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PARTIAL-WAVE ANALYSES OF HADRON SCATTERING BELOW 2 GeV

Progress Report
May 1992 - April 1993

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ABSTRACT

The Center for Analysis of Particle Scattering (CAPS) in the Department of Physics at Virginia Polytechnic Institute and State University has analyzed basic two-body hadron reactions below 2 GeV for the last two decades. Reactions studied were nucleon-nucleon, pion-nucleon, K^+-nucleon and pion photoproduction systems. In addition to analyses of these reactions, a computer graphics system (SAID) has been developed and disseminated to over 250 research institutions using VAX computers. The computer-interactive system for disseminating information on basic scattering reactions is also accessible to the physics community through TELNET on the VPI&SU physics department VAX.

DISCLAIMER

Nucleon-Nucleon Analyses:

With the collaboration of Mike McNaughton of LAMPF, the *NN* database has been updated. Redundant data sets have been removed and preliminary measurements have been replaced by final values, ensuring proper referencing. Some polarization data from LAMPF have also been corrected in order to account for a miscalculated beam polarization. This latter effort has affected data accumulated over the last decade at Los Alamos. The subsequent analysis of *NN* scattering data to 1.6 GeV has now been published[1]. Work was also done on the 0-350 MeV data base to render it approximately compatible with the Nijmegen data base.

We have added to the "standard" (ENDF-VI) set of low-energy (below 20 MeV) *n-p* differential cross sections. This set is periodically revised by a Los Alamos group who do R-matrix fits to low-energy *NN* data. Our extension[2] covers the range from 20-350 MeV. We have developed a fit to elastic *NN* data below 400 MeV and have created a subroutine which precisely duplicates the *n-p* cross section predictions of this fit; this subroutine will be circulated for use by groups requiring calibration information. We also have done a substantial amount of work to determine what appropriate accuracy should be ascribed to this "standard." It is our belief that, given the present state of experimental data, *n-p* differential cross sections are reliable only at the few-percent level; this is often the limiting factor determining the precision with which the NEANDC group can do their studies. This suggests the need for further direct measurements of cross sections and other observables required to "pin-down" the asymmetries in the *n-p* system. A detailed study of uncertainties in the low-energy *n-p* system has now been published[3].

Igor Strakovsky of Leningrad will be visiting our group this year in order to initiate an analysis of the reaction *pp* to πd. We are presently adding this reaction to the SAID data base. In the SAID program, revised versions of the Bonn and Nijmegen potentials have also been incorporated.

REFERENCES

[1] "Nucleon-nucleon partial-wave analysis to 1.6 GeV," R.A. Arndt, L.D. Roper, R.L. Workman and M.W. McNaughton, Phys. Rev. D 45, 3995 (1992).

[2] "The H(n,n)H Cross Section from 20 to 350 MeV," R.A. Arndt and R.L. Workman, contribution to the INDC/NEANDC Standards File, Uppsala, Sweden.

[3] "Uncertainties in np cross sections from 25-225 MeV," R.A. Arndt and R.L. Workman, Phys. Rev. D 46, 1192 (1992).

Pion-Nucleon Analyses:

Work on the pion-nucleon analyses is continuing. Our studies of the pion-nucleon coupling constant using interior dispersion relations[1] and the Goldberger-Miyazawa-Oehme sum rule[2] have now been published. We are presently studying the effect of adding further dispersion-relation constraints to our analyses. Some of this work has been carried out in collaboration with M. Pavan of TRIUMF. A working group of pion-nucleon scattering experts met for a week in Blacksburg this summer, hosted by the CAPS group. There were lively discussions regarding recent determinations of the pion-nucleon coupling constant from both pion-nucleon and nucleon-nucleon scattering data. There were also a number of presentations displaying the agreement between previous analyses and recent measurements. Some previous measurements of the charge-exchange reaction were criticized.

J.P. Pasupathy (Bangalore) visited for 2 weeks and discussed the methods used in extracting the sigma term from pion-nucleon analyses.

REFERENCES

[1] "Arndt *et al.* reply," R.A. Arndt, Z. Li, L.D. Roper and R.L. Workman, Phys. Rev. Lett. 68, 549 (1992).

[2] "On the Goldberger-Miyazawa-Oehme Sum Rule," R.L. Workman, R.A. Arndt and M. Pavan, Phys. Rev. Lett. 68, 1653 (1992).

K^+-Nucleon Analyses:

The analyses of K^+-nucleon scattering have now been completed and a paper reporting our analyses of this data, with laboratory kinetic energies below 2650 MeV, has now been published. In these analyses, K^+-deuteron elastic and inelastic scattering data have been included up to a laboratory kinetic energy of 1100 MeV.

REFERENCES

[1] "Partial-wave analysis of K^+-Nucleon Scattering," J.S. Hyslop, R.A. Arndt, L.D. Roper and R.L. Workman, Phys. Rev. D 46, 961 (1992).

Pion-Photoproduction Analyses:

Work done on the Drell-Hearn-Gerasimov (DHG) sum rule[1] and a hybrid model[2] of the Roper resonance has now been published. Two further works[3,4] related to the DHG sum rule have been completed and submitted for publication. This work is in support of experimental proposals to evaluate both the DHG sum rule and its generalization to non-zero Q^2 at CEBAF.

We have also made a study[5] of the E2/M1 ratio for the delta resonance, motivated by recent beam-asymmetry data from the LEGS division of Brookhaven National Laboratory. Our preliminary results were reported[5] during a Workshop held at Brookhaven this summer. A more detailed version has been accepted for publication[6].

Our analysis of pion-photoproduction data to 1.8 GeV is nearing completion. Refinements in our analyses of this reaction have paralleled those made in the pion-nucleon program. Some preliminary results are now available[7], with a more detailed description in preparation. A study[8] of the problems associated with gauge invariance has also been published.

Zhujun Li has now graduated with a Ph.D. on the topic of photoproduction analyses and has obtained a tenure-track position at Christopher Newport College, with a half-position at CEBAF.

REFERENCES

[1] "Saturation of the Drell-Hearn-Gerasimov sum rule revisited," R.L. Workman and R.A. Arndt, Phys. Rev. D 45, 1789 (1992).

[2] "Electroproduction of the Roper resonance as a hybrid state," Zhenping Li, V. Burkert and Zhujun Li, Phys. Rev. D 46, 70 (1992).

[3] "What do we know about the Q^2 evolution of the Gerasimov-Drell-Hearn sum rule?," V. Burkert and Z. Li, CEBAF-PR-92-017.

[4] "A modified Gerasimov-Drell-Hearn sum rule from extended current algebras," L.N. Chang, Y. Liang and R.L. Workman, contribution to Baryon 92, Yale, June 1992; submitted to Phys. Rev. Lett.

[5] "E2 excitations of the delta and the limitations of multipole analyses," R.L. Workman, R.A. Arndt and Z. Li, invited talk, Workshop on Hadron Structure from Photo-reactions at Intermediate Energies, Brookhaven National Laboratory, May, 1992; Brookhaven Report BNL 47972.

[6] "How well do we know the E2/M1 ratio for the $\Delta(1232)$?," R.L. Workman, R.A. Arndt and Z. Li, Phys. Rev. C, October 1992.

[7] "Photo-decay couplings of the N^* resonances," Z. Li, R.A. Arndt, L.D. Roper and R.L. Workman, contribution to Baryon 92.

[8] "Form-factors and gauge invariance in pion-photoproduction," R.L. Workman, H.W.L. Naus and S.J. Pollock, Phys. Rev. C 45, 2511 (1992).

TELNET ACCESS TO SAID:

We have provided TELNET access to a version of the SAID program running on the VAX-4000. This provides the user with our most recent analyses. This form of access also allows us to determine how often users log into SAID. Between September 1, 1991 and September 1, 1992, there where 950 logins to the SAID program running on our VAX-4000. The above number will likely increase as many users have only recently learned of this possibility.

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