AIP Conference Proceedings, E.V. Hungerford III, Editor
2nd International Conference on Meson Nuclear Physics New York 1979, 67-68
Houston, Texas

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A POSSIBLE POLE IN THE πNN VERTEX FUNCTION AND THE LOW ENERGY πN SCATTERING

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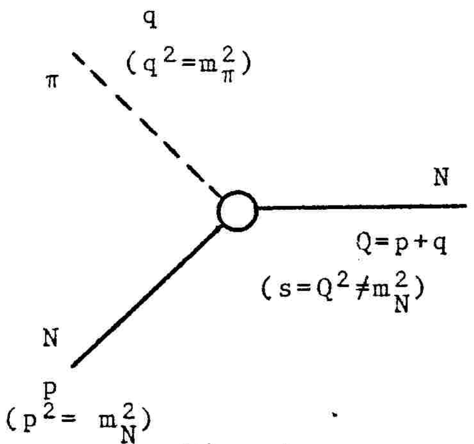

Fig. 1.

Using the πN phase shifts and inelasticities in the P_{11} and S_{11} partial waves, we have calculated the pion nucleon vertex function with one nucleon off-mass-shell through a dispersion approach[1] (the kinematical situation is shown in Fig. 1). We can summarize the result as follows. (i) As a function of W ($\equiv \pm\sqrt{s}$) the vertex function $\Gamma(W)$ has two poles in the unphysical region $|W| < m_N + m_\pi$: at $W_+ \sim 1030$ MeV and $W_- \sim -125$ MeV respectively, whereas the dressed nucleon propagator $S_F'(W)$ has zeros at the same positions. (ii) The pole position W_+ is very much sensitive to input variations whereas W_- is pretty stable. Considering the nature of approximations we have made, the existence of the pole at W_- (and the corresponding zero of $S_F'(W)$ at W_-) will be definite. (iii) The physical amplitudes in the P_{11} and S_{11} may be written as

$$f_\pm^{tot}(W) = - R_\pm(W)\ \Gamma(\pm W)\ S_F'(\pm W)\ \Gamma(\pm W) + f_\pm^{irr}(W)$$

$$(+ \ldots P_{11},\ - \ldots S_{11}) \qquad (W > 0) \qquad (1)$$

In eq. (1) the first term which is the dressed (direct) nucleon pole term ($R_\pm$ (W) is some kinematical factor) has turned out to have pole(s) at $W_-(W_+)$ with negative residue(s) (ghost(s) !). However, any such kind of pole has been shown to be cancelled exactly by the second term, viz. $f_\pm^{irr}(W)$ [2]. Thus even if the vertex function does have a pole, we may not be able to conceive of its existence through physical scattering data.

Fortunately there appears one limiting situation where the contribution comes only from the dressed (direct plus crossed) nucleon pole term so that we may observe some signal from the possible vertex pole(s). This is the well known soft pion limit : although not exactly physical, it can be close to physical situations. In such a limit Adler[3] showed using PCAC that the iso-symmetric πN invariant amplitude $A^{(+)}(s,u,t)$ at $s = u = o$ gets contributions from nucleon pole term and is equal to $G^2/4\pi m_N$ with G the strong πNN coupling constant.

We have calculated $A^{(+)}$ $(s = u = o,t)$ from the dressed nucleon pole term (direct and crossed) using our $\Gamma(W)$ and $S'_F(W)$ with the result :

$$A^{(+)}(s=u=o,t) = \frac{G^2}{4\pi m_N}\left[1-\Gamma^2(-m_N)J(-m_N)\right] = 1.07\times\frac{G^2}{4\pi m_N} \qquad (2)$$

with $$J(W) \equiv S'_F(W)/S_F(W) \quad , \quad S_F(W) \equiv \frac{1}{W-m_N}$$

(note that the above result is obtained not in the soft pion limit, so a deviation of $O(m_\pi^2/m_N^2)$ is to be naturally expected). The fact that it is very close to Adler's value is due to the small value of $\Gamma(-m_N)$, and the small $\Gamma(-m_N)$ has resulted from the very existence of the pole at W_- which has absorbed a good part of the strength in $\Gamma(W)$. Furthermore, the above result indicates that the effective πNN coupling to be used in low energy πN processes prefers pseudo-vector type.

As for the possible existence of the pole at W_+ we can say nothing definite at present.

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