POSSIBLE POLARIZATION MEASUREMENT FOR $\bar{p}p \to \bar{K}K$, $\pi^+\pi^-$ REACTION*

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Abstract

Polarization measurements are suggested for nucleon–antinucleon annihilation into two pseudoscalar mesons in the S region (total energy $\sim 1\cdot 9$–$2\cdot 0$ GeV). The particular purpose is to distinguish the dominant J value of suspected ^{3}D resonances; measurements with both beams *and* targets polarized would be especially revealing.

Recent experimental studies of $\bar{p}p$ and $\bar{p}n$ annihilation in the S region, $s^{\frac{1}{2}} \approx 1\cdot 9$–$2\cdot 0$ GeV, particularly with two pseudoscalars $K\bar{K}$ or $\pi^+\pi^-$ (Carson *et al.* 1972; Cline and Rutz 1972, and earlier references cited therein) indicate that the region is generally dominated by D-wave $\bar{p}p$ interactions. There is no current evidence for P or F waves, S waves are insufficient, and G waves are too remote. There is some suspicion of direct channel resonance formation (Benvenuti *et al.* 1971, and earlier references cited therein; Burrows *et al.* 1970; Peaslee 1972) that should be $^3D_1$ or $^3D_3$, but present data do not permit distinction between these alternatives. On the other hand, the J value of any ^{3}D resonance in this region is of crucial significance for the construction of straight-line Regge trajectories for bosons (Peaslee 1973). For $J = 3$ it is still possible to preserve parallelism among all the trajectories of the quark model, ^1L_L, ^3L_L, $^3L_{L}\pm 1$, but $J = 1$ probably indicates at least three different trajectory slopes.

As a possible aid to unraveling this situation an estimation is made here of the polarization effects to be expected in $\bar{p}p \to 2$ pseudoscalars, using polarized beams and/or targets. Use of the two-pseudoscalar channel limits consideration to triplet states, and there seems to be a general absence of odd-L interaction in this region. Accordingly, we calculate polarizations for a mixture of $^3S_1$, $^3D_1$, and $^3D_3$ states.

Let P be the target polarization and p that of the beam, both along the y axis perpendicular to the beam. With this spin quantization for the scattering function ψ and omitting the spin $S = 0$ state, we have

$$(4k)^2 \mathrm{d}\sigma/\mathrm{d}\Omega = [|\psi^+|^2 + |\psi^0|^2 + |\psi^-|^2] + (p+P)[|\psi^+|^2 - |\psi^-|^2] + pP[|\psi^+|^2 + |\psi^-|^2 - |\psi^0|^2]. \tag{1}$$

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Rotation of the spins to the z axis leaves invariant the intensity

$$I_0 = [|\psi^+|^2 + |\psi^0|^2 + |\psi^-|^2] \rightarrow [|\Psi^+|^2 + |\Psi^0|^2 + |\Psi^-|^2].$$

The polarization terms become

$$(p+P)I_1 \cos\theta \sin\theta \cos\phi = (p+P)\, 2\,\mathrm{Im}\{\Psi^{0*}(\Psi^1 - \Psi^{-1})/\sqrt{2}\} \quad \text{(2a)}$$

and

$$pP(I_0 - 2\sin^2\phi\, I_2) = pP[|\Psi^0|^2 - 2\,\mathrm{Re}\{\Psi^{-*}\Psi^+\}], \quad \text{(2b)}$$

where θ is the scattering angle and ϕ the angle between the polarization axis and the normal to the scattering plane $\boldsymbol{n}' \times \boldsymbol{n}$.

With dimensionless amplitudes normalized to $|S_1|^2 \leqslant 1$, $|D_1|^2 \leqslant 1$, and $|D_3|^2 \leqslant 1$, we have

$$I_0 = A_0 + A_2 P_2(\cos\theta) + A_4 P_4(\cos\theta), \quad \text{(3a}_1\text{)}$$

$$A_0 = 3|S_1|^2 + 3|D_1|^2 + 7|D_3|^2, \quad \text{(3a}_2\text{)}$$

$$A_2 = 3|D_1|^2 + 8|D_3|^2 + 6\,\mathrm{Re}\{S_1^*(\sqrt{7}\,D_3 - \sqrt{2}\,D_1) - \sqrt{\tfrac{2}{7}}\,D_1^* D_3\}, \quad \text{(3a}_3\text{)}$$

$$A_4 = 6|D_3|^2 - 36\sqrt{\tfrac{2}{7}}\,\mathrm{Re}\{D_1^* D_3\}; \quad \text{(3a}_4\text{)}$$

$$I_1 = B_0 + B_2 P_2(\cos\theta), \quad \text{(3b}_1\text{)}$$

$$B_0 = 3\sqrt{2}\,\mathrm{Im}\{S_1(3D_1^* + \sqrt{(14)}D_3^*)\}, \quad \text{(3b}_2\text{)}$$

$$B_2 = 15\sqrt{(14)}\,\mathrm{Im}\{D_1^* D_3\}; \quad \text{(3b}_3\text{)}$$

$$I_2 = \{C_0 + C_2 P_2(\cos\theta) + C_4 P_4(\cos\theta)\}\sin^2\theta, \quad \text{(3c}_1\text{)}$$

$$C_0 = 3|S_1 + D_1/\sqrt{2}|^2 + 2\sqrt{7}\,\mathrm{Re}\{D_3^*(S_1 + D_1/\sqrt{2}) + 14|D_3|^2\}, \quad \text{(3c}_2\text{)}$$

$$C_2 = 40|D_3|^2 + 10\sqrt{7}\,\mathrm{Re}\{D_3^*(S_1 + D_1/\sqrt{2})\}, \quad \text{(3c}_3\text{)}$$

$$C_4 = 30|D_3|^2. \quad \text{(3c}_4\text{)}$$

It is clear that terms of the I_2 type will be much more significant than those of type I_1. With a polarized target, existence of the I_2 terms depends on polarization in the beam, and at beam momenta around 500 MeV/c it seems quite possible that a $\bar{\mathrm{p}}$ beam will be initially polarized. This can be discovered by searching for the I_2 term, but it will be important for the polarized target to be rotatable so that $\boldsymbol{p}.\boldsymbol{P}$ can be maximized. It must be possible to measure the scattering angle θ in the plane of the target polarization P.