

Lawrence Berkeley National Laboratory

Recent Work

Title

THE SIGN OF THE UNNATURAL-PARITY CYLINDER

Permalink

<https://escholarship.org/uc/item/9538h0tq>

Author

Millan, Jaime.

Publication Date

1976-08-01

Submitted to Physical Review D
(Comments and Addenda)

LBL-5374
Preprint c.1

RECEIVED
LAWRENCE
BERKELEY LABORATORY
OCT 6 1976
LIBRARY AND
DOCUMENTS SECTION

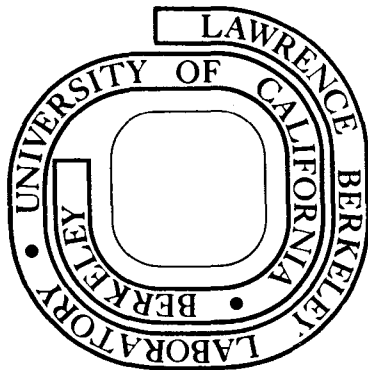
THE SIGN OF THE UNNATURAL-PARITY CYLINDER

Jaime Millan

August 17, 1976

For Reference

Not to be taken from this room



Prepared for the U. S. Energy Research and
Development Administration under Contract W-7405-ENG-48

00004601532

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

THE SIGN OF THE UNNATURAL-PARITY CYLINDER*

Jaime Millan**

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

August 17, 1976

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 less massive than the $I = 1 A_2$ by ≈ 40 MeV while the $I = \pi$ is more massive than the $I = 0 \eta$ 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

*This work was supported in part by the U. S. Energy Research and Development Administration.

**Participating Guest, LBL. On leave from Departamento de Fisica, Universidad del Valle, Cali, Colombia.

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 $\alpha_1(t_1)$, where the first physical particle occurs at $J = N_1$, is

$$S_1^P(t_1) = \exp(-i\pi(\alpha_1(t_1) - N_1)) \Gamma(N_1 - \alpha_1(t_1)) \dots (1)$$

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 $\exp(+i\pi\alpha_1(t_1))$:

$$S_1^{PX}(t_1) = \exp(i\pi\alpha_1(t_1))S_1^P(t_1) \quad (2)$$

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

$$S_1^{PX}(t_1) = (-1)^{N_1} \Gamma(N_1 - \alpha_1(t_1)) \quad (3)$$

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_1 by the residue of the nearest particle-pole, i.e. that at $\alpha_1(t_1) = N_1$. 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.

The author wishes to thank Professor G. F. Chew for suggesting this work and for his continuous help, guidance and encouragement. He

expresses his appreciation to the Rockefeller Foundation and Departamento de Física, Universidad del Valle, Cali, Colombia, for a Scholarship. He is also grateful to Professor J. D. Jackson for the warm hospitality at the Lawrence Berkeley Laboratory.

REFERENCES

1. G. F. Chew and C. Rosenzweig, Phys. Rev. D12, 3907 (1975).
2. G. F. Chew and C. Rosenzweig, Nuclear Physics B104 (1976) 290.
3. T. Inami, K. Kawarabayashi and S. Kitakado, Phys. Lett., 61B, 60 (1976).
4. G. Goldstein and J. Owens, Nuclear Physics B103 (1976) 145.

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.

00104601584

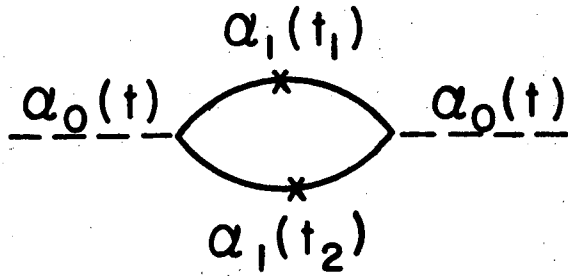
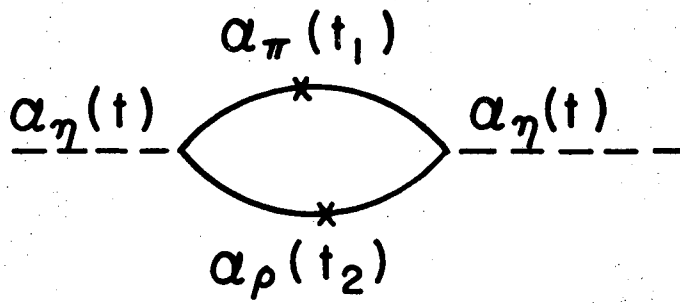


Fig. 1



XBL 768-3375

Fig. 2

This report was done with support from the United States Energy Research and Development Administration. Any conclusions or opinions expressed in this report represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the United States Energy Research and Development Administration.

TECHNICAL INFORMATION DIVISION
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720

5
4
3
2
1