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Inconsistency in the Value of the D/F Ratio for the Axial-Vector Current

M. L. Whippman
Research Institute for Theoretical Physics, University of Helsinki, Siltavuorenpenger 20B, Helsinki 17, Finland
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An inconsistency pointed out by Kaushal and Khanna is shown not to occur.

In a recent note,[1] Kaushal and Khanna claim to have shown that it is possible to get inconsistent results for the D/F ratio of the baryon axial-vector current if it is assumed that both the current and its divergence are SU(3) octet operators.

An essential ingredient of their proof is the assumption that all matrix elements of an octet operator taken between baryon states can be expressed in terms of just two parameters – an F- and a D-type coupling. This is true, of course, if the baryons transform like the components of an irreducible octet, which in turn is true only if the symmetry is unbroken. Correspondingly, the equations of Kaushal and Khanna have a perfectly consistent solution with all the baryon masses equal. When the symmetry is broken, however, the baryon states contain admixtures of other representations, and many more reduced matrix elements appear in the expression for the axial-vector current matrix elements. These terms are of the same order as the baryon mass differences, and must be included in the equations. When they are, no inconsistencies arise.

These terms are usually neglected in the most naive applications of Cabibbo theory; they should, nonetheless, be taken into account. It might be worth mentioning, however, that the conventional formalism of perturbation theory shows that they do not occur in the mass formula, to lowest order.

[1] V. Kaushal and M. P. Khanna, Phys. Rev. D 5, 1541 (1972).

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Shadow Channels in Potential Theory

M. Shah-Jahan
Atomic Energy Center, Dacca, Bangladesh
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The effect of coupling a shadow channel to a real channel is considered using separable potentials.

Shadow states have been of interest in local relativistic field theories, since they can save such theories from running into divergence difficulties.[1] The introduction of shadow states generates additional forces, i.e., it has effects on dynamics. Recently Moore has considered the effect of coupling a shadow channel to a real channel within the context of potential theory.[2] His model is a very restricted one, so we in this note propose to consider the same problem using single-term separable form factors for all forces.

For simplicity, we consider s-wave scattering and use the notation of Moore as far as possible.

The coupled Schrödinger equations are

$$\left(\frac{d^2}{dr^2}+K_i^2\right)u_i(r)=\int_0^\infty \sum_j V_{ij}(r,r')u_j(r')dr', \quad i=1,2;\; j=1,2. \quad (1)$$

Let us assume that the kernels $V_{ij}(r,r')$ are separable and that all of them have the same shape factor, i.e.,

$$V_{ij}(r,r')=\lambda_{ij}q(r)q(r'). \quad (2)$$

This condition readily implies that all forces have the same range.

Now one can easily obtain

$$\left(\frac{d^2}{dr^2}+K_i^2\right)u_i(r)=a_i q(r)\,, \tag{3}$$

where

$$a_i=\sum_j \lambda_{ij}\int_0^\infty q(r)u_j(r)dr\,. \tag{4}$$

The formal solutions to Eq. (3) are

$$u_i(r)=u_i^{\text{homo}}(r)+a_i\int_0^\infty G_i(r,r')q(r')dr'\,. \tag{5}$$

The Green's functions $G_i(r,r')$ depend upon the boundary conditions. We write

$$u_i(r)=u_i^{\text{homo}}(r)+a_i z_i(r)\,, \tag{6}$$

where

$$z_i=\int_0^\infty G_i(r,r')q(r')dr'. \tag{7}$$

If channels 1 and 2 are considered to be the real and the shadow channel, respectively, we can write

$$u_1(r)=u_1^{\text{homo}}(r)+a_1 z_1(r)\,, \tag{8}$$

with

$$z_1(r)=\int_0^\infty G_+(r,r')q(r')dr' \tag{9}$$

and

$$u_2(r)=a_2 z_2(r)\,, \tag{10}$$

with

$$z_2(r)=\int_0^\infty G_s(r,r')q(r')dr'\,. \tag{11}$$

Now one can use the equations (4), (8), and (10) to calculate a_1 and a_2.

The Schrödinger equation for the real channel in absence of coupling with the shadow channel is

$$\left(\frac{d^2}{dr^2}+K_1^2\right)u_1(r)=\lambda\int_0^\infty q(r)q(r')u_1(r')dr'\,. \tag{12}$$

Introducing the quantity

$$c_1=\int_0^\infty q(r)u_1(r)dr \tag{13}$$

and using (3), we can obtain the following equation for $u_1(r)$:

$$\left(\frac{d^2}{dr^2}+K_1^2\right)u_1(r)=\frac{a_1}{c_1}q(r)\int_0^\infty q(r')u_1(r')dr'\,. \tag{14}$$

Comparison of (12) and (14) shows that the coupled-channel equation for the real channel can be reduced to a single-channel problem with an effective strength $\lambda_{\text{eff}}=a_1/c_1$. After a bit of algebra one can show that in our model the scattering amplitude will have the same analytic properties as that of Moore.

In his model Moore has considered $V_2(r)=0$ and has used δ-shell potentials, which makes the model extremely restricted. In our calculation we do not have to put $\lambda_{22}=0$. Nevertheless, the use of same form factors for all forces makes the model severely restricted. So the conclusion that the shadow states change the dynamics can be shown exactly using very restricted models.

[1]E. C. G. Sudarshan, in *Fundamental Problems in Elementary Particle Physics: Proceedings of the Fourteenth Solvay Institute of Physics Conference* (Wiley, New York, 1968), p. 97; T. D. Lee and G. C. Wick, Nucl. Phys. B9, 209 (1969).

[2]R. J. Moore, Phys. Rev. D 4, 3755 (1971).