Progress Report for the Period August 1, 1980 to May 31, 1982

DOE Contract DE AC02-77-ERO-4444

From George H. Rawitscher, Principal Investigator

Written February 10, 1982

MASTER

Summary

- A. Results
- B. Publications
- C. Meetings Attended
- D. Visitors

DOE/ER/04444--4

DE82 016238

NOTICE

PORTIONS OF THIS REPORT ARE ILLEGIBLE. It
has been reproduced from the best available
copy to permit the broadest possible avail-
ability.

MN ONLY

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

A. Results

1. Effect of deuteron breakup on elastic deuteron scattering cross sections and polarizations.

The calculations at 80 MeV incident deuteron energy scattering off the nucleus of nickel are now completed and were made available to the experimental group at The Indiana Cyclotron Facility, notably E. J. Stephenson and C. C. Foster. The comparison with experiment is quite satisfactory in view of the fact that no free parameters exist which could have been adjusted. The comparison was displayed in the 1980 IUCF progress report¹⁾, is providing input and motivation for a series of papers by E. J. Stephenson,²⁾ and is motivating the proposal of new experiments at higher energies.³⁾

The calculation is still imperfect in several respects: a) Only second order breakup effects are thus far included, while higher order coupling terms should be included. b) Effects of antisymmetrization are lacking. c) Coupling to rearrangement channels are lacking. d) The non-locality of the input nucleon-nucleus optical potentials is not allowed for. Neither is the energy dependence of these potentials.

2. The validity of the discretization method. The so-called "k by k" discretization method is being investigated by the graduate student working on the project, Mr. Rene Rasoanaivo. His results are positive and are in the process of being written up.⁴⁾ A group of Japanese investigators⁵⁾ are also confirming the validity of the method, and a recent preprint by N. Austern⁶⁾ suggests that the present (truncated) discretization method may usefully serve as the starting point of a more complete calculation.
3. The effect of breakup on rearrangement reactions.

A paper examining this question for the case of 100 MeV deuterons incident on ^{23}Mg was submitted to Phys Lett.⁷⁾ This is the case of the transfer of a zero angular momentum neutron, filling a $2s\frac{1}{2}$ hole in ^{24}Mg . The DWBA matrix element is sensitive to the interior portion of the radial wave function. The "Spectacular Failure"⁸⁾ of the DWBA was not remedied by inclusion of the breakup effects. Further work is required, which examines other candidates for the resolution of this puzzling situation.

4. Formulation in terms of Hyperspherical Harmonics of the effect of breakup in Deuteron-Nucleus collisions.

This work, undertaken in collaboration with Professor W. Zickendraht, is now completed,⁹⁾ and no further work is contemplated at present. Two papers appeared in the Phys. Rev., which describe our findings: a) The coupling between various angular momentum states (both between

the n-p relative motion and between the motion of the center of mass of the n-p pair and the nucleus) is extensive.

b) The formulation proposed appears to lend itself to a feasible numerical solution of this three body scattering problem, but such a solution has not yet been attempted.

5. Formulation of scattering theory in terms of a basis of positive energy Weinberg functions.

An extended (theoretical) literature already exists on this subject, and a practical solution of scattering problems involving either non-local potentials or a set of coupled channel equations using this method is being attempted. The method consists in expanding the scattering portion of the wave function (or wave functions in each channel) in terms of a set of (auxiliary) positive energy Weinberg (or Sturmian) functions, thereby reducing the problem to the solution of algebraic equations and matrix diagonalizations.

The initial investigation appeared in a preprint from MIT.^{10,11} This paper outlines the basis of the method and gives a simple numerical application. In a subsequent study¹²⁾ the numerical convergence of the scattering matrix element to the exact answer, as the number of the basis functions is increased, is investigated. Also the convergence of the iterations which corrects for the truncation error, called the quasi particle method, is tested in the same example.¹²⁾ Excellent convergence is achieved. These results have been submitted for publication.¹³⁾

The case of N coupled channels is presently being studied. Non-local potentials which are equivalent to the coupling to the N-1 other channels are constructed in each channel. The Weinberg basis method enables one to express the non-locality of these potentials in a separable form. The number of terms required to represent the potentials is being studied in a numerical example.¹⁴⁾

Finally, in conjunction with Dr. G. Delic on visit at the University of Connecticut during the period from November 30, 1981 to February 5, 1982 (from the University of Witwaters-Rand, Johannesburg, South Africa), the numerical feasibility of obtaining the Weinberg states on a basis set of Chebyshev polynomials is being investigated.¹⁵⁾

References

1. IUCF Annual Report (1980), p. 60, unpublished.
2. E. J. Stephenson, et al, Nucl. Phys. A359, 316 (1981), Nucl. Phys. A371, 381 (1981).
3. Proposal for Experiment #84 at the Laboratoire National Saturne, "Measure de Diffusion Elastique de Deutons polarises a 200 et 400 MeV." Spokesman, J. Cameron and Van Sen Nguyen, submitted 9/21/81.
4. Rene Rasoanaivo, PhD dissertation in preparation.
5. M. Yahiro and M. Kamimura, Progr. Theo. Phys. 65 2051 (1981).
6. N. Austern, "Some Properties of Projected Three-Body Theories of Deuteron-Nucleus Collisions," Phys. Rev. to be published.
7. G. H. Rawitscher and S. N. Mukherjee, "Effect of deuteron Breakup on the $^{24}\text{Mg} (p,d) ^{23}\text{Mg} (\frac{1}{2}^+, 2.36 \text{ MeV})$ cross section near 100 MeV," Phys. Lett. to be published.
8. J. R. Shepard, E. Rost, and P. D. Kunz, Proc. of the Fifth Int'l Symp. on Polarization Phenomena in Nuclear Reactions (AIP Conf. Proc. 69, New York 1981), p. 361.
9. G. H. Rawitscher and W. Zickendraht, Phys. Rev. C23, 623 (1981).
W. Zickendraht and G. H. Rawitscher, Phys. Rev. C23, 633 (1981).
10. G. Rawitscher, "Positive Energy Weinberg States for the Solution of Scattering Problems," Preprint CPT #839 from MIT, February 1980.
11. G. Rawitscher, Bull. Am. Phys. Soc. 25, 558 (1980).
12. G. Rawitscher, Bull. Am. Phys. Soc. 26, 637 (1981).
13. G. H. Rawitscher, "Positive Energy Weinberg States for the Solution of Scattering Problems," submitted to Phys. Rev. C.
14. G. Rawitscher, Bull. Am. Phys. Soc. 26, 1135 (1981).
15. G. Delic and G. Rawitscher, abstract submitted to the 1982 APS meeting in Washington, D.C., "Weinberg States on a Chebyshev Polynomial Basis."

B. Publications

1. G. H. Rawitscher and S. N. Mukherjee,
"Second Order Breakup Corrections to Elastic Deuteron-Nickel
Scattering between 13 and 80 MeV Nucl. Phys. A342 (1980), 90-110.
2. G. H. Rawitscher and W. Zickendraht,
"Formulation in Terms of Hyperspherical Harmonics of the Effect
of Breakup in deuteron-nucleus collisions," Phys. Rev. C23 (1981)
623-632.
3. W. Zickendraht and G. H. Rawitscher,
"Breakup coupling potentials for deuteron-nucleus collisions in the
space of hyperspherical Harmonics," Phys. Rev. C23 (1981) 633-644.
4. G. H. Rawitscher and S. N. Mukherjee,
"The Deuteron Optical Potential," Proc. of AIP conference on
Polarization Phenomena. In Nucl. Phys. - 1980. (Ed. G. G. Ohlsen,
et al. AIP, New York 1981), p. 490.

Accepted for Publication

- G. H. Rawitscher and S. N. Mukherjee,
"Effect of deuteron breakup on the $^{24}\text{Mg} (p,d) ^{23}\text{Mg} (\frac{1}{2}^+, 2.36 \text{ MeV})$
Cross section near 100 MeV," Phys. Lett.

Submitted for Publication

- G. H. Rawitscher,
"Positive Energy Weinberg States for the Solution of Scattering Problems,"
Phys. Rev. C.

C. Meetings Attended

8/11-15/80 Fifth International Symposium on Polarization Phenomena
in Nuclear Physics, Santa Fe, NM.

9/9-11/80 APS Nucl. Phys. Division, Fall meeting, Minnesota, Minn.

4/20-23/81 APS Spring meeting, Baltimore, MD.

8/4-7/81 IUUCF Workshop on Deuteron Interactions with Nuclei.

10/28-30/81 APS Nuclear Physics Division Fall meeting, Asilomar, CA.

4/26-29/82 APS Spring meeting, Washington, DC.

D. Foreign Visitors

9/1-20/1980 S. N. Mukherjee, Banaras Hindu Univ., Varanasi, India

11/25-26/1980 M. Kawai, Kyushu University Fukuoka, Japan, Japan-Argonne

11/30/1981-2/6/1982 G. Delic, Univ. of Witwatersrand, Johannesburg, South Africa