Title
TEST OF PARITY CONSERVATION IN pp SCATTERING AT 46 MEV

Author
von Rossen, P.

Publication Date
1980-06-01

LBL-11122 c.2

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

To be presented at the 5th International Symposium on
Polarization in Nuclear Physics, Santa Fe, NM, August 11-15, 1980

TEST OF PARITY CONSERVATION IN pp SCATTERING AT 46 MEV

P. von Rossen, U. von Rossen, and H. E. Conzett

June 1980

Prepared for the U.S. Department of Energy under Contract W-7405-ENG-48

DISCLAIMER

LBL-11122

TEST OF PARITY CONSERVATION IN pp SCATTERING AT 46 MEV*

P. von Rossen[+], U. von Rossen, and H. E. Conzett
Lawrence Berkeley Laboratory, Berkeley, CA 94720

ABSTRACT

An experiment has been designed to measure the effect of parity non conservation in $\vec{p}$-p scattering near 50 MeV. A target-detector system has been constructed which permits an extremely accurate comparison of the cross sections for incident protons of positive versus negative helicity. Our first measurements give a value of $A_z=(-1.3\pm 2.3)\times 10^{-7}$ for the longitudinal analyzing power.

It has been calculated[1] that the parity non conserving weak-interaction part of the nucleon-nucleon interaction should result in a non-zero value of the longitudinal analyzing-power A_z in $\vec{p}$-p scattering. A_z is given by

$$A_z = \frac{1}{|p_z|}\frac{\sigma^+ - \sigma^-}{\sigma^+ + \sigma^-} ,$$

where p_z is the beam polarization and $\sigma^+(\sigma^-)$ is the cross section for incident protons of positive (negative) helicity. The calculations predict A_z to have a broad maximum near 50 MeV with a value of at most a few times 10^{-7}. Thus, extreme care and precision is required in order to reduce the experimental error to such a leval.

The present experiment is done with a 50-MeV polarized proton beam from the Lawrence Berkeley Laboratory 88-Inch cyclotron. The atomic-beam type polarized ion source permits selection of ground state atomic hydrogen hyperfine states to provide the reversal of the proton polarization. This is done by rapid and automatic switching of the weak and intermediate field RF transitions. This selection in the neutral atomic beam minimizes beam intensity and position modulations which are coherent (i.e. in phase) with the reversal of the spin, as compared with any scheme whereby the spin reversal is achieved by magnetic and/or electric fields acting on an ion beam. Since the polarization direction is provided by the magnetic field, the beam from the cyclotron has only transverse (vertical) polarization. As shown in Fig. 1, a solenoidal magnetic field is used to precess the spin axis 90° into the horizontal plane, after which a dipole magnet bends the beam through an angle of 47.7° and precesses the spin axis into the beam direction. Thus, spin-reversal at the ion source results in proton helicity reversal at the target.

---

*Work supported by USDOE under contract W-7405-ENG-48.

[+] On leave from Institut für Strahlen und Kernphysik der Universität Bonn, Germany. Supported by the Deutscher Akademischer Austausch dienst.

Since integrated scattering rates of 10^9 to 10^{10} per second are obtainable, it is not difficult to achieve a statistical accuracy at the level of 10^{-7}. The severe challenge is to reduce the systematic effects, which provide false asymmetries, to a comparable level. These systematic errors arise from coherent changes of the beam properties with spin reversal. In order to minimize these effects, a cylindrically symmetric target-detector system has been constructed (Fig. 1). It consists of a thin walled tube pressurized to 80-atm of H_2 surrounded by a He filled ionization chamber at the same pressure. The ionization chamber has a four-fold symmetry which permits one to continuously monitor and correct for the residual transverse polarization components. Two beam-position sensing elements, consisting of secondary electron monitors in a quadrant geometry, are used both to monitor and control the beam in position and angle through the target. The beam steering elements controlled by these position sensors are located upstream of the solenoid magnet in order to assure constant beam positioning through the solenoid and bending magnets, which are the important beam-preparation elements. Improvements have been made on the polarized ion source and on the cyclotron in order to minimize instabilities which affect the ultimate accuracy obtainable with our experimental apparatus.

In contrast with the approach used by the Zürich group[2], our design is to control the coherent beam modulations to such an extent that the remaining effects are not influencing the measured asymmetry in a significant way. The success of this approach is seen in Table I, where our coherent beam position and intensity modulation amplitudes are two to three orders of magnitude smaller than those of reference 2.

Twelve observables are monitored continuously by an on-line computer in order to measure their correlation to the spin-reversal, which is set at a rate of 60 H_z. We have considered the following sources of systematic false asymmetries: (1) Beam intensity modulation. This has been minimized with a fast current control system. A correction for the remaining modulation (about 1×10^{-7}) has been made. Its effect has been measured by providing a coherent modulation via a signal to the beam buncher in the axial injection line of the cyclotron. (2) Beam position modulation. This has been kept extremely small with an automatic beam-position stabilization system which reduced the average position modulation to about 10^{-2} μm. Through a controlled modulation of the beam position, it has been determined that such a modulation amplitude makes no significant contribution to the measured asymmetry. (3) Beam emittance modulation. This modulation is present at the relative level of 10^{-5}, and its contribution to the measured asymmetry has been estimated. (4) Transverse polarization components. The effect of an average transverse polarization has been measured by using a beam with a known transverse polarization. The average values for p_x and p_y

were about 1×10^{-3}. The distributions of the transverse polarization components as functions of the transverse positions in the beam have been measured at the entrance to and the exit of the target. This was done by measuring the left-right and up-down asymmetries in the proton scattering from vertical and horizontal carbon rods as they were passed through the beam. The error that results from the measured polarization inhomogeneities has been estimated. (5) β-decay asymmetry. Because of the production of polarized β-active nuclei in the Faraday cup and the target-detector system, the parity nonconserving asymmetry of the β-decay could produce a helicity-dependent contribution to the Faraday cup and/or ionization chamber current. Such a Faraday cup effect has been reduced by applying a transverse magnetic field of about 0.1T to the cup. An effect on the ionization chamber current has not been studied yet, but it is estimated to be small.[2] (6) Electronic asymmetries. These have been checked by using constant voltage sources to simulate Faraday cup and ionization chamber currents and comparing the results for the two electronic states that correspond to the two proton helicity states.

Our present results, which are summarized in Table I, were achieved in 3-4 days of data acquisition. The measured asymmetry is

$$\varepsilon = |p_z|A_z = (-1\pm1.8)\times10^{-7},$$

which, with a value of $|p_z| = 0.80$ gives the result

$$A_z = (-1.3\pm2.3)\times10^{-7}.$$

The listed error is the root square sum of the statistical and systematic errors. The main contributions to total error are the statistical error and the systematic error due to transverse polarization components. These both can be reduced substantially when a new ionizer for the polarized ion source is installed in a few months. A factor of ten increase in the polarized beam intensity is anticipated.

We are grateful to R. M. Larimer for her assistance during the various stages of the preparation and the running of this experiment.

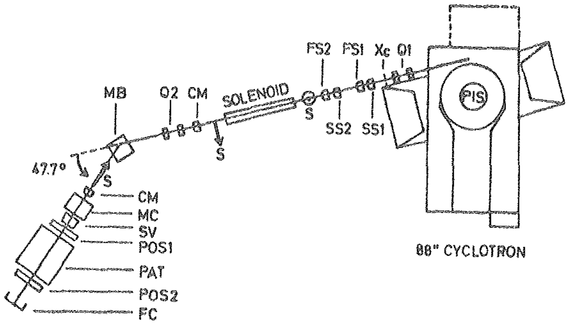

Fig. 1

The beam line and the experimental set-up. Q, quadrupole magnets; FS, fast steering magnets; SS, slow steering magnets; CM, centering magnets; MB, bending magnet; MC, monitor chamber; POS, beam position sensors; PAT target-detector assembly.

Table I. Summary of errors and results.

Systematic effect	Value	Contribution to error in $\|p_z\|A_z$ ($\times10^7$)
(1) Intensity modulation $(I^+-I^-)/(I^++I^-)$	$-1.3(3)\times10^{-7}$	0.2^a
(2) Position modulation $\langle x_1^+-x_1^-\rangle$	$-0.03(4)\times10^{-2}\,\mu m$	0.2
$\langle y_1^+-y_1^-\rangle$	$-0.2(1)\times10^{-2}\,\mu m$	0.2
$\langle x_2^+-x_2^-\rangle$	$0.4(2)\times10^{-2}\,\mu m$	0.2
$\langle y_2^+-y_2^-\rangle$	$1.6(4)\times10^{-2}\,\mu m$	0.2
(3) Emittance modulation $\delta Q/Q$	$\sim10^{-5}$	0.5
(4) Transverse polarization components		1.0
(5) Electronic asymmetry		0.3

measured $|p_z|$ A_z with statistical error $(-1.0\pm1.2)\times10^{-7}$
$|p_z|$ A_z with combined errors $(-1.0\pm1.8)\times10^{-7}$

[a] Includes estimate for β-decay asymmetry.

REFERENCES

1. M. Simonius, Phys. Lett. 41B, 415 (1972); Nucl. Phys. A220, 269 (1974). V. R. Brown, E. M. Henley, and F. R. Krejs, Phys. Rev. C 9, 935 (1974).
2. R. Balzer et al, Phys. Rev. Lett. 44, 699 (1980).