needed to close the algebra.[10] It seems that introducing the notion of a supersymmetric covariant derivative[11] simplifies the formulation of the theory. It would be interesting to see whether our theory can be obtained from the Nath-Arnowitt superspace approach[12] or from the Zumino non-Riemannian geometry.[12]

Details of this work will be published elsewhere.

This work was performed during the summer institute at the Ecole Normale Supérieure in Paris. We thank Professor Meyer for the hospitality extended to us.

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‡Work supported in part by the National Science Foundation Grant No. MPS-74-132-08-A01.

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Experimental Confirmation of the Parity of the Antiproton

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(Received 18 May 1976)

The reaction $\bar{p}p \to 2\pi$ with polarized targets exhibits asymmetry. From this we extract the intrinsic parity of the antiproton.

With the availability of intense antiproton beams and polarized targets we are now in a position to investigate fundamental properties of antiprotons. In particular, we would like to raise the question of the *experimental* determination of the parity of the antiproton. On general theoretical grounds one would expect this parity to be such that a $\bar{p}p$ state with orbital momentum L has a parity $(-1)^{L+1}$. If the proton is described by a local relativistic field which transforms in a local manner under both Poincaré and space inversion transformations, then the $\bar{p}$ parity is opposite that to the proton.[1,2] This is most easily seen in terms of the asymptotic proton field which contains annihilation operators for the proton and creation operators for the antiproton. This requirement of quantum field theory transcends the minimum requirement of relativistic invariance, since it is not possible to transform particles into antiparticles by a real Lorentz transformation.

At the present time the true nature of the proton is not known. Many imaginative models of an extended nature are under intense investigation at the present time. It will be important for such models[3] to know whether the intrinsic parity (η)

is the accepted one. We show in this Letter that existing and forthcoming experimental results can be used to extract directly the antiproton parity.

Consider $\bar{p}p$ annihilation into $\pi^+\pi^-$. We assume the *CP* transformation properties of the initial and final states to be the same as those given by, e.g., the local field theory,[2,4] except for the fact that the intrinsic parity of the antiproton, is allowed *a priori* to be either -1 or $+1$. Then the *CP* of the initial state with[5] spin s is $\eta(-1)^s$, and the *CP* of the final state is even. For the latter, we have made use of the assumption that the parities of π^+ and π^- are the same, which can be justified from the observed decay of $f^0 \to 2\pi^0$ and $\pi^+\pi^-$ with the proper *I*-spin branching ratio of $\frac{1}{2}$. Thus the conservation of *CP* in strong interactions leads to the following important conclusions: For $\eta=-1$, only the triplet $\bar{p}p$ spin states contribute, whereas, for $\eta=+1$, only singlet $\bar{p}p$ states contribute.

In experiments with polarized targets, asymmetries in the differential cross sections between the polarizations of target proton normal to and antinormal to the scattering plane are measured.[6] From rotational invariance and conservation of parity for strong interactions, one finds that such asymmetries can only result from the interference between $\bar{p}p$ states with $s_z=0$ and those with $s_z=\pm 1$ where z is taken to be along the beam direction. This interference is possible only among the triplet states corresponding to the $\eta=-1$ case, but not among the singlet states, which correspond to the $\eta=+1$ case. Consequently, *observation of asymmetry* in $\bar{p}p \to \pi^+\pi^-$ is an unambiguous proof that *the antiproton has a negative parity.*

Erlich *et al.*[6] have observed the reaction $\bar{p}p \to \pi^-\pi^+$ from polarized targets and reported nonzero asymmetry. A similar high-statistics experiment has also been performed at CERN, where again nonzero asymmetries have been observed.[7] On the basis of these experiments we conclude that the antiproton intrinsic parity is negative. To our knowledge this is the first explicit observation that the intrinsic parity of antiproton is experimentally confirmed to be that expected from general field theory arguments.

*Work supported in part by the National Science Foundation.

†Work supported in part by the U. S. Energy Research and Development Administration under Contract No. E(40-1)3992.

[1]Strictly speaking, what is involved is the product of the $\bar{p}$, p intrinsic parities. If we choose the convention that the proton parity is $+1$, then this means the $\bar{p}$ parity is -1. (See e.g., R. E. Marshak and E. C. G. Sudarshan, *Introduction to Elementary Particle Physics* (Interscience, New York, 1961), Chap. 4.

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[3]See e.g., P. Carruthers, *Collective Phenomena* (Gordon and Breach, New York, 1973), Vol. 1, p. 147.

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[5]Here the conventional term "spin" is used. Technically speaking, the spin states of $\bar{p}p$ system are defined only nonrelativistically. For a relativistic system, the spin content may be specified by helicity states. [See M. Jacob and G. C. Wick, Ann. Phys. (N.Y.) 7, 404 (1959)]. It can be shown that the singlet and triplet $\bar{p}p$ helicity states have the identical *C*,*P* transformation properties as those of the corresponding spin states used. So our argument below is valid in general.

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