J=I=1, Vector Mesons and Low-Energy π-N Scattering (*)

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Summary. — The effect of including a 2π-vector meson interaction into the Chew-Low interaction with pionic re-scattering has been examined. This model shows negligible corrections on the low-energy π-N s and p phase shifts for vector mesons with mass (3.5–5.5)μ. A vector meson of mass 4μ contributes to the J = 1/2 π-N cross-section sufficiently (∼150 mb) at 650 MeV but does not reproduce its width.

1. Introduction.

Bowcock, Cottingham and Lurie (1) have recently shown that by appropriate choices of the π-N spectral functions it is possible to fit the isotopic vector part of the nucleon form factors and to also improve on the low-energy π-N phase shifts of the Chew, Low, Goldberger and Nambu (2) calculation. Since the spectral functions of ref. (1) have a δ-function mass spectrum at an energy 4.7 μ, it is reasonable to seek its connection to the J = I = 1 meson (2).

It may be that such a detailed dynamical answer cannot be obtained at present since it involves untangling several strong interactions. Nevertheless,

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since the Chew-Low model offers a convenient method for doing low-energy calculations we have felt it worth-while to consider the additional effect of a direct vector meson-$2\pi$ interaction.

In the following, the isotopic spin flip $s$, $p$, $d$ wave amplitudes will be calculated by using a phenomenological (4) vector meson-$2\pi$ interaction in the Born approximation but including pionic re-scattering corrections in the one-pion approximation. This calculation differs from that of Itabashi et al. (5) by the inclusion of pionic re-scattering corrections which are ignored in their work.

2. Dynamics.

Let the total Hamiltonian be

$$H = \sum_k \omega(k) a_k^+ a_k + H_I,$$

then the scattering states are

$$\Psi^\pm_p = a_p^+ \Psi_0 + \frac{1}{\omega(p) - H + i\epsilon} [H_I, a_p^+] \Psi_0.$$

The scattering amplitude from an initial pion $q$ and nucleon $m$ to a final pion $p$ and nucleon $m'$ is

(1) \( \langle \Psi_p^+ | [H_I, a_q^-] | \Psi_0(m) \rangle = \langle \Psi_0(m') | [a_p, [H_I, a_q^-]] | \Psi_0(m) \rangle + \)

\[ + \langle \Psi_0(m') | [a_p, H_I] \frac{1}{\omega(p) - H + i\epsilon} [H_I, a_q^+] | \Psi_0(m) \rangle + \]

\[ + \langle \Psi_0(m') | [H_I, a_q^+] \frac{1}{\omega(p) + H} [H_I, a_p] | \Psi_0(m) \rangle. \]

Letting

$$H_I = H_I^\gamma + H_I^\rho,$$

where the first term is the pion-nucleon interaction of the Chew-Low theory and the second is

(2) \( H_I^\rho = -\sqrt{2} \int dx \sum_{\alpha\beta} \varepsilon_{\alpha\beta} \overleftrightarrow{B}_\mu^\beta, \)

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