Reports File

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF RESEARCH ADMINISTRATION

RESEARCH PROJECT INITIATION

Date: November 13, 1972

Project Title: "Low-Energy Nuclear Structure of Nuclei Near a Closed Shell Using Ge(Li)-Ge(Li) Coincidence Techniques"

Project No: G-41-624

Principal Investigator: Dr. D. A. McClure

Sponsor: Research Corporation

Agreement Period: From November 1, 1972 Until Open

Type Agreement: Research Grant

Amount: $17,500

Reports Required: Annual Progress Letters

Sponsor Contact Person (s):

Jack W. Powers
Research Corporation
6075 Roswell Road N. E.
Atlanta, Georgia 30328

Assigned to: Physics

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RA-3 (6-71)

GEORGIA INSTITUTE OF TECHNOLOGY

OFFICE OF RESEARCH ADMINISTRATION

RESEARCH PROJECT TERMINATION

Date: December 30, 1974

Project Title: Low-Energy Nuclear Structure of Nuclei Near Closed Shell Using Ge(Li)-Ge(Li) Coincidence Techniques

Project No: G-41-624

Principal Investigator: Dr. D. A. McClure

Sponsor: Research Corporation; New York City 10017

Effective Termination Date: 12-12-74 (Final Report submitted)

Clearance of Accounting Charges: N/A - all funds expended.

Grant Closeout Actions Remaining: None

Assigned to School of Physics

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G-41-624
Powers

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332
12 November 1973

SCHOOL OF PHYSICS

PROGRESS REPORT 11/01/73

TO: Dr. Jack W. Powers, Regional Director, Research Corporation

FROM: Dr. Donald A. McClure

SUBJECT: Research Corporation Cottrell Research Grant
Progress Report G-41-624

Scientific Findings

To date the work involving a large volume lithium drifted germanium [Ge(Li)] detector purchased with Research Corporation funds has been under three categories.

1) Timing Characteristics of large volume Ge(Li) detectors. It became apparent during the negotiations for the purchase of the Ge(Li) detector that no definitive study had been reported in the literature concerning the timing characteristics of large volume Ge(Li) detectors in the energy range below 300keV. It is imperative that the timing characteristics of large volume detectors be investigated in this energy range because many institutions are now performing two-parameter coincidence studies involving data collection over a wide energy range e.g. 0-3 MeV. We have performed such an investigation and the results will be published shortly.

2) Low-Lying Level Structure of transuranic elements. Recently several samples of transuranic elements have become available to the School of Chemistry at Georgia Tech from a collaboration with groups at Savannah River. The low-lying level structure of these nuclides is virtually unknown so a series of Ge(Li)-Ge(Li) gamma-ray coincidence studies is underway involving the levels populated by the α-decay of ^{243}Am, ^{249}Bk, and ^{254}Es. This research is related to the search for the heavy, relatively stable nuclides in the region of Z = 114, the existence of which has been implied by recent shell model calculations. Our investigations will test the validity of the Nilsson type wave functions in the mass region above the uranium isotopes. If the model is not successful in this region, its predictions for a proposed Z = 114 nuclide might be suspect.

3) Thermal neutron capture γ-ray studies. The nuclide ^{144}Nd has been studied at the thermal neutron capture facility at the Georgia Tech Research Reactor. Excellent quality Ge(Li)-Ge(Li-) γ-γ coincidence data have been obtained and these

data will be combined with results of groups at Oak Ridge and Los Alamos to delineate the decay and level structure of ^{144}Nd. These results are part of a series of investigations being performed on even-even nuclei near closed shells in an attempt to expose significant anomalies and/or gaps in our understanding of the structure of these relatively simple nuclei.

^{41}Ca has been the subject of several rather exciting investigations recently. In particular our investigation at the (n, γ) facility may definitely prove that the level of 3614 KeV is really a closely spaced doublet. (See Bul. Am. Phys. Soc. 18 (1973) 1406.)

Student Involvement

Two graduate students have been involved in the collection and analysis of the data obtained in these studies. One has graduated (M.S.) and one is continuing to work in this area on his Ph.D. degree.

Papers

A report has been given at the APS meeting in Washington, D. C. 26 April 1973, (See Bul. Am. Phys. Soc. 18 (1973) 718) concerning the Timing characteristics of large volume Ge(Li) detectors. Papers concerning ^{144}Nd are underway and the results of the other investigations will be published when data analysis is completed.

Changes in Research

A large volume Ge(Li) detector characterized by a FWHM of 2.1 KeV at 1.3 MeV and a 14.7% relative efficiency (73.1 cc.) has been purchased. The remaining funds (about $2500) will be added to funds from the School of Physics ($6500) to purchase a 7.2 million word storage disc to be added to the PDP-8E computer used in conjunction with the Ge(Li) detector. The disc will allow us to do the on-line data analysis so vital to the efficient use of the neutron capture gamma-ray facility.

Disposition of Funds

As of November 1, 1973:

funds expended for Ge(Li) detector	$15,006.74
bids being requested for disc storage	2,493.26
	$17,500.00

The School of Physics will provide an additional $6500 toward this latter purchase.

Donald A. McClure
Assistant Professor

xc: Dr. J. R. Stevenson
Dean H. S. Valk

G-41-624
Final

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

November 22, 1974

SCHOOL OF PHYSICS

Dr. Jack W. Powers
Regional Director
Research Corporation
6075 Roswell Road, N.E.
Atlanta, Georgia 30328

Dear Dr. Powers,

I wish to express my sincere gratitute to the Research Corporation for the Cottrell Grant extended to me for the thermal neutron capture gamma ray facility at Georgia Tech. This grant has enabled me to turn an adequate facility into one of the world's best and I expect the detector and computer system to function for many years. I will send you reprints of publications as they become available.

I was able to obtain travel funds from the National Science Foundation to allow me to attend two conferences (one on Neutron Capture Gamma Ray Spectroscopy and one on Nuclear Structure and Spectroscopy held in Amsterdam, the Netherlands). I have published a paper concerning data obtained under this grant in the proceedings of the Neutron Capture Gamma Ray Spectroscopy conference. The main reason I was able to obtain NSF funds was the excellent quality of the data obtained with the detector purchased under this grant. I am enclosing a report concerning this trip which was originally written for the NSF.

Please advise me if I can supply further information to you or provide some service for the Research Corporation in the future.

Sincerely,

Donald A. McClure
Assistant Professor

DAM:scm

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

November 20, 1974

SCHOOL OF PHYSICS

FINAL PROGRESS REPORT 11/1/74

TO: Dr. Jack W. Powers, Regional Director, Research Corporation

FROM: Dr. Donald A. McClure, Assistant Professor, School of Physics

SUBJECT: Research Corporation Cottrell Research Grant

Scientific Findings

The work involving the large volume lithium drifted germanium detector purchased entirely with Research Corporation funds and a disk storage unit purchased partially with Research Corporation funds has been under three categories.

1) Low-lying level structure of Transuranic elements. Samples of ^{243}Am, ^{249}Bk have been studied and an investigation of the decay of ^{254}Es is presently underway. These isotopes are fractions of samples produced at Oak Ridge National Laboratory as part of a program related to the study of fast breeder reactors. These studies are a collaboration between our group, Nuclear Chemistry at Georgia Tech and a Savannah River group. A paper concerning the decay of ^{243}Am has been submitted to Zeit-schrift fur Physik and preprints are available. The level and decay structure of these nuclides will have some bearing on the predictions of the Nilsson model in this region of the mass table and a failure of the Nilsson model in this mass region could cast some doubt on its prediction of the existance of relatively long lived isotopes in the region near Z=114. The one case studied this far fits the Nilsson model rather well.

2) Thermal neutron capture gamma ray studies. Both the $^{144}Nd(n,\gamma)$ ^{145}Nd and the $^{143}Nd(n,\gamma)$ ^{144}Nd reactions have been studied at the Georgia Tech Research Reactor under this project. A paper concerning the level structure of ^{145}Nd has been sub-

mitted to Nuclear Physics. This work has been combined with data from collaborators at Oak Ridge and the University of Tennessee to produce a comprehensive study of the level structure of ^{145}Nd. A collabrative study of the level structure of ^{144}Nd involving Georgia Tech, Oak Ridge and Los Alamos groups will be submitted for publication in the near future. Data concerning the ^{40}Ca(n,γ) ^{41}Ca reaction are presently being analyzed. A search for a proposed "doublet" level at 3.214 MeV excitation energy was the impetitus for this study but several additional contributions have been uncovered concerning levels in ^{41}Ca. The Ge(Li)-Ge(Li),γ-γ coincidance data obtained with this detector and computer analysis system are of excellent quality and have enabled Georgia Tech to make significant contributions to the understanding of the nuclear structure of several nuclides.

Student Involvement

At the present time there are no graduate students or undergraduate students involved in this project. There are two reasons for this. Graduate student enrolement is down from previous levels and nuclear physics is not one of the glamour areas at present. Several prospective students exist among the new first year students.

Papers

"Low-lying Excited States of ^{145}Nd Populated in the Capture of Thermal Neutrons." D. A. McClure, S. Raman and J. A. Harvey, Nuclear Structure Study with Neutrons-Contributions), ed. F. Ero and F. Szucs (Plenum, London 1974) p. 128.

"Multi-parameter Pulse Height Analysis with a PDP-8/e Computer", N. S. Kendrick and D. A. McClure accepted for publication in Nucl.Inst. and Meth.

"Energy Levels in ^{144}Nd" S. Raman, G. G. Slaughter, J. A. Harvey. D. A. McClure, J. C. Wells, Jr., Jung Lin and E. T. Jurney, accepted for publication in the Proceedings of the Second International Coference on Neutron Capture γ-ray Spectroscopy 2-6 September, 1974, Petten, The Netherlands.

"Neclear Spectroscopy of ^{145}Nd," D. L. Hillis, C.R. Bingham, D. A. McClure, N.S. Kendrick, Jr., J. C. Hill, S. Raman, J. B. Ball and J. A. Harvey. Submitted to Phys. Rev. C.

"Alpha Decay of ^{243}Am," K. R. Baker, R. W. Fink and D. A. McClure, submitted to Zeit-schrift fur Physik.

Papers Presented at Meetings

"Timing Characteristics of Large Volume Lithium Drifted Germanium Detectors." Bull. Am. Phys. Soc. 18 718 (1973).

"Multiparameter Pulse-Height Analysis with a PDP-8/e Computer", Decus Proceedings Fall 1973 (Digital Equipment Computer Users Society, Manard, Mass., 1973) p. 11.

"The ^{143}Nd(n,r) Reactions," Bull. Am. Phys. Soc. 19, 500 (1974).

Future Research

The detector and computer based analysis system will continue to be used at the Georgia Tech Research Reactor thermal neutron capture γ-ray facility and the work with transuranic elements will continue. In addition, this equipment will be used at the Universities on line isotope separator at Oak Ridge (UNISOR) in the analysis of data concerning new proton rich nuclei far from the line of stability, a very exciting new feild of research.

Final Dispostion of Funds

Large volume Ge(Li) detector 14.8% relative efficiency and 2.1 KeV resolution at 1.32 MeV.	$15,006.74
Disk storage for PDP-8/e computer based data analysis system ($6500 contributed by the School of Physics)	2,493.26
	$17,500.00

Donald A. McClure
Assistant Professor

xc: Dr. J. R. Stevenson
Dean H. S. Valk

NARRATIVE REPORT

The primary objective of this grant was to allow me to attend the Second International Symposium on Neutron Capture γ-ray Spectroscopy Sept. 2-6, 1974 Petten, The Netherlands. A paper was submitted entitled "Energy Levels in ^{144}Nd" which will appear in the conference proceedings. The bulk of the conference delt with the present theoretical and experimental understanding of the neutron capture process. A significant portion of the experimental effort in the last 5 years has been devoted to establishing a correlation between levels populated in the (d,p) reaction and levels populated in resonance neutron capture. The conclusion is that the neutron capture process is much more a direct reaction (rather than virtually 100% via compound nucleus formation) than had been suspected previously. Prof. P.M. Endt (Utrecht) pointed out the necessity of doing only the very best experimental investigation of neutron capture reactions particularly those studies concerned with low-lying nuclear structure. Much better data is obtained in these kinds of investigations when using Compton Suppression and pair spectrometers. Dr. I. Bergquist (Lund) pointed out that most 14MeV neutron capture cross sections are too large and need to be redone. There are about 13 laboratories outside the United States presently involved in proper neutron capture studies and about 5 in the United States. Georgia Tech and Brookhaven have the only labs in this country presently doing γ-γ coincidence studies for low-energy nuclear structure investigations compared to 10-12 in the rest of the world. Studies of multi-pole strength functions and nuclear structure phenomena need to be continued in this country at facilities which can study thermal, average resonance and discrete resonance neutron capture in order to aid both in understanding the capture mechanism and exposing low-lying nuclear structure. Both R. E. Chrien (Brookhaven) and O.W.B. Schult (Julich) discussed the superiority of the thermal neutron capture reaction over any other reaction or decay study for populating low-lying excited states of nuclei.

I also attended the International Conference on Nuclear Structure and Spectroscopy 9-13 Sept., 1974 Amsterdam the Netherlands. This conference was dominated by both experimental and theoretical (Shell Model) studies of nuclei with $A \leq 40$. Nuclear model calculations seem to have progressed very little in the last 10 years. However, a large amount of interesting experimental evidence concerning nuclear structure was presented; from (n,γ)-(d,p) correlations to "back-bending" effects. The sad correspondence between experimental data and theoretical model calculations represents a stark portrayal of the complexity of the problem of the study of nuclear phenomena. It seems apparent that an integration of both new experimental results with model calculations and new experimental results with other experimental results must be performed if any model or theory appropriate to a wide range of nuclei is to ever be developed. It seems that such integration of effort is not presently found on any large scale.

On my return trip to the United States I visited the ISOLDE facility located on the small cyclotron at CERN. This facility consits of an on-line isotope separator used to produce proton rich nuclei following the (p,xn) reaction. The ISOLDE facility is a main competitor of the UNISOR (an on-line isotope separator used following heavy ion reactions) facility at Oak Ridge. These two facilities are generating data concerning band structure, new 0+-0+ B-decay transitions, and high spin isomeric states. Future work at UNISOR will concern the production of new isotopes and studies of heavy ion reaction mechanisms. Both of these facilities involve the coordination of experimental-theoretical and systematic studies of nuclear data which I believe to be vital to the development of our understanding of nuclear phenomena.

It is my opinion that my program at Georgia Tech can best be fitted into a national program oriented toward the study of nuclear structure by adding a pair spectrometer — Compton Suppression capability to my present (n,γ) facility and by my becoming involved with the UNISOR program with its inherant coordination of theoretical and experimental investigations coupled with a study of systematic trends in nuclei.

I take this opportunity to express my gratitude to the National Science Foundation for this grant. I have returned with numerous ideas concerning the study of nuclear structure phenomena which I will apply in my future work.

Donald A. McClure
Georgia Institute of Technology