} + \frac{1}{x_0 + x}\right] + \sum_{n=0}^{n_{max}} A_n x^{2n}, \quad (1)$$

where we used the well-known analytical properties of the p-p scattering amplitude [in the same way as was done in [1] for $\sigma_{np}(\vartheta)$], and where $b = \mu^2/2k^2$, μ is the pion mass, k the momentum of the particle in the center of mass system, $x_0 = 1 + b$, $x = \cos\vartheta$, and a and A_n are undetermined coefficients.

We used the following facts to estimate n_{max} in (1). Using the Mandelstam representation and also the data in a paper by Cini and co-workers[7] one can show that the contribution to the polarization $P(\vartheta)\sigma_{pp}(\vartheta)$ from terms in the amplitude which are singular at $x = \pm x_0$ vanishes, when

$$P(\vartheta)\,\sigma_{pp}(\vartheta) = \sin\vartheta \sum_{n=0}^{n_{max}} c_n x^{2n-1},$$

where n_{max} is the same as the n_{max} in (1).* If one knows the angular dependence of the polarization one can thus establish at which orbital angular momenta the main contribution to the scattering cross section begins to give the pole term contained in the single-meson diagram.

The coefficients a_1 found for energies of 380 and 147 Mev give for f^2 values of 0.066 ± 0.014 and 0.07 ± 0.015 respectively for $v^2 = \chi^2/\bar{\chi}^2 = 0.6$, 1.6 and $n_{max} = 1$ and 0. These values agree well with the results obtained from considering in [1] $\sigma_{np}(\vartheta)$ and do not contradict $f^2 = 0.08$. Increasing n_{max} by unity does not change a_1 appreciably in either case. The fast increase of the error with increasing n_{max} makes it, however, impossible to consider data for which n_{max} is larger.

*A similar relation exists also in the neutron-proton scattering case.

The coefficient a_1 obtained for $E_p = 330$ Mev turned out to be approximately one order of magnitude larger than for $E_p = 380$ and 147 Mev, and $f^2 = 0.19 \pm 0.01$ ($n_{max} = 2$). A change in the number of terms in the expression for $\sigma_{pp}(\vartheta)$ does also in this case not influence the magnitude of the first coefficient greatly. The criterion of agreement, $v^2 = \chi^2/\overline{\chi^2}$ remains constant and inadequate when we change n_{max} in (1) from 2 to 4 ($v^2 = 3$). An attempt to satisfy the experimental data with a fixed coefficient $a_1 = f^4 = 0.0064$ increases v^2 to 3.9 and also gives $A_{n_{max}} < 0$. This may all possibly indicate that there is an appreciable error in the experimental data on $\sigma_{pp}(\vartheta)$ at that energy. One should mention, however, that in a discussion of the results obtained with L. I. Lapidus it was noted that this fact may be connected also with the "near-threshold singularities."[8]

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