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On the P' Regge Singularity

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Usually, vacuum quantum number exchange is parametrized in terms of the so-called P and P' trajectories. We recall that P' is associated to the exchange corresponding to the $f^0(1260)$ meson, built from direct channel resonances in the dual sense.[1)]

In this note we want to critically review the main phenomenological results concerning P' and present some arguments showing that this singularity may not be considered on an equal footing with the ordinary Regge trajectories, i.e., ρ, ω, etc.

Let us begin by recalling the difficulties faced by phenomenological analysis of π-N and K-N elastic scattering in connection with the P' singularity. Barger and Phillips[2)] obtained for the P' trajectory $\alpha_{P'}=0.56+0.86t$ with a three pole fit to π-N elastic scattering data, using continuous moment sum rules. Its extrapolation up to the value $m^2_{f^0}$ (square of the f^0 mass) gives a value close to the integer 2, so the first requirement to identify P' with f^0 exchange is fulfilled. The situation is less clear with respect to the P' residue function where we need an extrapolation procedure to check its consistency with the value of the residue of the corresponding amplitude at the f^0 pole, as computed by other methods.

In Ref. 2), the following ansatz is proposed for the P' residue function in the $A'^{(+)}\pi$-N amplitude:**)

$$\gamma_{P'}(t)=\lambda(t)\pi^2[\Gamma(\tfrac{1}{2}\alpha_{P'}(t))]^{-2}. \quad (1)$$

Equation (1) formally coincides with the modification of a previous Barger and Phillips cyclic ansatz[3)] proposed by Goldberg.[4)] The main difference appears in the function $\lambda(t)$. In Ref. 4) the following is used:

$$\lambda_0(t)=51.5e^{2.1t}+13.1e^{-0.41t}, \quad (2)$$

whereas in the new fit there results:[2)]

$$\lambda_N(t)=22.3+16.9e^{0.34t}. \quad (3)$$

Now, the consistency requirement between f^0 and P' would be that $\gamma_{P'}(t)$ extrapolates well to the value of the residue of the $A'^{(+)}$ at the f^0 pole (and correspondingly $\beta_{P'}(t)$ to $B^{(+)}$). In the case of the $B^{(+)}$ amplitude, Goldberg[5)] has obtained for the residue, when expressed in terms of Regge parameters, $\beta_{P'}(m^2_{f^0})\simeq+348.0\,\mathrm{GeV}^{-2}$. The consistency presented in Ref. 4) is certainly impressive because the extrapolation from Eq. (2) gives $\beta_{P'}(m^2_{f^0})\simeq+340.0\,\mathrm{GeV}^{-2}$. However, we remark as a first critical argument that the extrapolation procedure of the residue function is not free of suspicion. In Ref. 4) an arbitrary average value for $\lambda_0(t)$ (Eq. (2)) is taken because of its rapidly increasing behaviour for positive values of t. As the new fitted value $\lambda_N(t)$ (Eq. (3)) is not immediately divergent for positive t, we can try a direct calculation of this $\lambda_N(t)$ at the value $t=m^2_{f^0}$, which is free of the arbitrariness on the average procedure. In this way we found for the extrapolated Regge residue function $\beta_{P'}(m^2_{f^0})\simeq 500\,\mathrm{GeV}^{-2}$, so we see that the impressive agreement is lost. Moreover, a Lovelace analysis of π-N backward dispersion relations[6)] indicates a very small value for the product of couplings of the f^0 to the NN and $\pi\pi$ system. This leads to a value for $\beta_{P'}(m^2_{f^0})$ which is remarkably different and also its sign seems poorly determined.

We want to add a brief summary of

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**) We use the parametrization of Ref. 2) for the $A'^{(+)}$ and $B^{(+)}$ π-N amplitudes in terms of Regge exchanges.

several other inconsistencies referred to the P' singularity.

Fits to π-N elastic scattering give $\alpha_{P'}(0) \simeq 0.57$. However if the systematic errors are taken properly into account, the sum rules lead to a much smaller value ($\alpha_{P'}(0) \simeq 0.1-0.3$).[7),8)] If Regge cuts are considered, the intercept of the trajectory, which is poorly determined, can rise up to 0.4.[9)] With respect to K-N elastic scattering, similar low values for the trajectory intercept are found.[10)] We note that all these fits for P' are much less precise than those performed for other Regge poles and depend on the assumption of the strength of the Pomeron coupling.

Other phenomenological evidence is that P' decouples from the $A^{(+)}\pi$-N amplitude and so it is possible to explain the small value of the sum $P_+ + P_-$ of $\pi^+ p$ and $\pi^- p$ polarization data.[11)] It appears that P' is found in those amplitudes where also P is present.

Finally, let us remark on a recent result using global duality.[12)] It is found that the elastic part of the forward amplitude corresponds to the P' and can be ascribed to the ABFST cut.[13)]

We can conclude saying that a collection of evidence including a comparative study of the P' residue function in terms of Regge fits and the f^0 couplings to NN and $\pi\pi$ seems to indicate that the connection of P' trajectory with the f^0 meson is not valid and we have to understand P' as an effective singularity needed to introduce corrections to the Pomeron exchange in elastic scattering. In this context, one can relate P and P' with the nonresonating background in the direct channel, using the language of duality.

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