ЯФ, 1967, т6, в5, с995-997
11/IV-67

ОБЪЕДИНЕННЫЙ
ИНСТИТУТ
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ

Дубна

E1 - 3194

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ЛАБОРАТОРИЯ ЯДЕРНЫХ ПРОБЛЕМ

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Submitted to ЯФ

The results of the measurements of the angular dependence of the $\mathcal{A}(\theta)$ asymmetry of elastic pp-scattering at 635 MeV in the angle region from $28^{\circ}-90^{\circ}$ (c.m.s.) are reported. Here, according to [1] the asymmetry $\mathcal{A}(\theta)$ is the analysing power of hydrogen on a completely polarized beam. The major part of measurements has been performed to an accuracy of (2-3)% which is about three times higher than that of ref. [2].

The more complete results of asymmetry measurements than those obtained earlier in ref. [2] are necessary to check the polarization-asymmetry equality arising from the requirement of the time invariance of strong interactions. Besides, the measurements of elastic scattering parameters of higher accuracy are always desirable for further improvement of the phase shift analysis results.

The experiment was aimed at the determination of the $\epsilon(\theta)$ azimuthal asymmetry arising in elastic pp-scattering at an angle θ of the beam of known polarization. The experimental arrangement and geometry are similar to those of an earlier experiment [3]. The angular resolution was $\pm 1^{\circ}15'$.

The values of $\epsilon_{exp}(\theta)$ obtained directly from the experiment are given in Table 1. The errors given in the Table are summed values of absolute statistic errors.

The study of the possible contribution of false asymmetries to $\epsilon_{exp}(\theta)$ due to inaccurate experimental geometry, the proton energy spread in the beam, etc. has shown that

a) asymmetry due to the non-uniform proton density across the beam is smaller than 0.0015;

b) the effect of the scattered magnetic field of the accelerator along the particle track causes the asymmetry not larger than 0.001;

c) asymmetry arising due to the presence of the proton energy spectrum in the incident beam and the energy dependence of pp-scattering polarization is smaller than 0.0020.

Making use of the beam polarization $P_{beam} = 0.425 \pm 0.013$ found in ref.[3], we obtain the $\mathfrak{A}(\theta)$ asymmetry of elastic pp-scattering related to the completely polarized beam (See column 3 of Table 1). The errors presented for $\mathfrak{A}(\theta)$ do not include the error of the polarization determination of our beam.

The value $\mathfrak{A}(\theta)$ should coincide with polarization in pp-scatteing, if one considers that T-invariance is not violated in strong interactions.

The comparison of our results with those available in the literature for 596-725 MeV[2,4,5] show that the energy dependence of polarization in elastic pp-scattering appears to be more obvious in the region of 650-700 MeV.

Using the obtained results and data on $\sigma(\theta)$; $D(\theta)$; $R(\theta)$; $C_{nn}(\theta)$; $C_{kp}(90^{\circ})$ and $A(\theta)$ [5,6] the phase shifts of pp-scattering were improved which had been obtained in ref.[2]. Calculations have shown that the improved phase shift values vary insignificantly, whereas the errors of the basic phase shifts in $^1S_0$-, $^3P_{0,1,2}$ -states are decreased 2-3 times, perhaps, due to the use of the more accurate data on polarization.

Further a search was made for now solutions beginning from the random initial values of phase shifts. This search was necessary each time[7] if new and sufficently large experimental material was under analysis. The search was made with $\ell_{max} = 4$ and $\ell_{max} = 5$. Meson production was taken into account in the $^3P_{0,1,2}$, $^1D_2$- and $^3F_{2,3}$ -states. Three solutions were obtained with $\chi^2 =$ 71, 79, 87 with $\ell_{max} = 5$ ($\overline{\chi^2} = 79$)- and two solutions with $\chi^2 =$ 83, 95 with $\ell_{max} = 4$ ($\overline{\chi^2} = 80$) in the intervals $\overline{\chi^2} \leq \chi^2 \leq 1.3\,\overline{\chi^2}$. One of the solutions obtained with $\ell_{max} = 5$ coincide with the earlier known solution of ref.[2]. The remaining phase shift sets are similar, in general, with those obtained earlier[2,8] (See Table 2). Thus, no evidences has been found for the existence of a single phase shift set in the analysed energy region.

The authors wish to express their gratitude to Prof. V.P.Dzhelepov, Prof. L.I.Lapidus and Prof. Yu.M.Kazarinov for helpful discussions.

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Received by Publishing Department
on March 3,1967.

T a b l e   1

θ^0_{LS}	θ^0_{cms}	$\epsilon_{exp} \pm \Delta\epsilon_{exp}$	$a(\theta) \pm \Delta a(\theta)$
I2.0	27.6	0.202 ± 0.0I0	0.475 ± 0.024
I4.0	32.2	0.2I2 ± 0.009	0.499 ± 0.02I
I5.0	34.4	0.2II ± 0.0I0	0.496 ± 0.024
I6.0	36.7	0.222 ± 0.008	0.522 ± 0.0I9
I7.0	38.9	0.222 ± 0.008	0.522 ± 0.0I9
I8.0	4I.2	0.220 ± 0.006	0.5I8 ± 0.0I4
I9.0	43.4	0.2I7 ± 0.006	0.5II ± 0.0I4
I9.5	44.5	0.2I8 ± 0.008	0.5I3 ± 0.0I6
20.0	45.6	0.2I6 ± 0.006	0.508 ± 0.0I4
20.5	46.7	0.2I3 ± 0.006	0.50I ± 0.0I4
2I.0	47.8	0.206 ± 0.004	0.485 ± 0.009
2I.5	49.0	0.205 ± 0.008	0.482 ± 0.0I6
22.0	50.I	0.209 ± 0.006	0.492 ± 0.0I4
22.5	5I.2	0.209 ± 0.006	0.492 ± 0.0I4
23.0	52.3	0.205 ± 0.006	0.482 ± 0.0I4
24.0	54.5	0.I89 ± 0.006	0.445 ± 0.0I4
25.0	56.6	0.I78 ± 0.006	0.4I9 ± 0.0I4
26.0	58.8	0.I89 ± 0.007	0.455 ± 0.0I6
26.9	60.8	0.I68 ± 0.006	0.395 ± 0.0I4
28.0	63.I	0.I72 ± 0.0I0	0.405 ± 0.02I
32.I	7I.8	0.I26 ± 0.006	0.296 ± 0.0I4
35.9	79.9	0.077 ± 0.007	0.I8I ± 0.0I6
40.7	89.7	0.005 ± 0.004	0.0I2 ± 0.009

T a b l e   2

States	$\ell_{max} = 5$, $\bar{\chi}^2 = 79$			$\ell_{max} = 4$, $\bar{\chi}^2 = 80$	
	$\chi^2 = 71$	$\chi^2 = 79$	$\chi^2 = 87$	$\chi^2 = 83$	$\chi^2 = 95$
$^1S_0$	-I3.2± 3.0	-26.I± 4.4	-2I.I± 3.4	-I7.8± 3.9	-28.3± 7.0
$^3P_0$	-23.I± 4.7	-4I.3± 7.5	-27.3± 5.4	-I2.2± 4.4	-47.3±I7.9
$^3P_1$	-26.5± 3.9	-40.7± 6.5	-25.3± 4.I	-I9.0± 4.7	-44.6±II.9
$^3P_2$	33.3± I.3	I9.5± 2.4	38.7± I.6	37.7± 4.7	I9.3± 3.2
$^1D_2$	I6.3± 2.0	II.2± 2.3	8.7± 2.I	- I.3± 4.7	II.5± 2.9
ϵ_2	0.4± I.7	- I.8± 2.I	I.3± 2.0	- I.4± 4.5	- 2.0± 3.2
$^3F_2$	- I.7± I.0	- 7.8± 2.6	-2.4± I.4	- 0.9± 2.I	- 3.9± 2.6
$^3F_3$	3.0± I.9	- 3.4± I.6	4.2± I.9	3.3± 2.0	- I.0± 2.9
$^3F_4$	5.3± I.4	I.0± I.3	2.5± I,8	8.8± 0.9	3.2± I.4
$^1G_4$	7.6± 0.7	4.6± 0.9	5.5± I.0	7.4± I.3	5.9± I.I
ϵ_4	- 2.0± I.I	- 3.2± I.3	-2.3± I.2		
$^3H_4$	- 3.2± 0.9	I.0± I.0	-3.I± 0.8		
$^3H_5$	- 2.I± I.4	- 3.I± I.I	-I.8± I.4		
$^3H_6$	- 2.8± 0.9	I.5± 0.5	-3.4± 0.9		
Imaginary parts of phase shifts					
$^3P_0$				- 9.4± 7.6	7.7±I4.5
$^3P_1$	2.8± 0.6	2.5± 0.8	5.3± 0.9	- 4.8± 3.4	9.7±I3.6
$^3P_2$				I3.5± 3.9	-0.6± 4.6
$^1D_2$	I3.4± 3.I	I0.9± 5.3	- 0.6± I.8	24.9± 2.8	II.8± 5.8
$^3F_2$				3.3± 2.8	4.0± 3.3
$^3F_3$	2.I± 0.3	2.2± 0.5	3.9± 0.3	4.4± 2.I	5.0± 2.7

The solutions have been found without taking into account experimental data on inelastic processes.