Comments on "Duality and Nonleptonic Hyperon Decay"

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It is shown that the results of Nussinov and Rosner, for S-wave hyperon decay, do depend upon assuming current algebra and partially conserved axial-vector current, contrary to the claim made by them.

IN a recent Letter, Nussivov and Rosner[1] applied duality (in the sense of Dolen, Horn, and Schmid[2]) to nonleptonic hyperon decay and derived some interesting results for the S-wave amplitudes. We would like to point out in this note that, contrary to their claim, their results do depend upon the partially conserved axial-vector current (PCAC) hypothesis.

Let us first recapitulate their procedure briefly. They considered the scattering amplitude for

$$S+B\rightarrow B'+\pi, \tag{1}$$

which at the zero four-momentum of the spurion is proportional to the decay amplitude for

$$B\rightarrow B'+\pi. \tag{2}$$

They then assume (i) asymptotic Regge behavior, (ii) the usual analyticity properties, (iii) duality in the sense of Dolen, Horn, and Schmid, (iv) lack of exotic states in all channels, and (v) current-current form for the weak interaction.

They divide the contribution to the amplitude into two parts, (a) s- and u-channel poles and (b) contributions described by Regge exchange in the t channel. It is then argued that for P-wave amplitudes the baryon-pole contributions (in the s and u channels) are very large and thus, owing to these large fluctuations, the duality between (b) and (a) is not expected to hold. For S-wave amplitudes, the pole contributions are small and so the amplitudes should be well described by (b) alone, i.e., by the t-channel K^* and K^{**} exchanges. Their results follow immediately from this last conclusion.

We would like to point out the following: First, they have based their assumption that baryon poles are important (for P waves) on current-algebra results.[3] Although it does seem reasonable on general grounds that the baryon poles would play an important role in P-wave amplitudes without the current-algebra (and PCAC) calculation, one has no *a priori* knowledge of how (quantitatively) important this role is. Secondly, their assertion that baryon-pole contributions are small for S-wave amplitudes is also not correct *in general*. The mass-difference factors in the numerators mentioned by them arise only if one assumes derivative coupling (i.e., one incorporates PCAC), but not in general.[4] *A priori*, the baryon-pole contributions to S waves can be quite large,[5] and then the extrapolated Regge term would not describe the amplitude adequately. To summarize: Without appealing to current algebra and PCAC, one does not know whether the (s- and u-channel) pole contributions (for both S and P waves) are large or not; to that extent, duality (as used by Nussinov and Rosner[1]) does not offer an explanation of any features of nonleptonic hyperon decay.

We would like to point out that for S waves, when the baryon-pole terms are not neglected, there is the following interesting result. If in the baryon-pole terms we take baryon masses to be equal and $D/F=\sqrt{3}$, and in the Regge exchange assume pure F-type coupling of K^* and K^{**} trajectories, then the two contributions from (a) and (b) are algebraically identical.[6] So we do have duality between the two contributions. It is amusing that $D/F=\sqrt{3}$ for BBP coupling and pure F-type coupling for BBV and BBT residues are not too far from the observed values. Taking equal masses for baryons is not too bad either since only the sums of masses are involved. Finally, this gives a one-parameter fit to the amplitudes [$F=1$ in Eq. (5) of Ref. 1]:

$$(\sqrt{\tfrac{2}{3}})\Sigma_0{}^+=\Sigma_-{}^-=-(\sqrt{\tfrac{2}{3}})\Lambda_-{}^0=(\sqrt{\tfrac{2}{3}})\Xi_-{}^-,\ \Sigma_+{}^+=0,$$

which is fair, considering the approximations made.

We hope to return to the possibility of deriving octet dominance and to the difficult problem of P-wave amplitudes elsewhere.

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[1] S. Nussinov and J. Rosner, Phys. Rev. Letters **23**, 1264 (1969).

[2] R. Dolen, D. Horn, and C. Schmid, Phys. Rev. **166**, 1768 (1967).

[3] A. Kumar and J. C. Pati, Phys. Rev. Letters **18**, 1230 (1967), and references therein to earlier work.

[4] See, for example, D. S. Carlstone, S. P. Rosen, and S. Pakvasa, Phys. Rev. **174**, 1877 (1968).

[5] It is true that current-current form of H_W and $SU(3)$ forbid baryon poles for S-wave amplitudes [B. W. Lee and A. R. Swift, Phys. Rev. **136**, B228 (1964)]. However, such forbiddenness does not always prevent fairly large amplitudes; e.g., $K_1\rightarrow 2\pi$, which is also forbidden in the same limit but has an "allowed" (i.e., sizable) amplitude.

[6] The details may be found in Ref. 4. Note that we cannot derive octet dominance for the baryon-pole terms. So the statement made is only true for an octet Hamiltonian.