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STUDY OF NEUTRON - PROTON INTERACTION
IN THE 300-700 MeV ENERGY REGION

Final Progress Report

July 1991 - August 1994

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I. INTRODUCTION

The experimental program supported by the present grant is a continuation of the work supported under D.O.E. Contract DE-AS05-76ER04449. More detailed discussion of the experimental apparatus and earlier activities can be found in annual reports for that contract and this grant.¹ The primary objective of this program is investigation of the nucleon-nucleon (NN) interaction, in the medium-energy region, in both elastic and inelastic channels. This TAMU group has been working in pursuit of that objective primarily at LAMPF, but also in a few experiments at Brookhaven National Laboratory (BNL) and one experiment at the Japanese National Laboratory for High Energy Physics (KEK). The work has been done with many collaborators (listed in Sec. II.), and credit for the published results and the progress reported here must be shared with them. Most of the results of this research have already been published in refereed journals²⁻⁴⁸ and will not be discussed here.

Experimental activity during the period of this report included participation in the running of LAMPF experiments E876 [Spin Transfer Measurements for np Elastic Scattering], E1234 [K_{LL} and P for np elastic scattering] and E1293 [np Elastic Analyzing Power]. Tests were conducted on the cylindrical drift chamber built for E1097 [Single Pion Production on np Scattering] during the summers of 1991 and 1992 but activities on this experiment were terminated as the end of operations of the neutron beam in LAMPF Area B was projected as of September 1993. A significant effort has been made to analyze data and prepare manuscripts for publication. Fourteen papers have been published⁴⁹⁻⁶² and are appended as Attachments I-XIV. Several other manuscripts are being drafted at the present time. One student (A. J. Simon) received his PhD degree in June 1993 based on LAMPF E1072 [pp Elastic Absolute Cross Sections.]

II. PERSONNEL

The members of this group, the number of months they spent on the project in the period July 1991 to August 1994 are shown in Table I.

Table I. Number of months spent by personnel on the project

	JUL-DEC 1991	JAN-DEC 1992	JAN-DEC 1993	JAN-AUG 1994
L. C. Northcliffe, Prof., Physics Principal Investigator	1.0	2.0	1.5	---
J. C. Hiebert, Prof., Physics Co-Principal Investigator	1.0	2.0	2.0	---
G. Glass, Research Scientist, Physics	6.0	8.0	---	---
T. Shima, Asst. Res. Scientist, Physics	6.0	8.0	---	---
A. J. Simon, Grad. Student, Phys. Res. Assoc. , Phys	6.0 ---	5.0 ---	--- 1.8	--- ---
N. Mdeiwayeh, Grad. Student, Physics	---	3.0	---	---

Our collaborators in the LAMPF experiments during the period of this report have been:

LAMPF: J. Amann, J. J. Jarmer, K. Koch, K. Johnston, M. W. McNaughton, S. Pentilla, J. Santana, I. Supek, N. Tanaka, and R. York;

Argonne National Laboratory: H. Spinka;

University of Texas (Austin): D. A. Ambrose, P. Coffey, K. H. McNaughton, G. Pauletta, P. J. Riley;

University of Montana: R. H. Jeppeson;

Washington State University: G. E. Tripard;

University of California (Los Angeles): E. Gulmez, A. Ling and C. Whitten;

Rutgers University: D. B. Clayton, V. Cupps and R. Ransome;

Rice University: D. L. Adams;

University of Central Arkansas: H. L. Woolverton.

Our collaborators in the KEK experiment have been:

KEK: S. Hiramatsu, Y. Mori, H. Sato, A. Tagaki, T. Toyama, and A. Ueno;

Tokyo Institute of Technology: H. Ohnuma, H. Shimizu and H. Yoshida;

Kyoto University: K. Imai;

Tohoku University: K. Kobayashi, Y. Kobayashi and T. Nakagawa.

Our collaborators in the BNL Kaon-Nucleus Cross Section experiment have been:

BNL: S. Bart, R. E. Chrien, P. H. Pile, and R. J. Sutter;

Tel Aviv University: J. Alster, D. Ashery, M. A. Moinister, E. Piasetzky, and I. Yavin;

TRIUMF: R. Johnson and G. Scheffer.

III. EXPERIMENTAL METHOD AND APPARATUS

The methods and equipment used in earlier experiments at LAMPF, BNL and KEK have been discussed in earlier progress reports¹ and published papers.²⁻⁴⁸ The results obtained from two of the three experiments run during the present reporting period, LAMPF #876 and #1234 have been published.^{49,53,54,59} These papers which are included as Attachments I, V, VI and IX of this report present discussions of the methods and apparatus used in both phases of #876. The final LAMPF experiment, #1293, was run with essentially the same apparatus as phase II of #876 which is described in ref. 59 (Attachment IX).

IV. RESULTS OBTAINED

A. Acquisition of Data

The only data obtained during the period covered by this report are those for LAMPF experiments #876, #1234 and #1293. Publications resulting from these experiments are discussed in Section B below.

B. Analysis and Publication of Results

LAMPF exp. #876 - Spin Transfer Experiments for n-p Elastic Scattering

The 788 MeV elastic spin transfer data were analyzed and submitted for publication⁴⁹ prior to the previous report. A reprint of this paper is included as Attachment I. The measurements at 485 and 635 MeV have also been published⁵⁴ (see Attachment VI). The final data acquired during summer 1992 were the K_{NN} data at 485, 635 and 788 MeV and the results have been published⁵⁹ (see Attachment XI).

LAMPF exp. #518 - Polarized Beam and Target Experiments in the p-p System: Phase II.

Measurements of A_{LL} and A_{SL} for the d_{π^+} channel and for the elastic channel from 500 to 800 MeV.

Some of the results of this experiment have been reported in earlier papers.^{27, 31, 39} The manuscript presenting the final results has been published⁵¹ (see Attachment III).

LAMPF exps. #665 and #770 - Measurement of np Elastic Scattering Spin-Correlation

Parameters with L- and S-Type Polarized Beam and Target between 500 and 800 MeV.

Two brief papers on the elastic scattering results have been published in the past.^{36, 43} Two more comprehensive papers have now been published^{52, 56} (see Attachments IV and VIII). A draft of a final paper presenting additional results has been distributed to the collaboration for comments before submission to Phys. Rev. D.

LAMPF exp. #1234 - K_{LL} and P for np Elastic Scattering.

This experiment was completed in the summer of 1991 and the results have been published⁵³ (see Attachment V).

LAMPF exp. #255 - Differential Cross Sections for np Elastic Scattering at 459 MeV.

A paper reporting the results of these measurements has been published⁵⁷ (see Attachment IX).

LAMPF exp. #457 - Analyzing Powers in pn and pp Quasifree Scattering.

A paper reporting the results of these measurements has been published⁵⁸ (see Attachment X).

LAMPF exp. #1072 - pp Elastic Absolute Cross Sections.

A reprint of the article⁶⁰ on the absolute determination of integrated incident beam current is included as Attachment XII. The final results of this experiment have published⁶¹ (see Attachment XIII). This experiment served as the dissertation project for A. J. Simon of TAMU.

KEK exp. #174 - $A_y(E, \theta)$ Measurements for N-N Reactions.

This experiment served, in part, as the dissertation project for J. A. Holt of TAMU. A brief report on the pp elastic results has been published.⁴⁵ Papers have been published on results for the $pp \rightarrow d\pi^+$ reaction⁵⁰ (see Attachment II) and for pp elastic scattering which reveal narrow energy dependent structures⁶² (see Attachment XIV).

AGS exp. #835 - Kaon - Nucleus Total Cross Section Measurements and Partial Deconfinement in Nuclei.

This experiment served as the dissertation project for R. A. Krauss of TAMU. Early results have been reported⁴⁶ and the final results have now been published⁵⁵ (see Attachment VII).

LAMPF exp. #1293 - np Elastic Analyzing Power.

This experiment ran in the summer of 1993 and would appear to be the final experiment in the investigation of the NN interaction at LAMPF. High quality backward angle np analyzing powers were obtained in conjunction with the E876 measurements of K_{NN} in 1992. The goal of E1293 was to extend these measurements at 500, 650 and 800 MeV to small angles in order to be able to compare the relative magnitudes of the forward and backward angle peaks in the np analyzing power. The forward-backward asymmetry in np scattering arises from interference between isospin 0 and 1 components of the interaction. The interference terms are particularly sensitive as a probe of the isospin-0 inelasticities which are not well determined.

The data have been analyzed. Publication of these results has been delayed by both a job change and a serious illness experienced by Mike McNaughton in the past year.

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