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KEK ACTIVITIES WITH POLARIZATION PHENOMENA

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Abstract - The experiments at KEK cover the wide range of physics interests. In this paper, we introduce some experimental results concerning the polarization phenomena in N-N and N-N systems which have been performed in the past about two years, and also the experiments planned in the near future.

I. Introduction

The present experimental list in KEK includes some kinds of experiments in a various stages, that is, 2 theme in the running stage, 6 theme in the preparation one and nearly 20 theme in the analyzing one. Among these experiments, we would like to introduce firstly the experiments which have been performed for the past two years, and secondly the experiments which are scheduled in the near future, focusing on the polarization phenomena in N-N and N-N interactions.

II. Experiments Performed

(1) A-parameter in $\pi^+d \rightarrow \pi^+d/1$ and $K^+d \rightarrow K^+d$ Processes.

These experiments were performed by using the high momentum K-beam channel and the polarized deuteron target. As for the $K^+d$ process, the data are taken at $P_{\text{inc}} = 1.49$ GeV/c and the preliminary result will be presented in this Symposium as a contributed paper. A-parameter for $\pi^+d$ process was measured at $P_{\text{inc}} = 0.74$ GeV/c in the angles between $\theta_{\text{CM}} = 48^\circ \sim 100^\circ$. Data were compared with Glauber predictions in Fig. 1, together with the data of $d\sigma/d\Omega$ in the $\pi^-d$ process at $P_{\text{inc}} = 0.72$ GeV/c.

Fig. 1 - The comparison with Glauber predictions. As wave function and $\pi N$ phase shifts, Hashimoto and Kanai et al. adopt Hamada-Johnston and Karlsruhe-Helsinki, Reid and Saclay types. Predictions include dibaryons.
The disagreement between data and predictions shows that the consistent prediction has not yet been obtained even in the two parameters of $d\sigma/d\Omega$ and $\Lambda(\theta)$.

(2) Proton-Proton Scattering in the Energy Range of 0.9 ~ 2.0 GeV/c/2,3/.

$c_{\text{tot}}, c_{\text{elastic}}, c_{\text{pp}+\pi^+_2}, c_{\text{pp}+\pi^+\text{pn}}, c_{\text{pp}+\pi^+\text{pn}}$ and $d\sigma(\theta)/d\Omega$ data for proton-proton scattering in the energy range of 0.9 ~ 2.0 GeV/c were obtained by analyzing 220,000 pictures of 1m bubble chamber. The data were compared with some analyses. From those predictions, the following conclusions are derived.

(a) No structure for dibaryon is seen in any cross sections.
(b) The differential cross section for the elastic scattering is well reproduced by Hoshizaki's phase shift analysis including $^1D_2$ and $^3P_3$.
(c) For the inelastic processes, pp + πpn and pp + πpn proceed mainly (≈ 80%) through intermediate states nΔ++ and pΔ++.
(d) Single pion production cross sections agree well with Verwest & Arndt analysis, and don't agree with König & Kroll. Verwest & Arndt analysis concluded no possibility of $I = 0$ dibaryon below 1.7 GeV/c. (König & Kroll has tried a new analysis including $^3P_3$ resonance and succeeded in the data reproduction/4/.)

(3) Polarization of $\Lambda^n$ Inclusively Produced by 12 GeV/c Proton on Tungusten/5/.

The experiment was performed at 3 production angles in the kinematical region of $0.4 \leq P_T \leq 1.6$ GeV/c. The total number of $2.4 \times 10^5 \Lambda^n$ is identified. As seen from Fig. 2, the following results are derived.

(a) The data are consistent with previous one measured higher energies.
(b) $P_T$ dependence shows a tendency to level off for $P_T \geq 1.0$ GeV/c.

(4) Experiments by $\bar{P}$ Beam.

The recent experiments achieved by $\bar{P}$ are followings.

(i) $\bar{P}P + \gamma X, \pi^0 X$ nX and nX
(ii) $\sigma_{\text{pp}}(\bar{P}P), \sigma_{\text{pp}}(P\bar{P}), \sigma_{\text{abs}}(\bar{P}G, \bar{P}A, \bar{P}Cu)$

$do/d\Omega(\bar{P}P + \bar{P}P), do/d\Omega(\bar{P}P + \bar{P}P), do/d\Omega(\bar{P}P + \pi^+\text{nX}), do/d\Omega(\bar{P}P + \pi^+\text{nn})$

As some parts of these experiments are already published/6,7/, we report the preliminary results now being analyzed.

(a) Forward Real/Imaginary ratio for $\bar{P} \bar{P}$ and $\bar{P}n$.

These were measured in the incident momentum region of $350 \leq P_{\text{inc}} \leq 800$ MeV/c. The result of $\bar{P} \bar{P}$ process is generally consistent with other data and the momentum dependence is well predicted by the potential model as shown in Fig. 3(a). The result of $\bar{P}n$ which is measured firstly in this energy region shows a positive sign near zero and has a tendency to decrease slowly with momentum. The potential model fails to reproduce the data as seen in Fig. 3(b).

(b) Possible existence of a new meson resonance/8/.

The total and differential cross sections for $\bar{P}P + K^+K^-$ were measured at $0.39 \leq P_{\text{inc}} \leq 0.78$ GeV/c. From a big enhancement at 490 MeV/c in $\sigma_T$ and the special symmetrical feature in $d\sigma/d\Omega$ at the same momentum, a new meson resonance with following characteristics is suggested.

Mass $\sim 1935 \pm 15$ MeV, $\Gamma \leq 40$ MeV, $J^{PC} = 2^{++}, I = 0^+$ or $1^-$.
Fig. 3 - Forward Real/Imaginary for $\bar{p}p$ and $\bar{p}n$ processes. Solid lines for PP and Fn represent the predictions by Bryan & Phillips and Timmer et al., respectively. Dashed line in PP denotes Lacombe et al.

III. Experiments Planned.

As experimental plans which use the polarized beam facility, the following 3 experimental plans were proposed.

(1) The Measurement of Spin Correlation Parameter $A_{nn}$ at large $P_T$ Region in the $p^f n^f + pn$ Scattering.

(2) The Measurement of Spin Transfer in $p^f A + A^f X$ Reaction.

(3) The Acceleration of Polarized Deuteron and Measurement of Physical Quantities in $np$ Process Aiming at Dibaryons in $I=0$.

Among these experiments, only (1) theme is accepted by PAC in the limited condition that the experiment must be really feasible including the construction of the polarized beam facility. Others are left for the later chance. So we would like to mention about the (1) experiment.

The motivation is following.

(i) What behavior will be seen in $A_{nn}$ at large $P_T$ in pn process? Does "Anomaly" appear in pn, which is observed in pp process?

(ii) What kind of model is preferable to the large $P_T$ region in hadron-hadron scattering?

As well known, $A_{nn}$ in pp elastic scattering behaves extraordinarily at large $P_T$ region and some theoretical models are proposed to explain it. However, the general consensus to the reaction mechanism has not yet been established. In Table 1, the prediction by several quark models are presented.

<table>
<thead>
<tr>
<th>Model</th>
<th>$p$-$p$</th>
<th>$p$-$n$</th>
<th>$(d\sigma/dt)<em>{pp}/(d\sigma/dt)</em>{pp}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>QIM</td>
<td>$A_{nn}=A_{gg}^L-A_{SS}$</td>
<td>$A_{nn}=A_{gg}^L-A_{SS}$</td>
<td></td>
</tr>
<tr>
<td>(Farrar et al.)</td>
<td>$A_{nn}(90^o)=1/3$</td>
<td>$A_{nn}(90^o)=-0.44$</td>
<td>$\sim 0.6$</td>
</tr>
<tr>
<td>(Brodsky et al.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diquark spectator model (Welters)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q-Q scattering model (Chen)</td>
<td>$A_{nn}=-1/9$ with color</td>
<td>$A_{nn}=-0.22\pm0.22$</td>
<td></td>
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<tr>
<td></td>
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</tbody>
</table>
The planned experimental set up is shown in Fig. 4.

Fig. 4 - The beam line and schematic layout of the apparatus.

To perform this experiment, the following problems are expected.

(i) Low beam intensity ($10^8$ pps) and small $d\sigma/dt$ at $\theta_{cm} = 90^\circ$.
(ii) Background event from polarized deuteron target.
(iii) Neutron Fermi motion in D and background nucleus.

To overcome these problems and to get a better statistical error, one must take care of the following subjects.

As for (i), the large PT, a neutron counter with higher detection efficiency and the higher polarizations of beam and target are useful.

As for (ii) and (iii), the development of the polarized target with less background nuclei and the precise determination of kinematics of events are inevitable.

Following these requirements, we are now preparing some apparatus, that is,

(i) the polarized ND$_3$ target in dilution mode,
(ii) the beam defining counter in the high counting rate,
(iii) Si-strip detector for charged particles around the target and
(iv) position sensitive neutron counter consisted of the sandwich of iron plate and the array of plastic streamer tube.

From the simulation, it is found that the most effective method to select the real event is to use the coplanarity relation between proton and neutron. In Fig. 5, the event distribution in the coplanar plane is shown.

Fig. 5 - Event distribution from deuteron and nitrogen at $\theta_{cm} = 90^\circ$. $\varphi_3, \varphi_4$ correspond to azimuthal angle of proton and neutron, respectively. The solid line means the coplanarity.
References

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8. Nakamura K., Talk at European Antiproton Symposium, Durham, UK, 1984