JOINT INSTITUTE FOR NUCLEAR RESEARCH

Laboratory of Nuclear Problems

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ЖЭТФ, 1960, т38, в2, с 660-661

Dubna 1959

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DETERMINATION OF THE COUPLING CONSTANT OF PION-NUCLEON INTERACTION BY DIFFERENTIAL CROSS-SECTIONS FOR ELASTIC n–p SCATTERING AT 630 MEV

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In [1] the differential cross sections for elastic (n–p) collisions $\sigma_{np}(\vartheta)$ at $E_n = 630$ Mev in the angle range $160^\circ \leq \vartheta \leq 180^\circ$(c.m.s.) were used to determine the coupling constant of the π -meson-nucleon interaction f^2 by Chew method[2]. With this aim the measured cross sections $\sigma_{np}(\vartheta)$ were multiplied by the magnitude $X^2 = \left(1 + \frac{\mu^2}{2K^2} + \cos\vartheta\right)^2$, where μ is the π -meson mass, $\vec{K}$ is the nucleon momentum (c.m.s.) and the obtained values $X^2\sigma_{np}(\vartheta)$ were approximated by the least squares by a degree series of the following form:

$$X^2\sigma_{np}(\vartheta) = A + BX + CX^2 + \dots + dX^m$$

According to the existing meson theory the coefficient A of this series is expressed in terms of the constant f^2. In order to approximate the experimental values $X^2\sigma_{np}(\vartheta)$ some probe functions were employed beginning from the linear function up to the parabola of the fourth degree inclusively. The polynomials of higher degree ($m > 4$) were not used since the number of points $X^2\sigma_{np}(\vartheta)$ was not comparatively great.

The results of the calculations have shown that the values $f^2 = 0.04$ and $f^2 = 0.085$ are most reliable. However, a comparatively poor statistics and a small number of points on the curve $\sigma_{np}(\vartheta)$ in the above mentioned range of angles gave no possibility to choose one of the two values of the constant f^2. Besides, it turned out also that in all other cases (except the linear dependence $A + BX$) $0.04 \leq f^2 \leq 0.085$.

The averaging of all the obtained values f^2 provided the magnitude $f^2 = 0.06 \pm 0.02$. The necessity to obtain additional information for a more accurate determination of the constant f^2 made us continue the measurements and considerably increase the number of points on the curve $\sigma_{np}(\vartheta)$ in the angle range $160^\circ \leq \vartheta \leq 180^\circ$.

($0^\circ \leq \phi \leq 9^\circ$ ϕ is a recoil angle, lab.system.).

The measurements of differential cross sections for elastic (n–p) collisions at 630 MeV were performed by two methods : by the ringshaped scatterer method[3] and by a usual detector recording recoil protons.

As is known, the ring-shaped scatterer method is more advantageous since at small angular resolution the detector embraces a comparatively large solid angle. This method, however, allowed to investigate but a restricted angle region ($2.5^\circ \leq \phi \leq 8^\circ$).

A usual detector of recoil protons could work within all angle range under investigation. But as in our case a small angular resolution (0.5°) and a high energy threshold were required, with the available beam intensity it was impossible to perform the experiment during a short period of time.

Thus, both the methods supplemented each other. Differential cross sections were measured in relative units. Their absolute values were found from the known differential cross section for elastic (n–p) scattering at the angle $\phi = 8^\circ$, measured earlier in [1].

As a result of measurements the number of points of the curve $\sigma_{np}(\vartheta)$ in the angle range

$160^\circ \leq \vartheta \leq 180^\circ$ suitable for the determination of π -meson-nucleon interaction constant was increased twice if compared with the previous one. (10 points).

ϑ	159°15'	161°30'	163°50'	166°10'	168°30'
$\sigma_{np}(\vartheta)$ in $10^{-27} sm^2/ster.$	3.5 ± 0.4	4.0 ± 0.25	4.36 ± 0.3	4.68 ± 0.33	5.07 ± 0.33

170°45'	173°5'	174°10'	176°30'	180°
5.85 ± 0.41	5.97 ± 0.38	6.12 ± 0.38	7.26 ± 0.87	8.19 ± 0.60

The approximation of the obtained experimental dependence $x^2 \sigma_{np}(\vartheta)$ by a degree series of the form (1) was performed by the calculation bureau of the Joint Institute for Nuclear Research.

For this by the least square method the curves were drawn for probe functions on the experimental points beginning from linear dependence up to the polynomial of the fifth degree.

As it turned out a further increase of the number of series terms was senseless, since the calculations showed that the coefficients at x with the degrees higher than the fifth one had a small value when the error of the coefficient exceeded 100%.

From the above mentioned probe functions the series of the form: $A + Bx^2$ proved to be the best according to the criterion of reliability. In this case for the coupling constant of π -meson-nucleon interaction the coefficient A gives the value $f^2 = 0.04 \pm 0.005$.

Comparatively recently the authors of this paper received the letter from Berkeley in which Moravcsik, Cziffra and Larsen kindly informed us that they obtained the most probable value $f^2 = 0.04 \pm 0.015$ having used the elastic (n–p) scattering data at $E_n = 630$MeV./1/ These data were reported earlier at the International Conference on High Energy Physics (Kiev, 1959).

However, unlike in/1/ they used the whole investigated scattering angle region $11^\circ \leq \vartheta \leq 180^\circ$ as they did it at the energies $E_n = 90$ MeV and $E_n = 400$ MeV/4/.

Together with the values f^2 calculated in /4/ according to the $\sigma_{np}(\vartheta)$ values at the energies $E_n = 90$ MeV and $E_n = 400$ MeV the result of the present paper shows that when determining f^2 from neutron-proton scattering data by Chew method, the constant f^2 is found to be apparently, somewhat less than 0.08 obtained from π -meson scattering on protons.

The authors consider it to be their pleasant duty to express their gratitute to Yu.N. Simonov for the assistance in this work, S.N. Sokolov and G.I. Kochkina for carrying out necessary calculations and the discussion of the results.

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Received by Publishing Department
on November 11, 1959.