Charge Symmetry Breaking in the dd→$\alpha\pi^0$ Reaction

E.J. Stephenson and A.D. Bacher
Indiana University Cyclotron Facility, Bloomington, IN 47408

M.A. Pickar
Minnesota State University, Mankato, MN 56001

P.V. Pancella
Western Michigan University, Kalamazoo, MI 49008

The Cooler experiment to search for the isospin-forbidden and charge symmetry breaking (CSB) dd→$\alpha\pi^0$ reaction was completed at the end of July, 2002 with positive results. Following the experiment, there began a period of intensive data analysis aimed at obtaining total reaction cross sections for the process at the two energies where data was taken, 228.5 and 231.8 MeV. Values for the cross section were available by April, 2003 and reported at the spring meeting of the American Physical Society. These results were also summarized in the last IUCF Annual Report. Subsequently, a paper on the results was published in Physical Review Letters [1]. Crucial to the analysis was the minimization of the missing mass resolution and the handling of finite geometry effects in the calculation of the luminosity.

Work continued this summer along two lines: (1) a review of the steps in the analysis with a view toward making sure that the GEANT simulations were well matched to the experimental data, and (2) starting to organize the analysis of the d+d elastic scattering measurements made with polarized deuteron beam at the end of the experiment in 2002. We learned that with the latest version of GEANT, it was necessary to rematch the Pb-glass response. The Monte Carlo program provided a good simulation of the energy deposition associated with a photon, but we needed to provide empirical information on the characteristics of the light collection and the processing of the signals through the electronics. This was done by specifying a resolution function and adjusting its shape to match our data. Only small changes were noted in the efficiency of the Pb-glass detectors as used in the calculation of the total reaction cross section.

In parallel, we started a new Monte Carlo analysis of the response of the 44° scintillators used to monitor the luminosity. This was done to check an earlier Monte Carlo program that had been prepared from scratch. No significant differences were found in the losses due to the spread of the gas jet target distribution along the beam line. But the detailed matching of the Monte Carlo spectra to those recorded for the forward scintillators used to observe d+p elastic scattering is still in process. The response of these detectors was not linear, and it is important to match the cuts between the simulation and the experiment so that the efficiency for detecting the calibration d+p elastic scattering events is known well.

The d+d elastic scattering data was taken to provide a check on the distortions that are being used in the calculation of the CSB process. Both vector and tensor polarized deuterons were used, and data were taken with the PINTEX detectors. As was the case for the CSB experiment, d+p elastic scattering provided the reference, this time for both the cross section and the beam polarization. To the forward PINTEX detectors we added three rings of silicon detectors to observe the coincident recoil in d+d elastic scattering. The analysis began with the collection of the software needed for this work into a single program that would handle all types of events.

Next, work began on the systematic treatment of the geometry and detector efficiency. From the kinematics of the d+p and d+d elastic scattering processes, it is possible to verify the position of the wire chambers relative to the center of the gas target cell. Work on adjusting the gains and acceptances of the silicon detectors is continuing. There remain at present some problems with the uniformity of the efficiency as one compares the rates at different azimuthal angles into different detectors.

The immediate plan is to continue work along these two lines. The analysis of the d+d elastic scattering is needed as soon as possible as theoretical calculations already exist. This comparison will be written up in a separate report for publication. At the same time, we will complete the matching of the Monte Carlo calculations with the data and prepare a long paper summarizing the details of the experiment. At the same time, our collaborators on the theoretical work are preparing a paper discussing the operators thought to be the most important for the CSB process and are working on merging the calculations including operators, good wave functions, and distortions into a single program.

1. E.J. Stephenson *et al.,* Phys. Rev. Lett. **91**, 142302 (2003).