ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ

ЛАБОРАТОРИЯ ЯДЕРНЫХ ПРОБЛЕМ
ВЫЧИСЛИТЕЛЬНЫЙ ЦЕНТР

I. Bystritsky, R. Zul'kameev

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CONTRIBUTION OF ^3P AND ^3F WAVES TO MESON PRODUCTION IN pp – COLLISIONS AT 660 MEV

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Recently at Dubna the phase shift analysis of elastic pp- scattering at 660 MeV[1,2] was performed. It turned out that comparatively small additional amount of experimental material is necessary for a more strict analysis to be carried out. For such an analysis it is necessary, in our opinion, to vary all the phase shifts for $L \lesssim 6-7$. However, as is seen from[2] and [3], in the modified analysis it is sufficient to find only phase shift waves with $L < 5$. But from what states does pion production in pp -collisions at 660 MeV proceed (what imaginary parts of the phase shifts differ from zero) is not clear. One may follow only the indication of some interaction model here. Therefore, any analysis without the account of pion production even for one of S, P, D, G etc. states, generally speaking, cannot be sufficiently strict.

The analysis[1,2] with the account of pion production in the Mandelstam theory framework is also a certain approximation.

Here are some of the peculiarities of the analysis:

a) presence of a single solution in the interval $\bar{\chi}^2 < \chi^2 < 2\bar{\chi}^2$

b) clear difference from zero of the imaginary parts of $\bar{\delta}^I(^3P_2)$ and $\bar{\delta}^I(^1D_2)$.

It is very likely that the result 'a' is a consequence of introducing rather strict suppositions of the Mandelstam resonance theory. This naturally caused the restriction of space in which the search was carried out. Possible restriction of space was mentioned by us in[2]. Indeed, fixing of $\bar{\delta}^I(^1D_2)$ and using its semi-empirical value obtained on the basis of Soroko's paper[4] leads in the frame work of this model to the fact that in varying $\bar{\delta}^I(P_{0,1,2})$ there was the following restriction: $1,41\ \lambda^2(1-r^2(^3P)) = \sigma_{tot} - 5.5\ \lambda^2$, $r^2(^3P)$ is function of $\bar{\delta}^I(^3P_{0,1,2})$. This means that in search of ref.[2] only two parameters which describe transitions with pion emission in pp -collisions were varied. Under these conditions it is natural that the result 'b' is in agreement with the resonance model in which transitions from the initial P, D — states of the pp -system are supposed to be most important[5].

Now when it is stated that there is practically a single solution in the framework of the resonance theory*, it is reasonable to refuse from the indication of this model in searches.

In the present note there are given the results of the phase shift analysis carried out under the assumption that imaginary parts of the phase shifts of ^3F waves should not be neglected. Considering $\bar{\delta}^I(^3F_{2,3,4})$ we would like to stress that unlike in Hoshizaki-Machida's paper[4] in the present report the equations $\bar{\delta}^I(^3P_0) = \bar{\delta}^I(^3P_1) = \delta^I(^3P_2)$, $\bar{\delta}^I(^3F_2) = \bar{\delta}^I(^3F_3)$, $\epsilon_2^R = \epsilon_2^I = 0$ and formula (10) of ref.[4] were not used. The validity of them cannot be considered as confirmed experimentally. These assumptions without any change, as we learnt recently, were also used in ref.[5] (Azhgirey et al). The assumptions of the Japanese authors narrow considerably the group of unknown solutions and lead, therefore, to an inevitable loss of some of them in searches.

The search for solutions in the present work was performed by the method and with the experimental data used in[1]. This search was accomplished in two stages. In the first stage $\bar{\delta}^I(^3P_0)$, $\bar{\delta}^I(^3P_1)$, $\bar{\delta}^I(^3P_2)$, $\bar{\delta}^I(^3F_2)$, ϵ_2^I and $\bar{\delta}^I(^1D_2)$ were imaginary, while all the real parts of the phase shifts and ϵ_2^R were varied in the same way as in ref.[1]. After 60 searches not a single solution different from those obtained by us earlier in the interaval $\bar{\chi}^2 \leq \chi^2 \leq 2\bar{\chi}^2$ was found. Since previously in[2] it was found that $\epsilon_2^I < 2^{\circ}$, this fact may show the validity of the equation $\epsilon_2^I \approx 0$. Hence, further search with additional varying of $\bar{\delta}^I(^1D_2)$, $\bar{\delta}^I(^3F_{2,3,4})$ and ϵ_2^R was performed under the assumption that $\epsilon_2^I = 0$. After

60 attempts eight solutions have been found with χ^2 in the interval $\bar{\chi}^2 \leq \chi^2 \leq 2\bar{\chi}^2$. As solutions causing negative values of the πN -interaction constant and $\bar{\delta}^I(^3P_0)$, four solutions were omitted. The remaining four often repeated solutions have small values which are distributed for solutions I, II, III, IV as 26, 26, 32, 40, respectively.*

Phase shifts of the obtained solutions are listed in Table 1. Fig. 1 shows the angular dependence of a number of experimental values according to I, II, IV determined more precisely with varying f^2, ϵ_2^I etc. The stability of some of solutions is doubtful. For example, if for solution II one assumes that $\bar{\delta}^I(^3P_0)=0$ and finds χ^2_{min}, then one obtains the analogue of solution I with $\chi^2/\chi^2 \approx 1$. Hence, it is seen that the character of solutions may be dependent upon the way in which they are made more precise. Therefore, with the available experimental information, it is premature to speak about the completeness of the number of solutions obtained by varying $\bar{\delta}^I(^3F)$ etc. However, some interesting conclusions on meson production in pp -collisions with the energy of 660 MeV can be made already now.

Thus, solutions IV and solution III analogous to solution No. 1 obtained earlier in /1,2/ lead to more intensive pion production in ^3P, ^1D states, while solutions I and II in ^3F, ^1D states. The latter, from a certain point of view, mean that there is no pion production in the internal regions of the nucleon. On the other hand, the fact that for all the solutions $\bar{\delta}^I(^1D_2) \approx 9^\circ - 12^\circ$ and $\bar{\delta}^I(^3F_4) \neq 0$ can also show the importance of nonresonant transitions in meson production. The comparison of the same values of $\bar{\delta}^R$ for solutions I, II, IV with the corresponding calculations in the OPE approximation shows that in a number of cases they are in rather good agreement. If this is true, then the results of the present analysis and the analysis with $E \leq 300$ MeV show that the role of the OPE in elastic scattering with $L \geq 2$ may become predominating at higher energies and this may be used in the analysis of pp-scattering at 970 MeV, for inctance.

To confirm the conclusions of the present investigation more detailed experimental information is necessary not only about elastic scattering but about $pp\text{-}pp\pi^0$ and $pp\text{-}np\pi^+$ processes as well.

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*The solution I is found so in work /7/.

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T a b l e 1

Phase shifts in degrees

	Solution I $\chi^2 = 26$	Solution II $\chi^2 = 26$	Solution III $\chi^2 = 32$	Solution IV $\chi^2 = 40$	O P E
$\bar{\delta}^R(^1S_0)$	-33.40+550	-2I.62+8.20	-2I.62+8.20	-3.85+4.60	- 3.4
$\bar{\delta}^R(^3P_0)$	-6I.04+I0.50	-20.95+3.40	-40.52+I2.60	-6.54+I4.00	0.0
$\bar{\delta}^R(^3P_1)$	-42.00+5.00	-30.75+2.30	-2I.II+5.30	-II.22+2.30	-1.80
$\bar{\delta}^R(^3P_2)$	I4.23+3.30	6.86+5.30	47.88+7.60	-33.00+I.90	9.30
$\bar{\delta}^R(^1D_2)$	7.74+3.50	7.79+2.20	7.77+2.00	4.97+4.30	2.40
ϵ_2^R	3.80	-I.40	0.63	I.90	-9.50
$\bar{\delta}^R(^3F_2)$	-9.89+2.30	+4.89+2.30	-4.46+I.90	3.50+I.20	5.30
$\bar{\delta}^R(^3F_3)$	-0.67+3.40	-5.83+I.60	0.83+I.60	-0.78+I.80	-7.50
$\bar{\delta}^R(^3F_4)$	I2 I +I.50	6.58+0.70	-4.95+I.I0	I5.60+I.40	1.80
$\bar{\delta}^R(^1G_4)$	6.64+0.90	6.55+I.00	7.I8+I.I0	5.07+I.20	1.16
$\bar{\delta}^I(^1S_0)$	0	0	0	0	-
$\bar{\delta}^I(^3P_0)$	2.0I+6.30	-I2.80+4.20	9.94+9.80	27.30+I5.60	-
$\bar{\delta}^I(^3P_1)$	4.62+3.80	-4.44+4.00	2.04+3.I0	-3.37+I.I0	-
$\bar{\delta}^I(^3P_2)$	-0.64+I.70	29.29+8.I0	20.27+6.70	-I.83+3.30	-
$\bar{\delta}^I(^1D_2)$	I0.20	I0.00	I0.00	I7.50	-
$\bar{\delta}^I(^3F_2)$	3.65+4.I0	5.58+3.00	-0.58+I.80	3.08+2.20	-
$\bar{\delta}^I(^3F_3)$	5.0I +5.30	2.69+3.66	-0.36+2.20	2.38+4.I0	-
$\bar{\delta}^I(^3F_4)$	2.86+ I.I0	3.66+I.20	3.86+I.20	2.85+2.80	-
ε_2^I	-0.64	5.00	-2.00	-2.00	

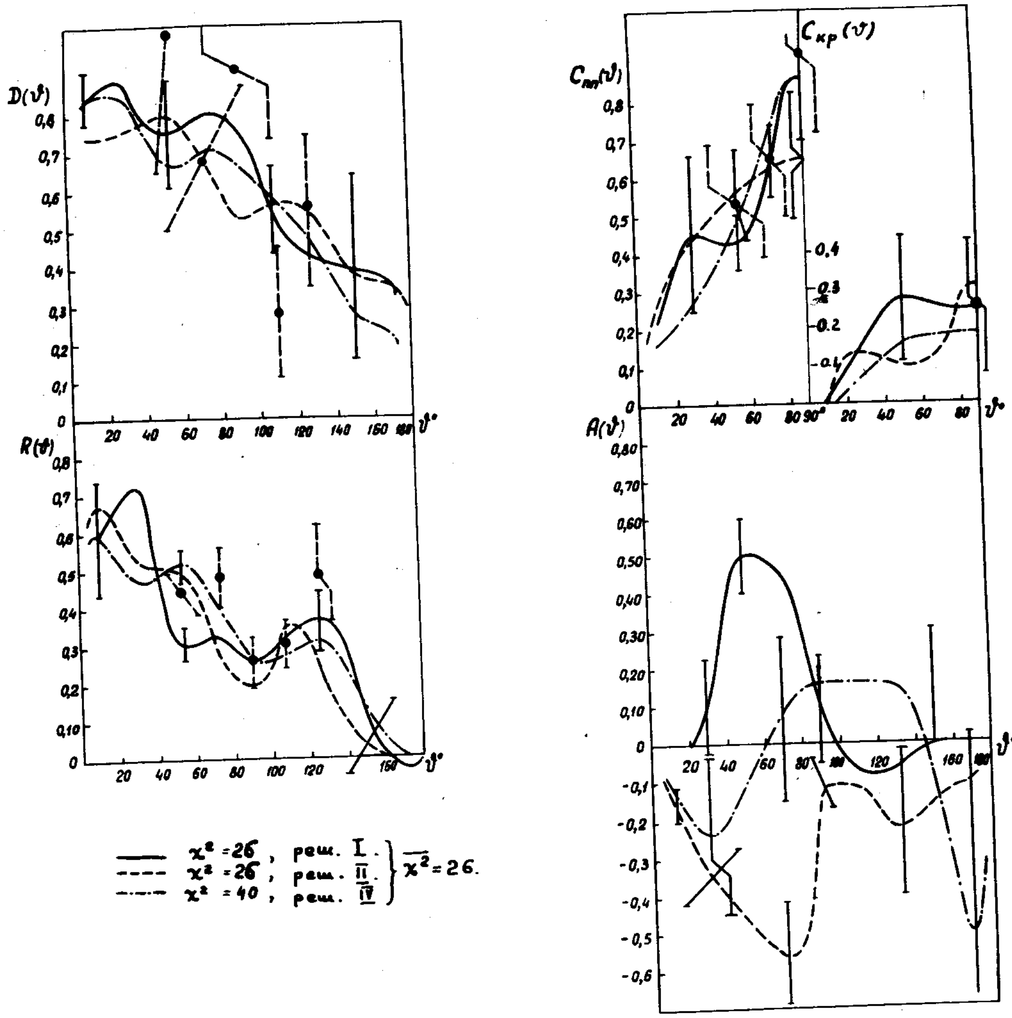

Fig..1. The dependence $C_{nn}(\theta)$, $C_{kp}(\theta)$, $D(\theta)$, $R(\theta)$, $A(\theta)$. according to solutions I, II, IV.

- experimental errors

calculated margin of errors.