

2
FINAL TECHNICAL REPORT, DE-FG05-93ER40791
Studies of the Spin-Isospin Response of the Nuclear Continuum Using Intermediate Energy Hadrons

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SUMMARY OF RESULTS

The work supported by this grant has had two main thrusts. One involved study of the spin, isospin, and multipole content of the continuum of nuclei, a continuation and completion of work done at LAMPF, Saturne, and TRIUMF. Most of the work has used (\bar{p}, \bar{p}') or (\bar{d}, \bar{d}') reactions, measuring spin observables to infer properties of the target nuclei. Publications resulting from this work have included seven refereed articles and letters, five abstracts and conference talks, one of which was invited. The second thrust involved preparatory work for experiments at CEBAF. I was involved in Hall A work and the construction, installation, and initial experiments using the proton focal plane polarimeter. Experiments began in 1997 and no refereed publications have yet been completed; ten abstracts and conference talks have been published.

The most important single accomplishment was the publication of a major review article in *Physics Reports*. This review, entitled "The Nuclear Spin Response to Intermediate Energy Protons and Deuterons at Low Momentum Transfer", reviewed work which has been done over the past decade at LAMPF, Saturne, and TRIUMF by several overlapping groups, all of which I have been a member. Work on this publication took more than two years and involved major efforts by the eleven authors, L. Bimbot, C. Djalali, C. Glashauser, H. Lenske, W. G. Love, M. Morlet, E. Tomasi-Gustafsson, J. Van de Wiele, J. Wambach, A. Willis, and myself. My main responsibility was to perform all RPA calculations and all DWIA calculations for the (\bar{p}, \bar{p}') analysis. This involved considerable computer code development. I also independently performed DWIA calculations for the (\bar{d}, \bar{d}') analysis as a check of the calculations done at

ORNL. Our main findings were:

- The isovector response in the nuclear continuum is dominated, at low momentum transfer, by S=1 transitions.
- The isoscalar response in the nuclear continuum is dominated, at low momentum transfer, by S=0 transitions.
- The S=0, T=0 continuum response observed in (\bar{d}, \bar{d}') scattering is much larger than expected based on established sum rules and is not consistent with (\bar{p}, \bar{p}') measurements.
- Generally our RPA/DWIA calculations describe the spin-flip probability data well for both (\bar{p}, \bar{p}') and (\bar{d}, \bar{d}') data.
- Although the shapes of the cross section spectra are well described by our calculations, the magnitudes are not; this is indicative either of contributions from reaction mechanisms other than one-step or of there being much more strength present than RPA sum rules would suggest.

I also presented an invited talk on this subject at The International Symposium on New Facets of Spin Giant Resonances held at the University of Tokyo in November 1997.

During the time of this grant I have also participated in the experimental program at CEBAF. I am a member of the Hall A collaboration. The grant supported a Research Associate, Dr. Paul Rutt, for the period 4/1/93-10/31/95. He was stationed at Rutgers University where the

We have no objection from a patent standpoint to the publication or dissemination of this material.

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 Office of Intellectual Property Counsel
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focal plane proton polarimeter for Hall A was designed, tested, and constructed. Dr. Rutt played a very pivotal role in this project. The polarimeter is now installed at CEBAF and the commissioning experiment, $^{16}\text{O}(\vec{e}, e' \vec{p})$, was performed in the summer of 1997.

GRADUATE STUDENTS

Three students have been partially or wholly supported by this grant. Bruce Storm received a Ph. D. in 1995, the title of his dissertation being "Spin and Multipole Decompositions of the ^{40}Ca Continuum". Stephen Mervin received an M. S. degree in 1995, the title of his thesis being "Octupole States of ^{192}Os and ^{198}Pt ". Jesse Hines is a junior graduate student who has become involved in the CEBAF work and received some support from this grant for one quarter.

PUBLICATIONS

Below are enumerated publications based on research supported by this grant and a log of experimental activity during the period of the grant.

ARTICLES

1. "Spin-longitudinal and Spin-transverse Response of ^{40}Ca to 500 MeV Protons at Low Momentum Transfer", A. Green *et al.*, Phys. Rev. Letters **60**, 734-737 (1993).
2. "Neutron Transition Densities from $^{88}\text{Sr}(\vec{p}, p')$ at $E_p=200$ MeV," J. J. Kelly *et al.*, Phys. Rev. **C47**, 2146-2158 (1993).
3. "Separation of $\Delta S = 0$ and $\Delta S = 1$ in the Response of ^{12}C to 318 MeV Protons," F. T. Baker *et al.*, Phys. Rev. **C48**, 1106-1115 (1993).
4. "Elastic and Inelastic Scattering of 0.8 GeV Polarized Protons from ^{18}O ," R. de Swiniarski *et al.*, Nuovo Cimento **106A**, 1119-1132 (1993).
5. "Energy Dependence of the $^{12}\text{C}(p, p')^{12}\text{C}^*$ Reaction from 200 to 800 MeV", K. W. Jones *et al.*, Phys. Rev. **C50**, 1982-1990 (1994).
6. "Isoscalar Spin Strength in ^{12}C Measured in 400 MeV Deuteron Inelastic Scattering", B. N. Johnson *et al.*, Phys. Rev. **C51**, 1726-1735 (1995).
7. "The Nuclear Spin Response to Intermediate Energy Protons and Deuterons at Low Momentum Transfer", F. T. Baker *et al.*, Phys. Rep. **289 v.4&5**, 235-382 (1997).

ABSTRACTS AND CONFERENCES

1. "Measurement of Recoil Polarization in the $^{16}\text{O}(e, e'p)$ Reaction with 2.445 GeV Electrons", E.J. Brash for The Hall A Collaboration, BAPS, DNP97, abstract AE.03, October 5 - 8, 1997, Whistler, BC.
2. "The Focal Plane Polarimeter in TJNAF Hall A: Commissioning Results", K. Wijesooriya for The Hall A Collaboration, BAPS, DNP97, abstract BF.06, October 5 - 8, 1997, Whistler, BC.
3. "The Focal Plane Proton Polarimeter at TJNAF Hall A: Commissioning Results", R. Gilman for the Hall A collaboration FPP working group, Santorini, Greece, October 21 - 26, 1997.
4. "Measurement of Recoil Polarization in the $^{16}\text{O}(e, e'p)$ Reaction", P. M. Rutt for the Hall A Collaboration, Santorini, Greece, October 21 - 26, 1997.

5. "Isoscalar Spin Response in Ca and ^{12}C ", E. Tomasi-Gustafsson *et al.*, International Conference on Nuclear Reaction Mechanisms, Varenna (Italy), 1994.
6. "Coherent Pion Production in $^{12}C(p,n\pi)$ at 800 MeV", R. Gilman *et al.*, Nucl. Phys. A577, 227c-232c (1994).
7. "Physics with a Focal Plane Proton Polarimeter for Hall A at CEBAF", R. Gilman *et al.*, SPIN94, Contributions to the Eighth Symposium on Polarization Phenomena in Nuclear Physics, Bloomington, IN USA, September 15-22, 328 (1994).
8. "Recent Results on the Isoscalar Spin Response in ^{12}C and ^{40}Ca ," M. Morlet *et al.*, Nucl. Phys. A577, 155 (1994).
9. "Aspects of the Nuclear Spin Response to Intermediate Energy Protons and Deuterons at Low Momentum Transfer", C. Glashauser *et al.*, 20 Years of Meson Factory Physics: Accomplishments and Prospects, Los Alamos Meson Physics Facility Symposium, (1996).
10. "Physics with a Focal Plane Proton Polarimeter for Hall A at CEBAF", R. Gilman *et al.*, SPIN94, Contributions to the Eighth Symposium on Polarization Phenomena in Nuclear Physics, Bloomington, IN USA, September 15-22, 328-329 (1994).
11. "Physics with a Focal Plane Proton Polarimeter for Hall A at CEBAF", R. Gilman, *et al.*, Eleventh International Symposium on High Energy Spin Physics, Bloomington, IN, AIP Conference Proceedings 343, 147-151, (eds) Kenneth J. Heller and Sandra L. Smith (1995).
12. "Status of the Focal Plane Polarimeter for Hall A at TJNAF", M. K. Jones *et al.*, Intersections 1997, in press.
13. "The Focal Plane Proton Polarimeter at TJNAF Hall A: Commissioning Results", R. Gilman for the Hall A collaboration FPP working group, Santorini, Greece, October 21-26, 1997.
14. "Measurement of Recoil Polarization in the $^{16}O(e,e'p)$ Reaction", P. M. Rutt for the Hall A Collaboration, Santorini, Greece, October 21 - 26, 1997.
15. "RPA/DWIA Description of Spin Excitations in the Continuum by (p,p') and (d,d') Reactions", International Symposium on New Facet of Spin Giant Resonances, University of Tokyo, November 17-20, 1997, Invited talk.

INVITED TALKS

"RPA/DWIA Description of Spin Excitations in the Continuum by (p,p') and (d,d') Reactions", International Symposium on New Facet of Spin Giant Resonances, University of Tokyo, November 17-20, 1997, Invited talk.

EXPERIMENTS PERFORMED

Experiment performed at LAMPF, Aug./Sept. 1993,

$^2H, ^{12}C(p,n\pi)$, $E_p = 800 \text{ MeV}$.

Experiment performed at SATURNE, Oct. 1993,

$^{12}C(\bar{d}, \bar{d}')$, $E_d = 600 \text{ MeV}$.

Experiment performed at SATURNE, May 1994,

$^{90}Zr, ^{208}Pb(\bar{d}, \bar{d}')$, $E_d = 400 \text{ MeV}$

Performed experiment at CEBAF, June 1997,

$^{16}O(e, e'p)$

Performed experiment at CEBAF, July 1997,

$^{16}O(\bar{e}, e'\bar{p})$