REGGE POLES IN THE N–N AND $\bar{N}$–N SCATTERING AMPLITUDES

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Regge poles [1] in the *N-N* scattering amplitude have been discussed recently [1-8]. In particular the spin structure of the *N-N* scattering amplitude, due to the main vacuum pole, or Pomeranchuk pole, has been discussed in detail in [8].

Here we are concerned with the spin structure of the *N-N* and $\bar{N}$-*N* scattering amplitudes appearing if Regge poles with other quantum numbers are taken into account.

It is shown that if the signature [4] and isotopic spin are fixed, three other systems of poles, besides the poles with the vacuum quantum numbers, contribute to the amplitudes.

The requirement of analyticity of the amplitudes leads to the statement that two of these three systems of poles will coincide at $t = 0$ (t being the momentum transfer) and the poles of the third system will have angular momenta which differ by ± 1 from the momenta of the poles of the first two systems.

Regge poles at $t = 0$ correspond to massless particles. The above coincidence means that the degeneration in parity and angular momenta occurs for massless particles not of the vacuum family.

This situation in its origin is analogous to the one discovered by one of the authors [9] in the meson-nucleon backward scattering amplitude. In this case the poles of the amplitudes with different parity at zero mass coincide. In both cases the degeneration in spin and parity is due to an additional symmetry which appears at $t = 0$ and is connected with the existence of only one preferred direction in space.

The main difference between boson Regge poles which we considered and Fermi poles considered in [9] is that poles with different quantum numbers do not become complex conjugate for $t < 0$.

As has been shown in [8] the contribution of the vacuum poles to the amplitudes considered does not depend on spin at $t = 0$. The other systems of poles considered here lead to a spin dependence of the forward scattering amplitude. It occurs that the spin structure is essentially different in the two cases where the angular momentum of the main pole of the third system differs from that of two other coinciding systems by $+1$ or by -1. In the first case the additional contribution to the forward scattering amplitude is of axial vector character and leads to a correlation of the longitudinal nucleon polarization. In the second case it is of tensor character and leads to a correlation of the transversal nucleon polarization.

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REGGE-POLES AND HIGH ENERGY SCATTERING

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1. The challenging idea—so often emphasized by Chew—that perhaps all the existing particles are manifestations of Regge poles, has still to overcome very serious difficulties. In fact, if it somehow turns out to be true, it would lead not only to a drastic change in our understanding of the " particle " concept but obviously to a complete revision of the mathematical apparatus by which we now try to describe scattering processes, bound states etc. In the present report we take a more modest standpoint and want to point out some consequences of the " Regge hypothesis " in high energy scattering. Part of the results we report, has been found independently by Gell-Mann [1a] and Gribov and Pomeranchuk [1b].

2. It has been shown earlier [2] that equations of the Mandelstam type (generalized unitarity plus double dispersion relations) can be asymptotically satisfied ($s \to \infty$) with an Ansatz of the form: $A_1(s, t) \sim \alpha(t) P_L(z)$. On the other hand, representing the pion-pion partial amplitude in N_l/D_l form, and solving the resulting equations by iteration, in every step of the iteration procedure, one obtains an amplitude meromorphic [3] in l; therefore one can hope that the most important properties of partial wave amplitudes established for potential scattering, will be carried over to field theory without any essential change.

Led by the analogy with potential scattering we " define " Regge poles as poles of the partial wave amplitudes on the second sheet of the Riemann surface belonging to the elastic cut [4]. In fact, with the help of the reality condition: $A_l(z^*) = A_{l^*}(z)^*$ and the generalized unitarity [5]

$$A_l - A_{l^*}^* = 2i\rho A_l A_{l^*}^* \tag{1}$$

(ρ is a phase space factor), we find the following expression for the amplitude on the second sheet:

$$A_l^{II} = \frac{A_l}{1 + 2i\rho A_l}. \tag{2}$$

The solutions of the equation

$$1 + 2i\rho A_l = 0 \tag{3}$$

give the equations of the Regge trajectories. Including other particles into the scheme, one immediately verifies that in the crossed reaction (square of energy $= t$) of an elastic process, the same poles appear for all the possible channels. Hence one finds by crossing symmetry that the diffraction scattering of all the possible particle combinations " is the same ", and that between total cross-sections there are relations of the type [1, 2, 4]

$$\begin{aligned} \sigma_{\pi N}^2 &= \sigma_{\pi\pi} \\ \sigma_{\pi K}^2 &= \sigma_{\pi\pi}\sigma_{KK} \\ \sigma_{\pi\pi}\sigma_{KN} &= \sigma_{\pi N}\sigma_{K\pi}, \text{ etc.} \end{aligned} \tag{4}$$