Observation of chiral properties of baryons in the threshold $\pi\eta$ production

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Recently, we have pointed out that there are two distinctive realizations of chiral symmetry in the baryon sector [1, 2, 3]. It has been shown that what we have called the naive and mirror assignments exhibits interesting differences in both phenomenology and theoretical aspects of chiral models.

The essence of the two assignments goes as follows. It emerges when we consider two kinds of baryons, and as chiral symmetry implies they are assumed to be positive and negative parity baryons which form a chiral multiplet. When there are two baryons, the chiral symmetry group allows to assign two distinctive axial (γ_5) transformations on the baryon fields [4, 5] ψ_1 and ψ_2:

$$[Q_A, \psi_1] = -g_A\gamma_5\psi_1\,, \quad [Q_A, \psi_2] = \mp g_A\gamma_5\psi_2\,, \tag{1}$$

where g_A is the axial charge and the sign $-$ on the second equation corresponds to the naive and $+$ to the mirror. In other words, in the mirror assignment, the second baryon ψ_2 carries g_A of opposite sign to ψ_1. Because of this, the mirror assignment leads to several interesting phenomenological consequences; one of most nontrivial one is that baryon masses can remain finite when chiral symmetry is restored. This raises a question on the mechanism of baryon mass generation [5].

Theoretical studies based on QCD are needed to understand such a chiral symmetry aspect of the baryons. On the other hand, recently we have studied it phenomenologically and proposed experiments to observe relative sign of g_A of ψ_1 and ψ_2.

Our setups are:

1. We assume that the negative parity nucleon which is supposed to be the chiral partner of the nucleon is $N(1535)$. This makes the experiments easier since the eta meson can be a signal of the resonance.

2. We observe another pion in the final state as well as eta. Since the pion couples both the nucleon and the resonance, we expect interference effects depending on the relative sign of the couplings.

In the figures below, we show cross sections of the pion induced and photon induced reactions. Since the coupling of the incident particles differ, the pattern of the interference appears differently. In both reactions, the effect is detectable in the present experimental setups.

References

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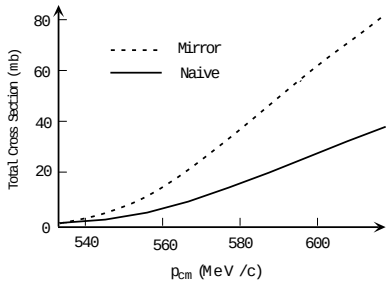

Figure 1: Total cross sections of $\pi^- p \to \eta\pi^- p$ for the naive and mirror models as functions of the initial pion momentum $P_{c.\ m.}$ in the center of mass frame.

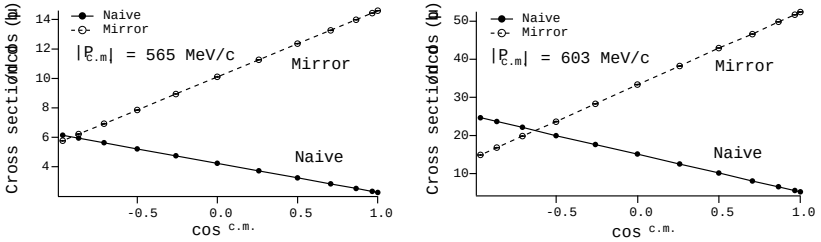

Figure 2: Angular distributions of the π^- in the final state.

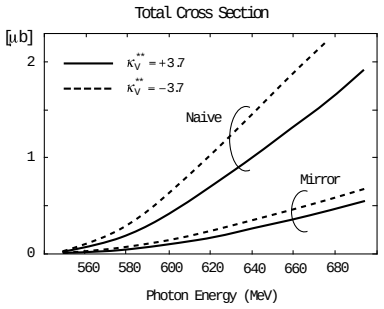

Figure 3: Total cross sections for $\gamma p \to \eta\pi^0 p$ for the naive and mirror models as functions of the initial pion momentum $P_{c.m.}$ in the center of mass frame.

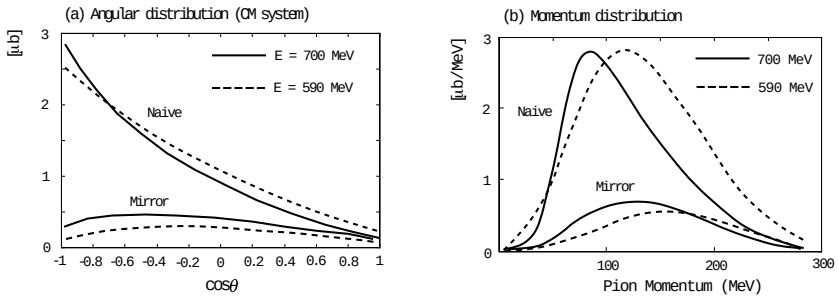

Figure 4: (a) Angular and (b) momentum distributions of π^0 in the final state. Cross sections at the incident photon energy $E = 590$ MeV are scaled by 10 for the angular distributions and 20/3 for the momentum distributions.