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Author
Millan, Jaime.

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Jaime Millan

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THE SIGN OF THE UNNATURAL-PARITY CYLINDER*

Jaime Millan**

Department of Physics and Lawrence Berkeley Laboratory
University of California, Berkeley, California 94720

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ABSTRACT

We explain the sign difference between the natural-parity and the unnatural-parity cylinder by using a Reggeon-loop model proposed previously by Chew and Rosenzweig.

It is an empirical fact that the pseudoscalar mesons π, η and η' display a deviation from "ideal" behavior strikingly different from the deviation exhibited by the vector-tensor mesons ρ, ω, ϕ, and A_2, f, f'. Not only is the magnitude of the deviation much larger for the pseudoscalars but the direction is opposite. For example, comparing particles of even charge conjugation, the I = 0 f is <u>less</u> massive than the I = 1 A_2 by ≈ 40 MeV while the I = π is <u>more</u> massive than the I = 0 η by ≈ 400 MeV. A comparison of mixing angles reveals a similar difference of magnitude and sign. In refs. 1 and 2 the vector-tensor deviation from ideal, both in masses (or Regge intercepts) and in mixing angles, was discussed through the topological expansion and

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related to the so-called "cylinder". It has been pointed out[2,3] that the same general consideration should apply to unnatural-parity states, but no explanation has been given of the opposite sign that is experimentally required for the cylinder. The present note explains this sign difference through a Reggeon-loop model of the cylinder. The same model can be used to estimate the magnitude of the unnatural parity cylinder, but we shall defer the question of magnitude to a subsequent lengthier paper. The sign is a simple matter, at least near t = 0.

Positivity of total cross sections implies that the even charge-conjugation natural-parity cylinder is positive at t = 0.[2] In the context of a simple Reggeon-loop model with each link twisted as depicted in Fig. 1, this positivity emerges from the symmetrical character of the loop. Since both links of the loop correspond to the same twisted (planar) reggeon, the product of propagators at t = 0, where $t_1 = t_2$, is positive. For the unnatural-parity cylinder, parity conservation at t = 0 requires an unsymmetrical loop, one link carrying natural parity and the other link unnatural parity.[4] We now show that such an unsymmetrical loop, built from leading planar trajectories such as shown in Fig. 2, will have a sign opposite to that of a symmetrical loop.

We start from the general observation that, because planar discontinuities (of elastic amplitudes) are positive, the residues of the poles in a planar Reggeon propagator are all positive. For example, a familiar model for a planar propagator associated with a trajectory $\alpha_i(t_i)$, where the first physical particle occurs at $J = N_i$, is

$$S_i^P(t_i) = \exp(-i\pi(\alpha_i(t_i) - N_i))\,\Gamma(N_i - \alpha_i(t_i)) \quad . \quad (1)$$

The alternation in sign of the gamma function poles in formula (1) is compensated by the oscillating exponential factor. Twisted propagators, needed for the links of the Reggeon loops that build the cylinder through the model of Fig. 1 or 2, are obtained from corresponding planar propagators by adding a factor $\exp(+i\pi\alpha_i(t_i)$:

$$S_i^{PX}(t_i) = \exp(i\pi\alpha_i(t_i))S_i^{P}(t_i) \qquad (2)$$

Such a factor makes negative the residues of all poles of odd J, leaving positive the even-J poles. For example, corresponding to the model planar propagator of formula (1), one has the model twisted propagator

$$S_i^{PX}(t_i) = (-1)^{N_i}\,\Gamma(N_i - \alpha_i(t_i)) \qquad (3)$$

For the planar and the cylinder loop at $t = 0$ one requires t_1 and t_2 to be both negative. What sign may we expect for each twisted propagator? The sign is likely to be controlled at negative t_i by the residue of the nearest particle-pole, i.e. that at $\alpha_i(t_i) = N_i$. The model of formula (3) exhibits this property. If this first particle has odd J the twisted propagator is negative; when the leading particle has even J, the twisted propagator is positive. Therefore, for an unsymmetrical loop such as shown in Fig. 2, where the leading unnatural-parity particle (π) is even while the leading natural-parity particle (ρ) is odd, the overall sign is negative.

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FIGURE CAPTIONS

Fig. 1. Symmetrical Reggeon loop model of the natural parity cylinder. The notation is the same as in ref. 2.

Fig. 2. Unsymmetrical Reggeon loop model of the unnatural-parity cylinder.

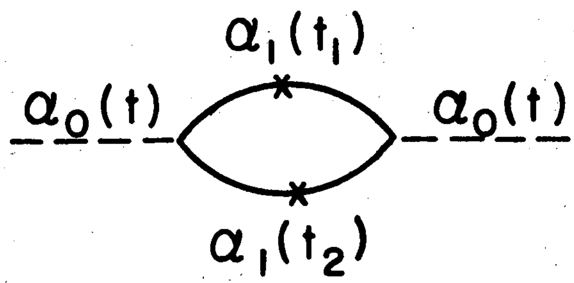

Fig. 1

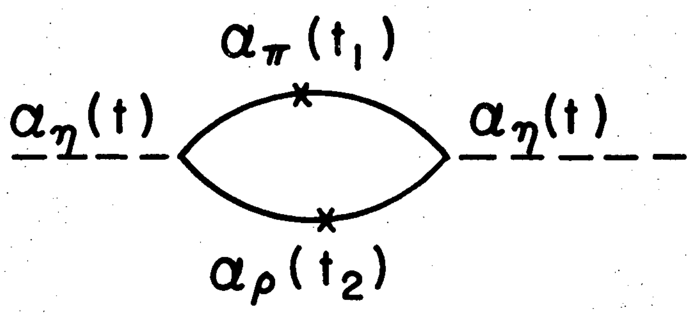

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Fig. 2

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LAWRENCE BERKELEY LABORATORY
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