

Lawrence Berkeley National Laboratory

Recent Work

Title

THEORETICAL ANGULAR DISTRIBUTION OF NUCLEON-ANTINUCLEON SCATTERING AT 140 MeV

Permalink

<https://escholarship.org/uc/item/8ww4q57k>

Author

Fulco, Jose R.

Publication Date

1958-02-18

UNIVERSITY OF
CALIFORNIA

*Radiation
Laboratory*

TWO-WEEK LOAN COPY

*This is a Library Circulating Copy
which may be borrowed for two weeks.
For a personal retention copy, call
Tech. Info. Division, Ext. 5545*

BERKELEY, CALIFORNIA

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.

UCRL-8183

UNIVERSITY OF CALIFORNIA

Radiation Laboratory
Berkeley, California

Contract No. W-7405-eng-48

THEORETICAL ANGULAR DISTRIBUTION OF
NUCLEON-ANTINUCLEON SCATTERING AT 140 Mev

Jose R. Fulco

February 18, 1958

Printed for the U. S. Atomic Energy Commission

THEORETICAL ANGULAR DISTRIBUTION OF NUCLEON-ANTINUCLEON SCATTERING AT 140 MEV

JOSE R. FULCO*

Radiation Laboratory
University of California
Berkeley, California

February 18, 1958

A possible explanation of the "large" value of the nucleon-antinucleon cross section,¹ in the intermediate energy range, has been given by the work of Ball and Chew² on the basis of the Yukawa interaction with a "black central hole" to account for the annihilation. Using the Gartenhaus potential,³ with the spin-orbit term added by Signell and Marshak,⁴ in the WKB approximation, they obtained results in satisfactory agreement with the experimental data available at the time.

In recent months, experiments both with bubble chambers and with emulsions have been planned and are now being carried out in order to obtain a more complete knowledge of the $p-\bar{p}$ interaction. In connection with this program it has seemed worth while to perform the calculation of the angular distribution of antinucleon-nucleon scattering, using the transmission coefficients and the phase shifts given in Reference 2. This is a report of the results of the calculation.

There are two important differences between the $N-N$ and $N-\bar{N}$ interactions. One is the annihilation process and the other the possibility of charge exchange: $p + \bar{p} \rightarrow n + \bar{n}$. The first is easily considered by using

*A visitor from the Argentine Army.

-3-

diagonal-scattering matrix elements of the form $S_\alpha = R_\alpha e^{2i\delta_\alpha}$ where R_α are the reflection coefficients and δ_α the real scattering phase shifts for the α eigenstate. The second involves isotopic-spin considerations.⁵ If the amplitudes for scattering in isotopic-spin singlet and triplet states are represented by f^1 and f^3 respectively, then the amplitudes for ordinary (o) and exchange (e) $p\text{-}\bar{p}$ and $n\text{-}\bar{n}$ scattering are given by

$$f^e = \frac{1}{2} \left(f^1 \pm f^3 \right).$$

For the $p\text{-}\bar{n}$ and $n\text{-}\bar{p}$ systems, which are pure isotopic triplets, there is no exchange scattering and the ordinary scattering amplitude is simply f^3 . Once these complications are recognized, the formalism developed by Blatt and Biedenharn⁶ can be consistently used.

Since in the WKB approximation there is no way to calculate "mixture parameters," interchange between waves with the same total angular momentum and parity but with different orbital angular momentum has not been considered in Reference 2. Therefore it must be assumed that the mixture parameters are small if this method is expected to give good accuracy. With mixing neglected, the scattering cross sections were calculated; the results are plotted in Figs. 1 and 2.

The forward peak in the ordinary scattering is largely a diffraction effect, since the S and P waves are mostly absorbed, leading to annihilation. The forward peak in the exchange scattering is much weaker.

Notwithstanding the very limited experimental data available up to now,⁷ a crude test of the theory can already be made by integrating the $p\text{-}\bar{p}$ elastic differential cross section of Fig. 1 over the forward and backward hemispheres separately to obtain 70 mb in the forward direction and 5 mb in

-4-

the backward. The six emulsion events found at Berkeley in the energy range between 40 and 200 Mev⁷ are all in the forward direction.

Further work is being done to extend the scope of this paper.

The author wishes to thank Professor Geoffrey F. Chew for his guidance and help throughout the work.

This work was done under the auspices of the United States Atomic Energy Commission.

REFERENCES

1. (a) Cork, Lambertson, Piccioni, and Wenzel, Phys. Rev. 107, 248 (1957).
(b) Chamberlain, Keller, Mermod, Segrè, Steiner, and Ypsilantis, Experiments on Antiprotons: Antiproton-Nucleon Cross Sections, UCRL-3876, July 1957.
2. James S. Ball and Geoffrey F. Chew, The Nucleon-Antinucleon Interaction at Intermediate Energies, UCRL-3922, Aug. 1957.
3. S. Gartenhaus, Phys. Rev. 100, 900 (1955).
4. P. Signell and A. Marshak, Phys. Rev. 106, 832 (1957).
5. T. D. Lee and C. N. Yang, Nuovo cimento 3, 749 (1956).
6. J. M. Blatt and L. C. Biedenharn, Revs. Modern Phys. 24, 258 (1952).
7. Chamberlain, Goldhaber, Jauneau, Kalogeropoulos, Silberberg, and Segre, Study of the Antiproton Annihilation Process with a Separated Antiproton Beam, UCRL-3900, Aug. 1957; and also the talk by G. Goldhaber at the International Conference on Mesons and Recently Discovered Particles, Venice-Padua, September 1957.

Legends

Fig. 1. Scattering cross section of \bar{p} - p^+ and \bar{n} - n , at $E_{\text{lab}} = 140$ Mev (in the c.m. system), (neglecting Coulomb scattering).

Fig. 2. Scattering cross section of \bar{p} - n and \bar{n} - p at $E_{\text{lab}} = 140$ Mev (in the c.m. system).



