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NUCLEON POLARIZATION IN THE REACTION $\pi^- p \to n \pi^+ \pi^-$

H.Becker, W.Blum, V.Chabaud, H.de Groot, H.Dietl, J.Gallisn, B.Gotteschalk, G.Hentschel, B.Hyams, E.Lorenz, G.Lutjens, G.Lutz, W.Manner, B.Niczyporuk, D.Notz, T.Papadooulou, R.Richter, K.Rybicki, U.Stierlin, B.Stringfellow, M.Turala, P.Weilhammer, A.Zalewska

CERN-Munich Collaboration

Presented by G.Lutz

Preliminary results from a high statistics measurements (1 M events) of the reaction $\pi^- p \to n \pi^+ \pi^-$ on a polarized target at 17.2 GeV show unexpected strong nucleon polarization effects which must be attributed to amplitudes corresponding to A_1 exchange. The evidence is

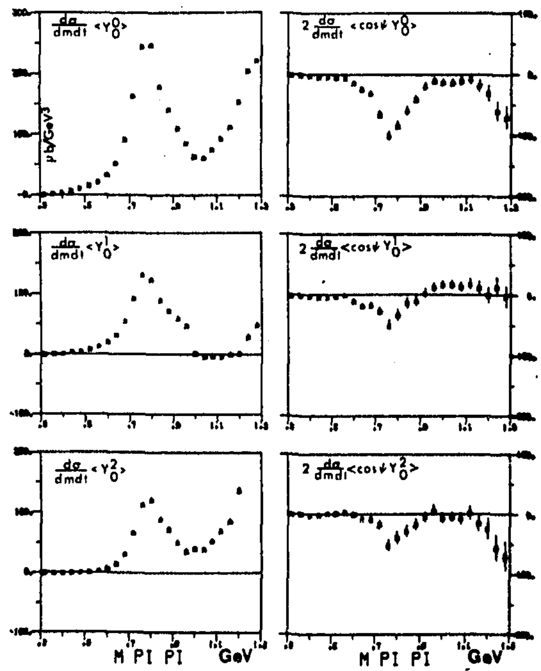

Fig.1. Mass dependence of Unnormalized moments $\frac{d\sigma}{dmdt} \langle Y_0^\ell \rangle$ and $\frac{d\sigma}{dmdt} \langle \cos\psi\, Y_0^\ell \rangle$ in the low t region $(0.01 < |t| < .2\ GeV^2)$

shown in fig.1, where the helicity zero moments of angular distribution for 100% transversely polarized protons are given as function of the mass of the pion pair. Small four momentum transfer to the nucleons ($0.01 < |t| < 0.2\ GeV^2$) has been selected. The spherical harmonics Y_0^1 are expressed in the t channel (or Gottfried-Jackson) angles of the π^-. ψ is the angle between the normale to the production plane ($\vec{p}_n \times \vec{p}_{Beam}$) and the (transverse) polarisation direction of the target. There is a preliminary uncertainty of 25% between the polarisation dependent moments $\langle\cos\psi\, \mathrm{Re} Y_m^l\rangle$ obtained in this experiment and the polarisation independent moments $\langle \mathrm{Re}\, Y_m^l\rangle$ taken from the hydrogen experiment/1/.

Supprising is the large size of the polarisation dependent moments in this t-range which was supposed to be dominated by one pion exchange and should therefore show little or no nucleon polarization effect. For the left-right-asymmetry which is given by the ratio of the moments

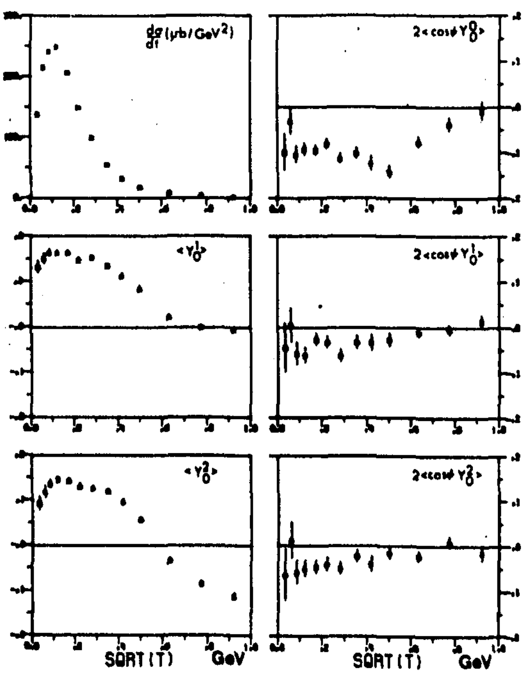

Fig.2. t-dependence of
Cross section $\frac{d\sigma}{dt}$ and normalised moments $\langle Y_0^l\rangle$ and $\langle\cos\psi\, Y_0^l\rangle$
for the ρ-mass region ($.71 < m_{\pi\pi} < .83$)

$2\langle\cos\psi\, Y_0^1\rangle / \langle Y_0^1\rangle$ one obtains 0.35 in the ρ mass region.

The occurence of $\langle\cos\psi\, \mathrm{Re}\, Y_m^l\rangle$ moments requires the simultaneous presence of nucleon spin flip and nonflip amplitudes for equal naturality of the exchange. The moment $\langle\cos\psi\, Y_0^1\rangle$ for example is given by the interference of the (unnatural) S wave and P wave helicity zero amplitudes (assuming absence of D and higher waves) with different nucleon spin flip.

$[2\langle\cos\psi\, Y_0^1\rangle = \mathrm{Im}(n_0 f_s - n_s f_0)$ f. flip, n nonflip]

The corresponding moments $\mathrm{Re}\langle Y_m^1\rangle$ combine flip with flip and nonflip amplitudes

The $\langle\cos\psi\, \mathrm{Re}\, Y_m^1\rangle$ moments resemble (with opposite sign) the $\langle \mathrm{Re}\, Y_m^1\rangle$ moments in the low t region where natural parity exchange is small. Earlier investigations of the density matrix /2/ showed the vanishing of one unnatural eigenvalue in the ρ mass region. This in turn gives a relation between nonflip and flip amplitudes $n = c f$ with the complex constant c independent of spin and helisity of the π-pair system. One then obtains a constant ratio

$$R = \frac{2\langle\cos\psi\, \mathrm{Re}\, Y_m^1\rangle}{\langle \mathrm{Re}\, Y_m^1\rangle} = \frac{2\, \mathrm{Im}\, c}{1 + |c|^2}$$

for all moments or moments combinations which contain only unnatural parity exchange amplitudes. The relation seems to work in the limited region where it be has been tested. R decreases with m and has no strong variation with t in the ρ mass region. The minimum nonflip amplitude is obtained by assuming c pure imaginary. In the mass region this assumption helds to A_1-exchange (unnatural parity exchange nucleon spin nonflip) amplitude of roughly 20% of the corresponding flip amplitudes.

Amplitude analysis

A model independent determination of nucleon spin flip and nonflip amplitudes is not possible from this experiment since the polarization of the recoiling neutrons is not measured. One can however determine two sets of "transversity" amplitudes g and h corresponding to a polarization of the neutron perpendicular to the production plane ($g^u = \frac{1}{\sqrt{2}}(n^u + i f^u)$, $h^u = \frac{1}{\sqrt{2}}(n^u - i f^u)$, $g^N = \frac{1}{\sqrt{2}}(n^N + i f^N)$, $h^N = \frac{1}{\sqrt{2}}(n^N - i f^N)$), n and f-nonflip, flip, indices N, u- natural, unnatural parity exchange. The relative phase between the set of g and the set of h - amplitudes remains unmeasurable.

Up to the ρ mass region where only s and ρ waves have to be considered 14 real quantities (8 amplitudes and 6 relative phases) are determined by 15 moments ($\sigma\langle Re\, Y^{l}_{m}\rangle$, $\sigma\langle \cos\psi\, Re\, Y^{1}_{m}\rangle$ and $3\langle \sin\psi\, Im\, Y^{1}_{m}\rangle$ moments) giving one constraint Suitable combination of the moments allows a splitting of the set of 15 equations into 4 subsets which can be solved analytically. The analysis has been performed in the ρ mass region ($.71 < m < .83$) for several bins in t. The analytical solution were taken as starting values for a χ^2 minimalization to satisfy the constraint. In most cases only one unique result for the magnitude of the amplitudes was obtained. The question of phase ambiguities is still under investigation.

The solutions for the transversity amplitudes of the S-wave (g_S, h_S), the helicity zero P_0-wave (g_0, h_0 - the helicity one unnatural parity exchange P_- - wave (g_u, h_u) and the natural parity exchange P_+-wave (g_N, h_N) are shown in fig.3. The solid curves are obtained from a fit

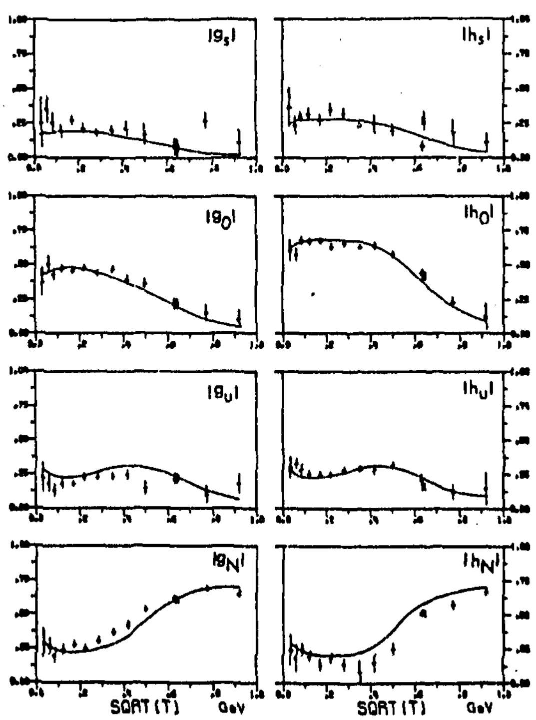

Fig.3. t-dependence of "nucleon transversity" amplitudes in the ρ-mass region ($.71 < m_{\pi\pi} < .83$).

of the moments by adding A_1 and A_2 exchange to the "poor man s absorbtion"model/3,4/. The amplitudes are normalised so that the squares enter with equal weight in the cross section.

Without the presence of nonflip amplitudes g and corresponding h amplitude would have the same magnitude. A lower limit for the nonflip amplitude is given by relation

$|n| > ||g| - |h||/\sqrt{2}$.

The knowledge of the transversity amplitudes allows a determination of the intensity $|n|^2 + |f|^2 = |g|^2 + |h|^2$ for each partial wave separately (fig.4) and

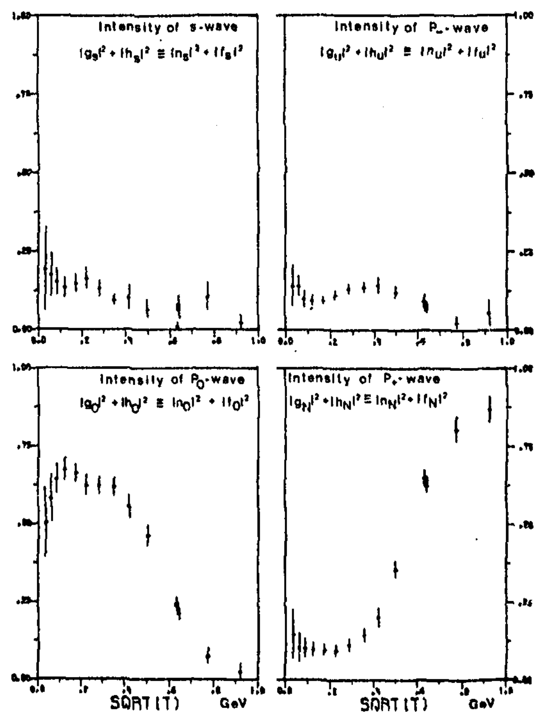

Fig.4. Intensities of the partial waves calculated from the transversity amplitudes.

therefore a exact splitting of the cross section into natural and unnatural parity exchange contributions.

Conclusions

The strong nucleon polarization effect found in a kinematic region which was supposed to be dominated by one pion exchange was completely unexpected. If it is due to the exchange of an additional particle this object has the quantum number of the A_1. Possibly it can also be explaned-similarity to the helicity one moments in one pion exchange - by final state interaction. The problem is of particular interest for $\pi\pi$ scattering as A_1 exchange has been assumed to be absent in all $\pi\pi$ phase hift analysis. A continuation of the unfinished analysis will hopefully clarify the situation.

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PARALLEL SESSION ON BARYON SPECTROSCOPY

RESONANCES AND RESONANCE PARAMETERS FROM A πN PARTIAL WAVE ANALYSIS BETWEEN 0.8 AND 2.0 GeV/c

R.E.Cutkosky, R.E.Hendrick
Carnegie-Mellon University, Pittsburgh,

R.L.Kelly
Lawrence Berkeley Laboratory, Berkeley, California

Phenomenological models of baryon structure have been studied with increasing interest in recent years. The SU(6)xO(3) harmonic oscillator model proposed by Greenberg, and its relativistic[2] and diquark[3] variations, have had notable success in reproducing the observed baryon mass spectrum. More recent developments such as the "dual string"[4] and "bag"[5] models of baryons have again focused attention on the spectrum of baryon resonances.

The primary source of information to test such models comes from partial wave analyses. For distinguishing among models, resonances on non-leading trajectories are of critical importance. It is hard to study such resonances, because they occur in partial waves which have low statistical weights and which are strongly affected by phase ambiguities. They also have small inelasticities and tend to overlap. For the unbiased determination of resonances in low partial waves, accurate data and sophisticated partial wave analysis methods are necessary.

We have analyzed amalgamated pion proton scattering data at 26 momenta in the range $0.8 \leq P_{lab} \leq 2.0$ GeV/c using the accelerated convergence expansion (ACE) method, in which higher partial waves are not required to vanish, but are determined by particle exchange processes and by extrapolation from lower partial waves. Dispersion relations along curves which lie within the physical region for scattering were used to remove ambiguities and to generate predicted amplitudes at each energy.