Modification of the Chew-Low Formula for the $(\frac{3}{2}, \frac{3}{2})$ π-$\mathcal{N}$ Resonance.

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The theory of Chew and Low for π-$\mathcal{N}$ scattering results in a formula, containing two parameters, which may be used to fit the observed phase shifts. It is most useful in the case of the $T=\frac{3}{2}$, $J=\frac{3}{2}$ state which contains the well-known resonance at approximately 2(?)0 MeV (lab.). The usual form [1] is

$$\frac{\eta^3}{\omega^*}\operatorname{ctg}\alpha_{33} = \frac{3}{4f^2}\left(1-\frac{\omega^*}{\omega_0}\right), \tag{1}$$

where $\eta=p/m_\pi c$ and p is the pion c.m. momentum, $(mc^2\omega^*)$ is the π-$\mathcal{N}$ c.m. energy less one nucleon mass, ω_0 is the resonance value and f is the coupling constant. For $\omega^* < \omega_0$ the straight line form of (1) agrees well with experiment, but for $\omega^* > \omega_c$ there is serious disagreement, as one might expect for a theory derived in a low energy approximation. However, it is possible to obtain good agreement with the data by noting that (1) actually [2] should contain $\eta^3[V(K)]^2$ in place of η^3. As explained by Wick

$$V(K) = \int \exp[i\boldsymbol{K}\cdot\boldsymbol{x}]\,\varrho(\boldsymbol{x})\,\mathrm{d}\boldsymbol{x}\,, \tag{2}$$

where K is the wave number

$$\left(K=\eta\left(\frac{\hbar}{m_\pi c}\right)\right),$$

and $\varrho(\boldsymbol{x})$ is the « extended source distribution » for the nucleon. In formula (1) $V(K)=1$ and $\varrho(\boldsymbol{x})=\delta(\boldsymbol{x})$. Actually, in a convergent theory one must introduce a cutoff. Instead of the usual sharp cutoff at $\omega^*=M/m_\pi$ (M=nucleon mass), I have considered the following:

$$\varrho(\boldsymbol{x}) = \frac{a^2\exp[-ar]}{4\pi r}\,. \tag{3}$$

This is a Yukawa source distribution, and yields a smooth cutoff for $V(K)$ or $V(\eta)$:

$$V(K) = \frac{1}{1+K^2a^{-2}}\,. \tag{4}$$

Introducing this into (1) it is possible to fit the data with $a^{-1}=0.38$ fermi

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($0.27(\hbar/m_\pi c)$ or $1.8(\hbar/Mc)$). The other constants are approximately in agreement with those of JOHNSON and CAMAC [7]:

$$f^2 = 0.087\,,$$

$$\omega_0 = 2.17\,.$$

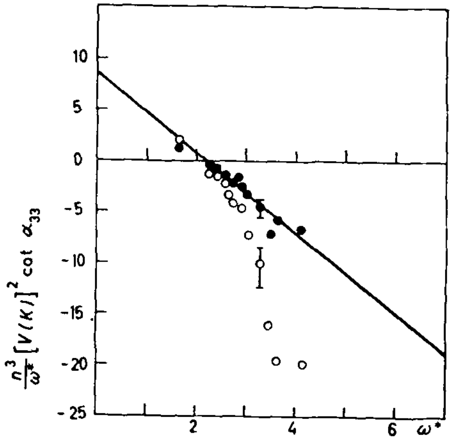

Fig. 1. – A Chew-Low plot for two values of $V(K)$ is shown above. The points are from the data of references [3-6]. The straight line is for $f^2 = 0.087$, $\omega_0 = 2.17$.

Since the Chew-Low theory is for a non-relativistic static nucleon problem and relies on the assumption that a complicated integral expression [8] can be approximated as a constant effective range (or equivalent ω_0), the agreement achieved with (4) may be fortuitous. Nevertheless it is interesting to note that the simple application of a more « realistic » nucleon source of approximately nucleonic dimensions brings theory and experiment together, as shown in the figure.

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