PROTON-ANTIPROTON ANNIHILATION IN $M(12)$ SYMMETRY MODEL*

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In this Letter we would like to discuss possible tests of the $M(12)$ symmetry model,[1-3] which is a relativistic generalization of the SU(6) symmetry model. For the tests scattering processes are not suitable. For example, it is obvious that peripheral scatterings do not satisfy the $M(12)$ symmetry if they are dominated by nonet vector-meson exchange and/or nonet pseudoscalar-meson exchange. Since intermediate states of $M(12)$-invariant amplitudes are not restricted by equations of motion, most $M(12)$-invariant amplitudes should be interpreted as due to contact interactions.[4] Therefore, even if the $M(12)$ symmetry model is a good one for some physical quantities, such as the D/F ratio of the magnetic moment of the octet baryon, scattering amplitudes are sums of $M(12)$-symmetric amplitudes and SU(6)-multiplet exchange amplitudes,[5] which break the $M(12)$ symmetry. At present it is a mysterious fact that scattering amplitudes are not $M(12)$ symmetric while their singularities form SU(6) multiplets.

Until now the success of the $M(12)$ or SU(6) symmetry model has been limited only to vertices with no (or small) momentum transfer. In this Letter we propose to test the $M(12)$ invariance of vertices with large momentum transfer.

Let us consider the electromagnetic interaction of the baryon in the model,[1,2]

$$f(q^2)\left[J_\rho^{(V)}A_\rho - \frac{1}{\mu}J_{\rho\sigma}^{(T)}\mathfrak{F}_{\rho\sigma}\right], \qquad (1)$$

where we make use of the assumption that a photon transforms like the $\sqrt{3}\rho^0-\varphi^0$ component of the 143-plet meson (M_{143} or $M_\alpha{}^\beta$), which consists of a nonet of vector mesons and a nonet of pseudoscalar mesons. The q^2 is the momentum transfer squared. Then, the D/F ratio for Sachs's electric form factor[1,2] $G_E(q^2)$ of the octet baryon is equal to zero and that for the magnetic form factor $G_M(q^2)$ is equal to $\frac{3}{2}$. In order to satisfy the condition that $G_E=G_M$ at $q^2=-4m_p^2$, both G_E and G_M must be equal to zero there since they have different D/F ratios. Since both $J_\rho^{(V)}$ and $J_{\rho\sigma}^{(T)}$ have a kinematical factor, $1+(q^2/4m_p^2)$ (see Tables II and III of reference 1), $G_E=G_M=0$ at $q^2=-4m_p^2$ [if $f(q^2)$ is nonsingular there]. Therefore, we find

$$\sigma(p+\bar{p}\text{ at rest}\to e^+ + e^-)=0 \qquad (2)$$

in the model. We consider this as one suitable test for the relativistic SU(6) symmetry model.

For the test of SU(3) symmetry models the annihilation of proton and antiproton into two octet pseudoscalar mesons (P_8) has been used.[6,7] As has been explained above, the vertex of proton and the M_{143} vanishes at the threshold of the process $p+\bar{p}\to 2P_8$. Therefore,

$$\sigma(p+\bar{p}\text{ at rest}\to 2P_8)\approx 0, \qquad (3)$$

if we assume that the annihilation is dominated by the process $p+\bar{p}\to M_{143}\to M_{143}+M_{143}$ which breaks the $M(12)$ symmetry. Since the cross section of the process is not large, about 0.2 mb or less,[8] we may regard the annihilation at rest as an $M(12)$-forbidden process.

Besides the above mechanism, there are the following three $M(12)$-invariant amplitudes:

$$\bar{B}^{\alpha\beta\gamma}B_{\alpha\beta\gamma}M_\epsilon{}^\delta M_\delta{}^\epsilon, \qquad (4)$$

$$\bar{B}^{\alpha\beta\gamma}B_{\alpha\beta\delta}M_\epsilon{}^\delta M_\gamma{}^\epsilon, \qquad (5)$$

$$\bar{B}^{\alpha\beta\gamma}B_{\alpha\delta\epsilon}M_\beta{}^\delta M_\gamma{}^\epsilon, \qquad (6)$$

where the $B_{\alpha\beta\gamma}$ is the field of the 364-plet which consists of an octet and a decuplet of baryons. At low energies $p\bar{p}$ pairs annihilate mostly in S states. Since the $M(12)$ singlet has spin-parity 0^+ (or the $^3P_0$ state of the $p\bar{p}$ system), the amplitude (4) does not contribute to our process. The amplitudes (4), (5), and (6) also have kinematical zeros at the threshold of the process $p+\bar{p}\to 2M_{143}$, but they can be canceled by the poles of their form factors in this case. If they give finite contributions by the cancellation, we obtain the following relations among cross sections:

$$\sigma(p+\bar{p}\to\pi^{+}+\pi^{-}):\sigma(p+\bar{p}\to K^{+}+K^{-}):\sigma(p+\bar{p}\to K_1^{0}+K_2^{0})=49A+B:4A:25A, \quad (7)$$

where A is the contribution from[9] (5) and B is that from (6). Since the experimental result[8] is about 3:1:0.43, and since it is far from (7), we had better regard the process $p+\bar{p}\to 2P_8$ to be forbidden in the $M(12)$ symmetry model on the assumption that the form factors of the amplitudes (4)-(6) are nonsingular at the threshold of the processes. Then $p+\bar{p}\to P_9+V_9$ and $p+\bar{p}\to 2V_9$ must be regarded as $M(12)$-forbidden processes, too. Among them, only $p+\bar{p}\to\rho^0+\pi^0$ has been observed.[10]

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OBSERVATION OF THE LOW-ENERGY Λ-p INTERACTION*†

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In this report we present preliminary results on the measurement of the spectrum of K^+ mesons produced in p-p collisions at 2.85 and 2.40 BeV. The experiment was performed at the Brookhaven Cosmotron; the external proton beam (5×10^{10} protons/pulse) was incident on a 12-in. liquid-hydrogen target, and three spectrometer channels were established at 0°, 17°, and 32°. Each channel was equipped with focusing quadrupoles and appropriate bending magnets in an arrangement similar to the one previously used for the measurement of the pion spectra.[1] The momentum resolution was 1.2% for the 0° beam and 2% for the other angles with a solid angle $\Delta\Omega\sim2\times10^{-4}$ sr.

The K^+ mesons were identified by momentum analysis and velocity discrimination in differential Cherenkov counters, with either gas or liquid[2] radiators. Since the fraction of K^+ mesons in the secondary beams, at the location of the detectors, is of the order of 3×10^{-4} (3×10^{-3} at 17°), rejection as high as 10^5 to 10^6 was required; this was achieved by combining two Cherenkov counters in coincidence. The efficiency of the two-counter system was obtained either by using protons of the same β (as the K^+ mesons) or by using a third counter in coincidence with the system; the combined efficiency ranged from 55 to 85%.

The observed K^+-meson yields have been corrected for decay which typically at 0° amounts to a factor of 4.5 for 2.0-BeV/c and to a factor of 15 for 1.0-BeV/c K's. Corrections for Coulomb and nuclear scattering in the radiators have been also estimated and compared with these effects on pions and protons which