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400-1000 MeV NN Scattering in OBE-πNN Dynamics and Dibaryons —— Δ Off-shell Effect and the backward going pion contribution ——

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Many people have argued the origin for the anomalies appearing in the 1D2 and 3F3 phase parameters of 400-1000 MeV pp scattering. Is it possible to describe them by π, N and Δ degrees or beyond it ? This arguement has been made by examining deviation of some theoretical result based on the calculation of π, N and Δ degrees from the empirical phase parameters. Among all relatively reasonable calculations are three-body calculations of πNN system. However conclusions from such calculations by several groups are not always in accord. Then the interpretation of the 3F3 and 1D2 anomalies in terms of the πNN dynamics [1] has been often questioned.

However I would like to emphasize that important elements with which conclusions from the πNN calculations branch in favor or in disfavor for the interpretation are (i) the off-shell effect of the input πN P33 interaction, (ii)the backward going pion contribution (BGπC) in time to the Δ, (fig. 1) and (iii) the heavy meson exchange contributions [2]. The πNN calculation with careful choice of those elements reproduces very well the pp scattering observables [3]. (This is presented in this conference.)

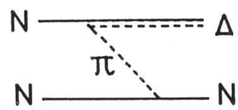


fig.1 BGπC

In this paper we show the importance of elements (i) and (ii) for the 3F3 phase parameter by using the model presented in this conference [3]. Let us see (1) the effect on the 3F3 phase parameter when off-shell structure of the input πN P33 interaction is changed with its on shell structure unchanged and (2) the effect when the BGπC is changed.

(1) πN P33 off-shell effect. The πN potential is given in a rank-one separable form: $V(p',p) = - g(p')\, g(p)$, where

$$g(p) = p\sum_{n=1}^{5} \frac{C_n}{p^2+(n\beta)^2} \cdot \frac{1+a}{1+a\exp\left[(p/p_c)^2\right]} \qquad (1)$$

The P33 phase shifts at E_L = 0-400 MeV are very well represented with

$$C_1,\cdots,C_5 = -0.04176,\ 6.980,\ -47.08,\ 96.53,\ -57.72$$
$$\beta = 1\ \mathrm{fm}^{-1},\ a = 0.2,\ \text{and}\ p_c = 6\ \mathrm{fm}^{-1}. \qquad (\mathrm{I})$$

This set of parameters is adopted in ref. 3. (Be I.) However the phase shifts are equally well represented with the set (be called as II),

$$C_1,\cdots,C_5 = -0.2447,\ 12.55,-87.65,\ 190.7,\ -122.2$$
$$\beta = 1\ \mathrm{fm}^{-1},\ a = 0.2,\ \text{and}\ p_c = 5\ \mathrm{fm}^{-1}. \qquad (\mathrm{II})$$

We consider also the form factors by Araki and Ueda[4] and by Thomas [5]. All those four reproduce very well the P33 phase shifts below 400 MeV — on shell equivalent. However the off shell structures are quite different. Incidentaly we show the form factors in fig.2 and the πN wave functions ψ(r) in fig.3 wnich is defined by,

$$\psi(r) = N\int_0^\infty dp\, p^2\, j_1(pr)\left[E_\Delta - \sqrt{p^2+m_\pi{}^2} - p^2/2m_N\right]^{-1} g(p), \qquad (2)$$

where E_Δ is the Δ energy: E_Δ = (1234-i60)MeV - m_N and N is the normalization factor.

The 3F3 phase parametere is calculated by use of the four P33 potentials with all other parts kept unchanged. The result in fig.4 displays remarkably large effect of the off shell structure. A form factor with more peripheral r structure in Re $\psi(r)$ creates a stronger anomaly in the phase parameters. This indicates that careful choice of the πN P33 potential is crucially important for argument of the 3F3 anomaly.

(2) In ref. 3 the BGπC G_B is introduced in the three-body Green function G ($G = G_F + G_B$) as follows.

$$G_B = [\, E - E_\pi(q_\pi) - E_N(q_1) - E_\Delta(q_2)]^{-1} - \xi[\, E - E_X(q_\pi) - E_N(q_1) - E_\Delta(q_2)]^{-1}, \quad (3)$$

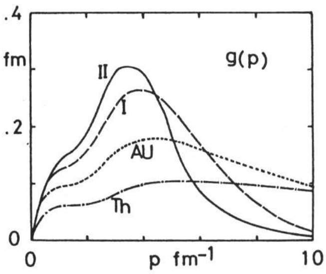
where the second term represents the cutoff of the large momentum transfer part. Now we put as

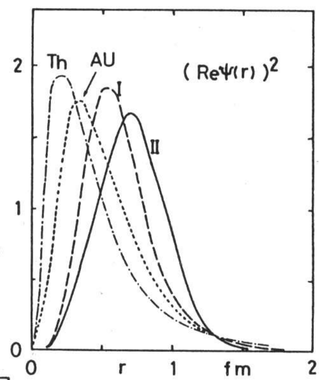
$$G = G_F + \zeta\, G_B, \qquad (4)$$

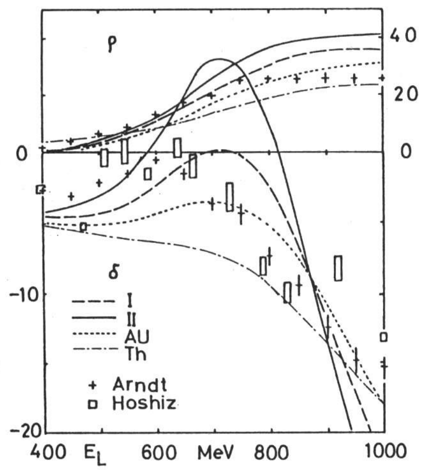
and show the 3F3 phase parameter for various cases of ξ and ζ . The result in fig. 5 indicates that with $\zeta < 0.5$ the anomalous structure becomes flattened and thus the BGπC is found to be importnant.

In intermediate energy physics πN P33 interaction plays a fundamental role. However, generally, the effect of the off shell structure is not well recognized. Therefore I would like for people to take attention to the off shell structure in relation to various anomalous phenomena in the intermediate nuclear physics of the Δ energy region.

Finally it is another problem whether the 1D2 and 3F3 anomalies are associated with the pole structure in the complex energy plane or not. Let us note ref. 6 for this problem where we concluded the pole structure in those states.







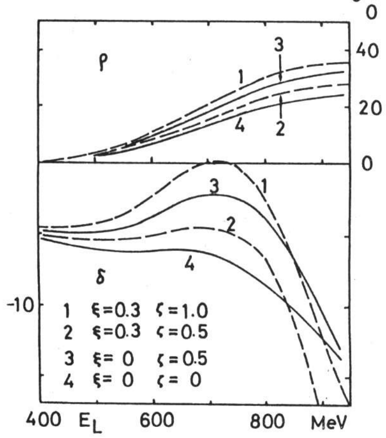


fig.2 (Upper-left) Form factors, I,II, Araki-Ueda[4] and Thomas[5].

fig.3 (Upper-center) The πN wave functions.

fig.4 (Upper-right) The off shell effect on the 3F3 phase shift δ and absorption angle ρ.

fig.5 (Down-left) The BGπC to the 3F3 phase shift δ and absorption angle ρ.

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